DRAUGHTSMAN CIVIL

NSQF LEVEL - 4

1st Year

TRADE THEORY

SECTOR : CONSTRUCTION

(As per revised syllabus July 2022 - 1200 hrs)

Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

Post Box No. 3142, CTI Campus, Guindy, Chennai - 600 032

Sector : **Construction**

Duration : **2 Years**

Trade : **Draughtsman Civil - 1st Year Trade Theory- NSQF Level - 4 (Revised 2022)**

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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 2020 to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Mentor Councils comprising various stakeholder's viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai has now come up with instructional material to suit the revised curriculum for **Draughtsman Civil 1st Year Trade Theory NSQF Level - 4 (Revised 2022) in Construction Sector.** The NSQF Level - 4 (Revised 2022) Trade Practical will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 4 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

The Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

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PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of the Federal Republic of Germany. The prime objective of this institute is to develop and provide instructional materials for various trades as per the prescribed syllabi (NSQF LEVEL - 4) under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVT/NAC in India, which is to help an individual to master skills to do a job. The instructional materials are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book, Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and Transparencies) and other support materials.

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and transparencies are unique, as they not only help the instructor to effectively present a topic but also help him to assess the trainee's understanding. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and demonstrations.

In order to perform the skills in a productive manner instructional videos are embedded in QR code of the exercise in this instructional material so as to integrate the skill learning with the procedural practical steps given in the exercise. The instructional videos will improve the quality of standard on practical training and will motivate the trainees to focus and perform the skill seamlessly.

IMPs also deals with the complex skills required to be developed for effective team work. Necessary care has also been taken to include important skill areas of allied trades as prescribed in the syllabus.

The availability of a complete Instructional Media Package in an institute helps both the trainer and management to impart effective training.

The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media Development Committees specially drawn from Public and Private sector industries, various training institutes under the Directorate General of Training (DGT), Government and Private ITIs.

NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment & Training of various State Governments, Training Departments of Industries both in the Public and Private sectors, Officers of DGT and DGT field institutes, proof readers, individual media developers and coordinators, but for whose active support NIMI would not have been able to bring out this materials.

Chennai - 600 032 **EXECUTIVE DIRECTOR**

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisations to bring out this Instructional Material **(Trade Theory)** for the trade of **Draughtsman Civil** (NSQF LEVEL - 4) (Revised 2022) under **Construction** Sector for ITIs.

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NIMI records its appreciation for the Data Entry, CAD, DTP operators for their excellent and devoted services in the process of development of this Instructional Material.

NIMI also acknowledges with thanks the invaluable efforts rendered by all other NIMI staff who have contributed towards the development of this Instructional Material.

NIMI is also grateful to everyone who has directly or indirectly helped in developing this Instructional Material.

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intended to be used in workshop . It consists of a series of practical exercises to be completed by the trainees during the course of the **Draughtsman civil** trade supplemented and supported by instructions/ informations to assist in performing the exercises. These exercises are designed to ensure that all the skills in compliance with NSQF LEVEL - 4 (Revised 2022).

Module 1 - Safety

Module 2 - Basic Engineering Drawing

Module 3 - Masonry

Module 4 - Foundation

Module 5 - Temporary Structure

Module 6 - Treatment for Building

Module 7 - Arches and Lintels

Module 8 - Chain surveying

Module 9 - Compass surveying

Module 10 - Plane table surveying

Module 11 - Carpentry

Module 12 - Electrical wiring

Module 13 - Floors

Module 14 - Vertical movement

Module 15 - Pitched roof

Module 16 - Levelling

Module 17 - Theodolite survey

The skill training in the shop floor is planned through a series of practical exercises centered around some practical project. However, there are few instances where the individual exercise does not form a part of project.

While developing the practical manual a sincere effort was made to prepare each exercise which will be easy to understand and carry out even by below average trainee. However the development team accept that there is a scope for further improvement. NIMI, looks forward to the suggestions from the experienced training faculty for improving the manual.

TRADE THEORY

The manual of trade theory consists of theoretical information for the course of the **Draughtsman civil** Trade. The contents are sequenced according to the practical exercise contained in the manual on Trade practical. Attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This co-relation is maintained to help the trainees to develop the perceptional capabilities for performing the skills.

The Trade theory has to be taught and learnt along with the corresponding exercise contained in the manual on trade practical. The indicating about the corresponding practical exercise are given in every sheet of this manual.

It will be preferable to teach/learn the trade theory connected to each exercise at least one class before performing the related skills in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

The material is not the purpose of self learning and should be considered as supplementary to class room instruction.

CONTENTS

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

Sl.No.	Learning Outcome	Exercise No.
1	Draw free hand sketches of hand tools used in civil work following safety precautions.	1.1.01 - 08 & 1.2.13
2	Draw plane figures applying drawing instruments with proper layout and folding of drawing sheets.	1.2.14 - 1.2.16
3	Construct plain scale, comparative scale, diagonal scale and vernier scale.	1.2.17
4	Draw orthographic projections of different objects with proper lines, lettering and dimensioning.	1.2.18 - 1.2.21
5	Draw Isometric, oblique and perspective views of different solid, hollow and cut sections with proper lines and dimensions as per standard convension.	1.2.18 - 1.2.21
6	Draw component parts of a single storied residential building with suitable symbols and scales.	1.3.22
7	Draw different types of stone and brick masonry.	1.3.23 & 1.3.24
8	Draw different types of shallow and deep foundation.	1.4.25 - 1.4.30
9	Draw different types of shoring, scaffolding, underpinning, form work and timbering.	1.5.31 - 1.5.34
10	Drawing of different types of damp proofing in different position.	1.6.35 - 1.6.37
11	Drawing of different types of arches and lintels with chajja.	1.7.38 - 1.7.40
12	Perform site survey with chain / tape and prepare site plan.	1.8.41 - 1.8.45
13	Perform site survey using prismatic compass and prepare site plan.	1.9.46 - 1.10.51
14	Perform site survey with plane table and prepare a map.	1.10.52
15	Drawing of different types of carpentry joints.	1.11.53 - 1.11.54
16	Draw different types of doors and windows according to manner of construction, arrangement of component, and working operation	1.11.55
17	Prepare the detailed drawing of electrical wiring system.	1.12.56 & 1.12.57
18	Draw types of ground and upper floors.	1.13.58 & 1.13.59
19	Draw different types of vertical movement according to shape, location, materials by using stair, lift, ramp and escalator.	1.14.60 - 1.14.62
20	Draw different types of roofs, truss according to shape, construction, purpose and span	1.15.63 - 1.15.65
21	Make topography map by contours with levelling instruments.	1.16.66 - 1.16.81
22	Perform a site survey with theodolite and prepare site plan.	1.17.82 - 1.17.90

SYLLABUS FOR DRAUGHTSMAN CIVIL

Duration: Two Year

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) With Indicative Hours	Professional Knowledge (Trade Theory)
Professional Skill 56Hrs; Professional Knowledge 14Hrs	Draw free hand sketches of hand tools used in civil work following safety precautions.	1. Importance of trade training, demonstrate tools &equipments used in the trade.(02 hrs) 2. Importance of housekeeping & good shop floor practices. (02 hrs) Occupational Safety & Health : 3. Introduction to safetyequipmentsand their uses. Introduction of first aid. Health, Safety andEnvironment guidelines, legislations & regulations as applicable.(04 hrs) 4. Disposal procedure of wastematerials of the trade. (03hrs) 5. Personal protective Equipments (PPE):-Basic injuryprevention, Basic first aid. (04hrs) 6. Hazard identification and avoidance, safety signs for Danger, Warning, caution & personal safety message. (03hrs) 7. Preventive measures forelectrical accidents & Carpenter works :- steps tobe taken insuchaccidents. (02 hrs) 8. Use of Fire extinguishers.(08hrs)	• Importance of safety and general precautions observed in the in the industry/shop floor. All necessary guidance to be provided to the new comers to become familiar with the working of Industrial Training Institute system including stores procedures. Soft Skills: its importance and • Job area after completion of training. • Introduction of First aid. Introduction of PPEs. Introduction to 5S concept& its application. • Response to emergencies e.g.; power failure, fire alarm, etc. (07 hrs.)
		9. Awareness about the job-sheets made by the ex. Trainees. (02hrs) 10. Use of drawing instruments and equipment with care. (03hrs) 11. Method of fixing of drawing sheet on the drawing board. (03hrs) 12. Layout of different size ofDrawing sheets and foldingof sheets. (06hrs) 13. Draw free hand sketch of hand tools used in civil work.(14hrs)	• Familiarisation& information about rules and regulations of the Institute and Trade. • Overview of the subjects to be taught for each year. • List of the Instruments, equipments and materials to be used during training. (07 hrs.)
Professional Skill 56Hrs; Professional Knowledge 12Hrs	Draw plane figures applying drawing instruments with proper layout and folding of drawing sheets.	14. Symbols & conventional representation for materials in sections as per IS 962-1989, SP-46:2003 for buildingdrawings. (15hrs) 15. Lines, lettering andDimensioning. (24hrs) 16. Construction of plaingeometrical figures. (17hrs)	• Importance of B.I.S. • Introduction of Code for practice of Architectural and • Building Drawings (IS: 962-1989, SP-46:2003). • Layout of drawing. Lines, Lettering, Dimensioning. (12 hrs.)

Professional Skill 28Hrs; Professional Knowledge 06Hrs	Construct plain scale, comparative scale, diagonal scale and vernier scale.	17. Drawing of:-Construction of scales - Plain, comparative, diagonal, vernier& scale of cords. (28hrs)	• Knowledge of different types of scale. Principle of R.F. Materials:- • Stones :-characteristics, types & uses. • Bricks -. Manufacturing, characteristics of good bricks, types,uses and hollow bricks. • Lime- characteristics, types, manufacturing &its uses. • Pozzolanic :- characteristics, types & uses. • Cement :- Manufacturing, characteristics, types, uses and test of good cement. (06 hrs.)
Professional Skill 56Hrs; Professional Knowledge 12Hrs	Draw orthographic projections of different objects with proper lines, lettering and dimensioning. Draw Isometric, oblique and perspective views of different solid, hollow and cut sections with proper lines and dimensions as per standard convension.	Drawing of :- 18. Three views in OrthographicProjection of Line, plane, Solid objects& section of solids. (18hrs) 19. Isometric Projection of geometrical solids. (10hrs) 20. Construction of solid geometrical figures. (10hrs) 21. Oblique and Perspective views of step block. (18hrs)	• Different types of projection views: Orthographic, Isometric, Oblique and Perspective. Building materials:- • Sand:-characteristics, types&uses. • Clay Products :- types, earthenware, stoneware, porcelain, terracotta, glazing. • Mortar&Concrete:-Types,uses, preparation, proportion, admixtures and applications. (12 hrs.)
Professional Skill 28Hrs; Professional Knowledge 06Hrs	Draw component parts of a single storied residential building with suitable symbols and scales.	Drawing of :- 22. Component parts of a single storied residential building. (in sectional details)Showing Foundation, Plinth, Doors, Windows, Brick work, Roof, Lintel and Chajjah, etc. (28hrs)	Building materials:- • Timber:- Types, Structure, disease & defects, characterstic, seasoning, preservation and uitility. • Alternaative material to Timber • Plywood, Block board, Particle board, Fireproof reinforced plastic(FRP), Medium density fireboard (MDF) etc. • Tar, bitumen, asphalt:- • Properties, application and uses. (06 hrs.)
Professional Skill 56Hrs; Professional Knowledge 12Hrs	Draw different types of stone and brick masonry.	23. Draw Details of stone masonryincluding stone joints. (26hrs) 24. Drawing of :-Different types of brick bondingShowing arrangement of bricks in different layers as per thickness of wall, pillars, copying, etc. (30hrs).	Protective materials:- • Paints:- characteristic, types, uses. • Varnishes :- characteristics and uses. • Metal:- characteristic, types, uses.

			• Plastics :- characteristic, types, uses. Building Construction:- • Sequence of construction of a building. • Name of different parts of building. • Stone masonry:- • Terms, use and classification. • Principle of construction, composite masonry. • Strength of walls. • Strength of masonry. • Brick masonry - principles of construction of bonds. Tools and equipments used. (12 hrs.)
Professional Skill 56Hrs; Professional Knowledge 18Hrs	Draw different types of shallow and deep foundation.	Drawing of Foundation:- Drawing of different types of foundation - Shallow :- 25. Spread Footing. (06hrs) 26. Grillage foundation. (06hrs) Deep - 27. Pile foundation. (12hrs) 28. Raft foundation. (12hrs) 29. Well foundation. (12hrs) 30. Special foundation. (8hrs)	Building Construction:-Foundation:- • Purpose of foundation • Causes of failure of foundation • Bearing capacity of soils • Dead and live loads • Examination of ground • Types of foundation • Drawing of footing foundation setting out of building on ground excavation Simple machine foundation (18 hrs.)
Professional Skill 28Hrs; Professional Knowledge 06Hrs	Draw different types of shoring, scaffolding, underpinning, form work and timbering.	Drawing of :- 31. Shoring.(7hrs) 32. Scaffolding.(7hrs) 33. Underpinning. (7hrs) 34. Timbering. (7hrs)	Building Construction:- • Types of shoring and scaffolding in details. • Types of Underpinning and Timbering in detail (06 hrs.)
Professional Skill 28Hrs; Professional Knowledge 06Hrs	Drawing of different types of damp proofing in different position.	Drawing details of treatments in building:- 35. Damp proofing. (06hrs) 36. Anti-termites. (06hrs) 37. Fire proofing. (16hrs)	Treatments of building structures:- • DPC Sources and effects of dampness • Method of prevention of dampness in building • Damp proofing materials - properties, function and types. • Anti-termite treatment - objectives, uses and applications.
Professional Skill 56Hrs; Professional Knowledge 12Hrs	Drawing of different types of arches and lintels with chajja.	Draw different forms of :- 38. Arches. (22hrs) 39. Lintels. (12hrs) 40. Lintels with Chajjahs. (22 hrs)	• Arches: - Technical terms-. types, centring • Lintel :-types,wooden, brick, stone, steel & RCC. • Chajjahs - characteristics, Centring& Shuttering (12 hrs.)

Professional Skill 84Hrs; Professional Knowledge 18Hrs	Perform site survey with chain / tape and prepare site plan. Perfom site survey using prismatic compassand prepare site plan. Lo 14 ,15to 18 Perform site survey with plane table and prepare a map.	Surveying:- Chain Survey :- (35 hrs.) 41. Equipment and instrument used to perform surveying.(06hrs) 42. Distance measuring with chainand tape. (08hrs 43. Entering Field book and plotting. (05hrs) 44. Calculating the area of site. (07hrs) 45. Prepare site planwith the helpof Mouza map. (09hrs Compass survey:- (42hrs) 46. Field work of prismatic compass survey. (07hrs 47. Plotting of prismatic compasssurvey. (05hrs 48. Testing and adjusting thecompass. (08hrs 49. Observation of bearings. (08hrs 50. Bearing a line. (05hrs 51. F.B.,B.B., R.B.,W.C.B. of aLine,Traverse and also checkthe close traversing. (09hrs) Plane Table Survey :- (07hrs) 52. Surveying of a Building sitewith Plane Table. (07hrs)	Surveying:- • Introduction, History and principles of chain survey. • Instrument employed. • Use, care, maintenance and common terms. • Classification, accuracy, types. • Main divisions (plane & geodetic). • Chaining. • Speed in field and office work. • Knowledge of Mouza Map. Compass survey:- • Instrument and its setting up • Bearing and each included angle of close traverse. • Local attraction. • Magnetic declination and its true bearing. • Precaution in using prismatic compass. Plane table survey:- • Instrument used in plane table survey • Care and maintenance of plane table (18 hrs.)
Professional Skill 28Hrs; Professional Knowledge 12Hrs	Drawing of different types of carpentry joints. Draw different types of doors and windows according to Manner of construction, Arrangement of component, and working operation	Making detailed drawing of :- 53. Carpentry joints:- lengthening, bearing, housing, framing, panelling&moulding. (11hrs) 54. Different Types doors including panelled, glazed and flush door. (11hrs) 55. Different types windows and ventilators. (06hrs)	• Carpentry joints :- terms,classification of joints, Uses, types of fixtures , fastenings. • Doors -Parts, Location, standard sizes, types. • Windows-types. • Ventilators-purpose-types. (12 hrs.)
Professional Skill 28Hrs; Professional Knowledge 06Hrs	Prepare the detailed drawing of electrical wiring system.	Electrical Wiring:- Prepare drawing of 56. Wiring in different system.(08hrs) 57. Electrical wiring plan with all fittings showing in drawing.(20 hrs)	Electrical Wiring:- • Safety precaution and elementary first aid. • Artificial respiration and treatment of electrical shock • Elementary electricity. • General ideas of supply system.

			• Wireman's tools kit. Wiring materials. Electrical fittings. • System of wirings. Wiring installation for domestic lightings (06 hrs.)
Professional Skill 28Hrs; Professional Knowledge 06Hrs	Draw types of ground and upper floors.	Drawing details of:- 58. Types of ground & upper floors. (14hrs) 59. Various floor finishing, sequence of construction. (14hrs)	• Floors - Ground floor & upper floor-Types. • Flooring- materials used types. (06 hrs.)
Professional Skill 56Hrs; Professional Knowledge 12Hrs	Draw different types of vertical movement according to shape, location, materials by using stair, lift, ramp and escalator.	Drawing different forms of vertical movements:- 60. As per shape - Drawing of straight, open newel, dog- legged, geometrical and bifurcated stairs & spiral stairs. (18hrs) 61. As per material - brick, stone, wooden, steel & RCC stairs. (20 hrs) 62. Drawing of Lift and Escalator. (18hrs)	• Stairs:- Terms. Requirements,Planning and designing of stair and details of construction. • Basic concept of lift and Escalator (12 hrs.)
Professional Skill56Hrs; Professional Knowledge 18Hrs	Draw different types of roofs, truss according to shape, construction, purpose and span	Drawing details of:- 63. Slopped/Pitched Roof Truss - King Post and Queen Postroof trusses showing detailed connections. (23hrs) 64. Steel roof trusses showing detailed connections. (21hrs) 65. Wooden roof truss, showing detailed connections. (12hrs)	Roofs & Roof coverings: - • purposes,Elements, Types, Fla, pitched. • Truss-king post, queen post, mansard, bel-fast, steel, composite. • Roof & coverings - objectives, types & uses. (18 hrs.)
Professional Skill 56Hrs; Professional Knowledge 12Hrs	Make tropography map by contours with leveling instruments.	Levelling:- (03 hrs.) 66. Handling of levellinginstruments& their settings(04 hrs.) 67. Temporary adjustment of alevel. (03 hrs.) 68. Simple levelling. 69. Differential levelling (Fly levelling). (03 hrs.) 70. Carry out Levelling field book. (03 hrs.) 71. Equate Reduction of levels - Height of collimation and Riseand Fall method - Comparisonof methods. (04 hrs.) 72. Solve problems on reduction of levels. (03 hrs.) 73. Calculate Missing data and how to fill it up-calculations &Arithmaticalcheckin various problems and its solution. (04 hrs.)	Levelling:- • Auto level , dumpy Level, Tilting Level - introduction, definition • Principle of levelling. • Levelling staffs, its graduation & types. • Minimum equipment required • Types,component / part and function. • Temporary and permanent adjust ment, procedure in setting up. • Level& horizontal surface. Datum Benchmark, Focussing& parallax • Deduction of levels / Reduced Level. • Types of leveling, Application to chain and Levelling Instrument to Building construction.

		74. Practice leveling with different instruments. (04 hrs.) 75. Check levelling. (04 hrs.) 76. Profile levelling or Longitudinal, plotting the profile. (03 hrs.) 77. Surveying of a building site with chain and Levelling Instrument with a view to computing earth work. (04 hrs.) 78. Contour - Direct and Indirect methods. (03 hrs.) 79. Make Topography map, contours map. (04 hrs.) 80. Solve trigonometric problems. (03 hrs.) 81. Prepare a road project in a certain alignment. (04 hrs.)	• Contouring ;-Definition, Characteristics, Methods. • Direct and Indirect methods • Interpolation of Contour, Contour gradient , Uses of Contour plan and Map. • Knowledge on road project. (12 hrs.)
Professional Skill 56 Hrs; Professional Knowledge 12 Hrs	Perform a site survey with Theodolite and prepare site plan.	Theodolite survey:- 82. Field work of theodolite. (05 hrs.) 83. Horizontal angle. (05 hrs.) 84. Vertical angle. (05 hrs.) 85. Magnetic bearing of a line. (05 hrs.) 86. Levelling with a theodolite. (05 hrs.) 87. Calculation of area from traverse. (04 hrs.) 88. Determination of Heights. (06 hrs.) 89. Calculation of departure, latitude, northing and easting- (5hrs) 90. Setting out work-Building,culvert, centre line of Dams,Bridges and Slope of Earth work, etc. (16hrs)	Theodolite survey:- • Introduction. • Types of theodolite. • Uses, Methods of Plotting. • Transit vernier theodolite. • Terms of transit theodolite. • Fundamental line of theodolite. • Adjustment of theodolite. • Checks, Adjustment of errors. • Open and closed traverse and their application to Engineering Problems. • Vernier scale- types. • Measurement of horizontal angle. • Measurement of vertical angle. • Adjustment of a close traverse. • Problems in transit theodolite- departure, latitude, northing and easting. (12 hrs.)

Occupational safety and health

Objectives: At the end of this lesson you shall be able to
- **define occupational safety and health**
- **state the importance of safety and health at workplace**
- **state the role of employer, trade union & employee for health & safety program.**

Occupational Safety and Health (OSH) is an area concerned with protecting the safety, health and welfare of people engaged in co-workers, family members, employees, customers, and many others who might be affected by the workspace environment.

Workspace safety : Owner/Occupier of industries have to comply with legal directions to take care for the safety, health and welfare of their employees. Equally the workers have moral responsibilities to follow all safety norms and healthy on the shop- floor (Fig 1).

Fig 1

Occupational health : Health at work is also called occupational health. It is concerned with enabling an individual to undertake their day to day work fully knowing the health hazards they are exposed to and preventing them at the workspace.

Good safety and health practices can also reduce employee injury and illness related costs, including medical care, sick leave and disability benefit costs. (Fig 2)

Fig 2

The joint ILO/WHO committee on occupational health (1995) main focus in occupational health is on three different objectives.

i The maintenance and promotion of workers health and working capacity.

ii The improvement of working environment and work to become conductive to safety and health.

iii Development of work organization and working cultures in a direction which supports health and safety at work and in doing so also promotes a positive social climate and smooth operation and may enhance productivity of the undertakings.

Prevention is better than cure : No place of work can always be completely safe all the time and whilst some work places present greater risks than others. Industry nowhere is immune to the possibility of an accident. Hence all industries should develop the ability to carry out risk assessment processes and to take all precautionary steps to ensure the safety of the workforce. It is a group collective effort that includes each and every member of the workforce. Employers should always ensure they do the following.

- Provide adequate control of the health and safety risks.
- Consult with employees on matters affecting their health and safety.
- Provide and maintain safe plant and equipment.
- Ensure safe handing and use of substances.
- Provide information, instruction, supervision and training so that employees are competent to carry out their role.
- Review and revise all these policies regularly.

Health and Safety programmes

For all of the reasons (Fig 3), it is crucial that employers, workers and unions are committed to health and safety, addressing the following areas.

Fig 3

- Workplace hazards are controlled - at the source whenever possible.

- Records of any exposure are maintained for many years.
- Both workers and employers are informed about health and safety risks in the workplace.
- Establish an active and effective health and safety committee that includes both workers and management.
- To observe that the workers' health and safety efforts are ongoing.

Effective workplace health and safety programmes can help to save the lives of workers by reducing hazards and their consequences. Health and safety programmes also have positive effects on both worker morale and productivity, which are important benefits. At the same time, effective programmes can save employers a great deal of money.

Healthy workplace, hazard free work environment, zero accident work-life can help to save the lives of workers by reducing hazards and diseases. Effective programmes can also have positive effects on both worker morale and productivity. All put together enhance the human values at work and prosperity of the nation.

1 Occupational health and safety encompasses the social, mental and physical well-being of workers in all occupations.

2 Poor working conditions have the potential to affect a worker's health and safety.

3 Unhealthy or unsafe working conditions can be found anywhere, whether the workplace is indoor or outdoor.

4 Poor working conditions can affect the environment workers live in. This means that workers, their families, other people in the community, and the physical environment around the workplace, can all be at risk from exposure to workplace hazards.

5 Employers have a moral and often legal responsibility to protect workers.

6 Work-related accidents and diseases are common in all parts of the world and often have many direct and indirect negative consequences for workers and their families. A single accident or illness can mean enormous financial loss to both worker and employers.

7 Effective workplace health and safety programmes can help to save the lives of workers by reducing hazards and their consequences.

8 Effective programmes can also have positive effects on both worker morale and productivity, and can save employers a great deal of money.

Occupational hazard

Objectives: At the end of this lesson you shall be able to
- **explain various occupational hazard**
- **state occupational hygiene**
- **describe occupational disease disorders and its prevention.**

All jobs, primarily provides many economic and other benefits, But equally there are a wide varieties of workplace dangers and hazards, which are risky to the health and safety of people at work.

Basic hazards : Employers have a responsibility to protect workers against health and safety hazards at work. Workers have the right to know about potential hazards and to refuse work that they believe is dangerous. Workers also have a responsibility to work safely with hazardous materials. Health and Safety hazards exist in every workplace. Some are easily identified and corrected, while others create extremely dangerous situations that could be a threat to your life or long-term health. The best way to protect oneself is to learn to recognize and prevent hazards in the workplaces.

Physical hazards are the most common hazards and are present in most workplace at some point of time. Examples include; live electrical cords, unguarded machinery, exposed moving parts, constant load noise, vibrations, working from ladders, scaffolding or heights, spills, tripping hazards. Physical hazards are a common source of injuries in many industries. Noise and vibration, Electricity, Heat, Ventilation, Illumination, Pressure, Radiation etc.

- **Ventilation** and air circulation have major say on the health and working comfort of the worker. There must be good ventilation, a supply of fresh, clean air drawn from outside is required. It must be uncontaminated and circulated around the workspace. Closed of confined spaces also present a work hazard, which has limited openings for entry and exit and unfavorable natural ventilation, and which is not intended for continuous employee occupancy.

Spaces of this kind can include storage tanks, ship compartments, sewers, and pipelines. Asphyxiation is another potential work hazard in certain situations. Confined spaces can pose a hazard not just to workers, but also to people who try to rescue them.

- **Noise and Vibration :** Noise and vibration are both fluctuations in the pressure of air (or other media) which affect the human body. Vibrations that are detected by the human ear are classified as sound. We use the term 'noise to indicate unwanted sound. Noise and vibration can harm workers when they occur at high levels, or continue for a long time. (Fig 1)
- **Electricity** poses a danger to many workers. Electrical injuries caused by contact with electric energy can be divided into four types

Fig 1

- fatal electrocution,
- electric shock,
- burns,
- falls .

Wires and electrical equipment pose safety threats in the workspace. When employees mishandle electrical equipment and wires, they are taking risks. (Fig 2)

Fig 2

- **Temperature (Heat Stress) :** A reasonable working temperature, for strenuous work, local heating or cooling where a comfortable temperature is to be maintained which is safe and does not give off dangerous or offensive fumes, Thermal clothing and rest facilities where necessary (for example, for 'hot work' or work in cold storage areas). Sufficient space in workrooms etc. are under the legislation for implementation by the owner of the factories.
- **Illumination (lighting) :** Good light lighting is essential for productivity Natural light is preferred where possible. Glare and flickering should be avoided.

Chemical hazards are present when you are exposed to any chemical preparation (solid, liquid or gas) in the workplace. Examples include: cleaning products and solvents, vapours and fumes, carbon monoxide or other gases, gasoline or other flammable materials. Chemicals hazards are the major causes of concern. Many chemicals are used not on generic names but on brands. The chemicals have biological effects on the human body if digested, inhaled or if direct skin contact with the chemicals, injuries occurs.

Accidents involving chemical spills, exposure and inhalation can lead to burns, blindness, rashes and other ailments. Most of them cause acute poisoning when taken orally, eye-skin irritation, Respiratory injuries etc. Long term effects of chemicals on blood, nerve, bones, kidneys, livers etc., my lead to serious diseases/disorders. The only way is to understand their chemical nature and handle them very carefully.

HEAT EXHAUSTION/HEAT STROKE & TREATMENT

- NORMAL BODY CORE TEMPERATURE - 37°C
- HEAT EXHAUSTION - 38°C - 40°C
- HEAT STROKE 41°C AND HIGHER

SIGNS AND SYMPTOMS

HEAT EXHAUSTION	HEAT STROKE
• RESTLESS	• REDUCED LEVEL OF CONCIOUSNESS
• WEAK	• IRRITABLE
• DIZZY	• MUSCULAR PAIN
• RAPID PULSE	• RAPID PULSE
• LOW BLOOD PRESSURE	• HIGH BLOOD PRESSURE
• NAUSEA	• NAUSEA
• VOMITTING	• VOMITTING
• MENTAL STATUS - NORMAL	• MENTAL STATUS - CONFUSED
• BEHAVIOR - NORMAL	• BEHAVIOUR - ERRATIC
	• HOT, DAY, RED SKIN
	• DEATH
TREATMENT	
• LAY PERSON DOWN & ELEVATE LEGS	• MOVE PERSON TO COOL VENTILATED AREA
• ENSURE NORMAL BREATHING	• CHECK FOR BREATHING, PULSE & CIRCULATION
• IF THIRSTY GIVE WATER TO DRINK	• IF POSSIBLE COVER THE PERSON WITH ICE PACKS OR COLD WATER TO REDUCE THE BODY TEMPERATURE
• REPORT INCIDENT TO SUPERVISOR	• GIVE WATER TO DRINK
	• MONITOR VITAL SIGNS
	• GET PERSON TO HOSPITAL
	• REPORT INCIDENT TO SUPERVISOR

CHEMICAL POISONING

Poison : An agent or substances which may cause structural damage or functional disorders when introduced into the body by :

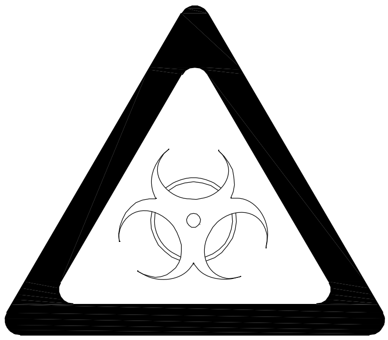
- **Ingestion**
- **Inhalation**
- **Absorption or**
- **Injection**

Biological hazards (Fig 3) come for working with people, animals or infectious plant material. Examples include; blood or other bodily fluids, bacteria and viruses, insect bites, animal and bird droppings. Biological hazards are due agent like bacteria, virus, fungi, mold, blood-borne pathogens etc., are main agents to cause various illness. (Fig 4)

Ergonomic hazards (Fig 5)

Ergonomic hazards occur when the type of work you do, your body position and/or your working conditions put a strain on your body. They are difficult to identify because you don't immediately recognize the harm they are doing to your health. Examples include : poor lighting, improperly adjusted workstations and chairs, frequent lifting, repetitive or awkward movements. Muscular Skeletal Disorders (MSDs) affect the muscles, nerves and tendons. Work related MSDs are one of the leading causes injury and illness.

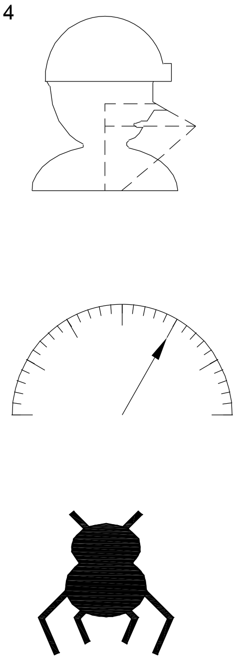
Fig 3



BIOLOGICAL HAZARD

DCN110123

Fig 4



BIOLOGICAL HAZARD

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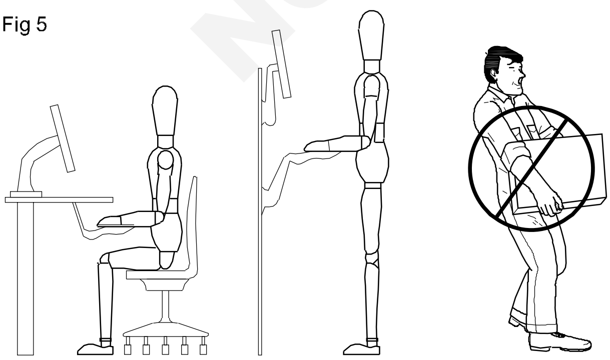
Fig 5



ERGONOMIC HAZARDS

DCN110125

Workers in many different industries and occupations can be exposed to risk factors at work, such as lifting heavy items, bending, reaching overhead, pushing and pulling heavy loads, working in awkward body postures and performing the same or similar tasks repetitively. Exposure to these known risk factors for MSDs increases a worker's risk of injury.

Mechanical hazards are factor arise out of varieties of machines in industries including manufacturing, mining, construction and agriculture. They are dangerous to the worker when operated without training and experience. Operating machines can be risky business, especially large, dangerous machines. When employees don't know how to properly use machinery or equipment, they risk such injuries as broken bones, amputated limbs and crushed fingers. Many machines involve moving parts, sharp edges, hot surfaces and other hazards with the potential to crush, burn, cut, shear, stab or otherwise strike or wound workers if used unsafely.

Various safety measures exists to minimize these hazards, lockout-tagout procedures for machine maintenance and roll over protection systems for vehicles. Machines are also often involved indirectly in worker deaths and injuries, such as in cases in which a worker slips and falls, possibly upon a sharp or pointed object. Safeguarding machinery decreases accidents and keeps employees who use the machine safer.

Falls (Fig 6) are a common cause of occupational injuries and fatalities, especially in construction, extraction, transportation, healthcare, and building cleaning and maintenance. Slips and falls to be the leading cause of workplace injuries and fatalities. From slippery surfaces to un-railed staircases, the possibility of slipping, tripping or falling on the job is a workplace safety hazard. Broken bones, fractures, sprained wrists and twisted ankles constitute some of the physical injuries caused by falling accidents.

Fig 6

DCN110126

Falls in the workplace is effectively prevented by putting caution signs around slippery surfaces (Fig 7), having rails on every staircase and making sure that wires on the floor are covered to avoid tripping. They are perhaps unavoidable in certain industries, such as construction and mining, but over time people have developed safety methods and procedures to manage the risks of physical danger in the workplace. Employment of children may pose special problems.

Fig 7

CAUTION BOARD

DCN110127

Psychosocial hazards : psychosocial hazards are related to the way work is designed, organized and managed, as well as the economic and social contexts of work and are associated with psychiatric, psychological and/or physical injury or illness. Linked to psychosocial risks are issues such as occupational stress and workplace violence which are becoming a major challenge to occupational health and safety.

Workplace inspections prevent hazards

Regular workplace inspections are another important factor in preventing injuries and illnesses. By critically examining all aspects of the workplace, inspections identify and record hazards that must be addressed and corrected.

A workplace inspection should include

- Listening to the concerns of workers and supervisors.
- Gaining further understanding of jobs and tasks.
- Identifying existing and potential hazards.
- Determining underlying causes of hazards.
- Monitoring hazard controls (Personal protective equipment, engineering controls, policies, procedures)
- Recommending corrective action.

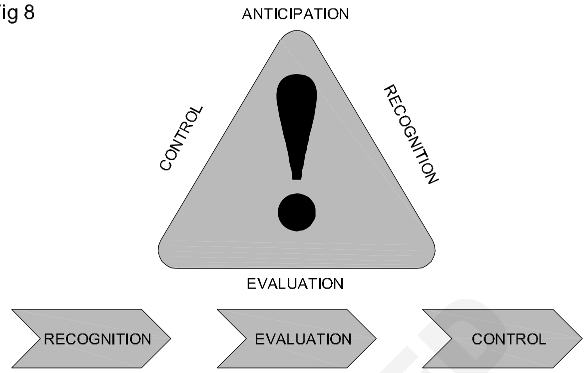
Occupational hygiene

Occupational hygiene (Industrial hygiene) (Fig 8) is the discipline of anticipating, recognizing, evaluating and controlling health hazards in the working environment with the objective of protecting worker health and well-being and safeguarding the community at large.

Occupational hygiene uses science and engineering to prevent ill health caused by the environment in which people work. It helps employers and employees to understand the risks and improve working conditions and working practices. (Fig 9)

Occupational disease/Disorders & its prevention : Occupational disease, illness incurred because of the conditions or environment of employment. Unlike with accidents, some time usually elapses between exposure to the cause and development of symptoms. In some instances, symptoms may not become evident for may years and hence the relationship between work and disease is ignored.

Fig 8



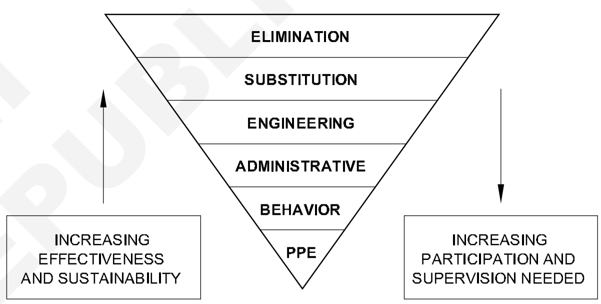
INTRODUCTION TO INDUSTRIAL HYGIENE

DCN110128

Fig 9

HIERARCHY OF CONTROL

APPLY THE HIGHEST LEVEL OF CONTROL COMMENSURATE WITH THE RISK LEVEL LOWER VALUE CONTROLS MAY BE USED IN THE INTERIM UNTIL LONG TERM CONTROLS ARE IMPLEMENTED.



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Among the environmental causes of occupational disease are subjection to extremes of temperature leading to heatstroke, air contaminants of dust, gas, fumes causing diseases of the respiratory tract, skin, or muscles and joints or changes in atmospheric pressure causing decompression sickness, excessive noise causing hearing loss, exposure to infrared or ultraviolet radiation or to radioactive substances. The widespread use of X rays, radium and materials essential to the production of nuclear power has led to an special awareness of the dangers of radiation sickness. Hence careful checking of equipment and the proper protection of all personnel are now mandatory.

In addition there are industries in which metal dusts, chemical substances, and unusual exposure to infective substances constitute occupational hazards. The most common of the dust and fiber inspired disorders are the lung diseases caused by silica, beryllium, bauxite and iron ore to which miners, granite workers and many others are exposed causing pneumoconiosis and those caused by asbestos is cancer - mesothelioma, Fumes, Smoke and Toxic liquids from a great number of chemicals are other occupational dangers. Carbon monoxide, Carbon tetrachloride, Chlorine, Creosote, Cyanides, Dinitrobenzene, Mercury, Lead Phosphorus and nitrous chloride are but a few of the substances that on entering through the skin, respiratory tract or digestive tract cause serious and often fatal illness.

Occupational hazards also are presented by infective sources. Persons who come into contact with infected animals in a living or deceased state are in danger of acquiring such diseases as anthrax. Doctors, Nurses and other hospital personnel are prime targets for the tuberculosis bacillus and for many other infectious organisms.

Fire safety

Objectives: At the end of this lesson you shall be able to
- **state different type of fire**
- **state the different types of fire extinguishers and their basic function.**

Fire safety : Fire is the most common serious hazard that one faces in a typical chemistry laboratory. While proper procedure and training can minimize the chances of an accidental fire, you must still be prepared to deal with a fire emergency should it occur.

Typically, a fire extinguisher consists of a hand-held cylindrical pressure vessel containing an agent which can be discharged to extinguish a fire.

There are two main types of fire extinguishers :

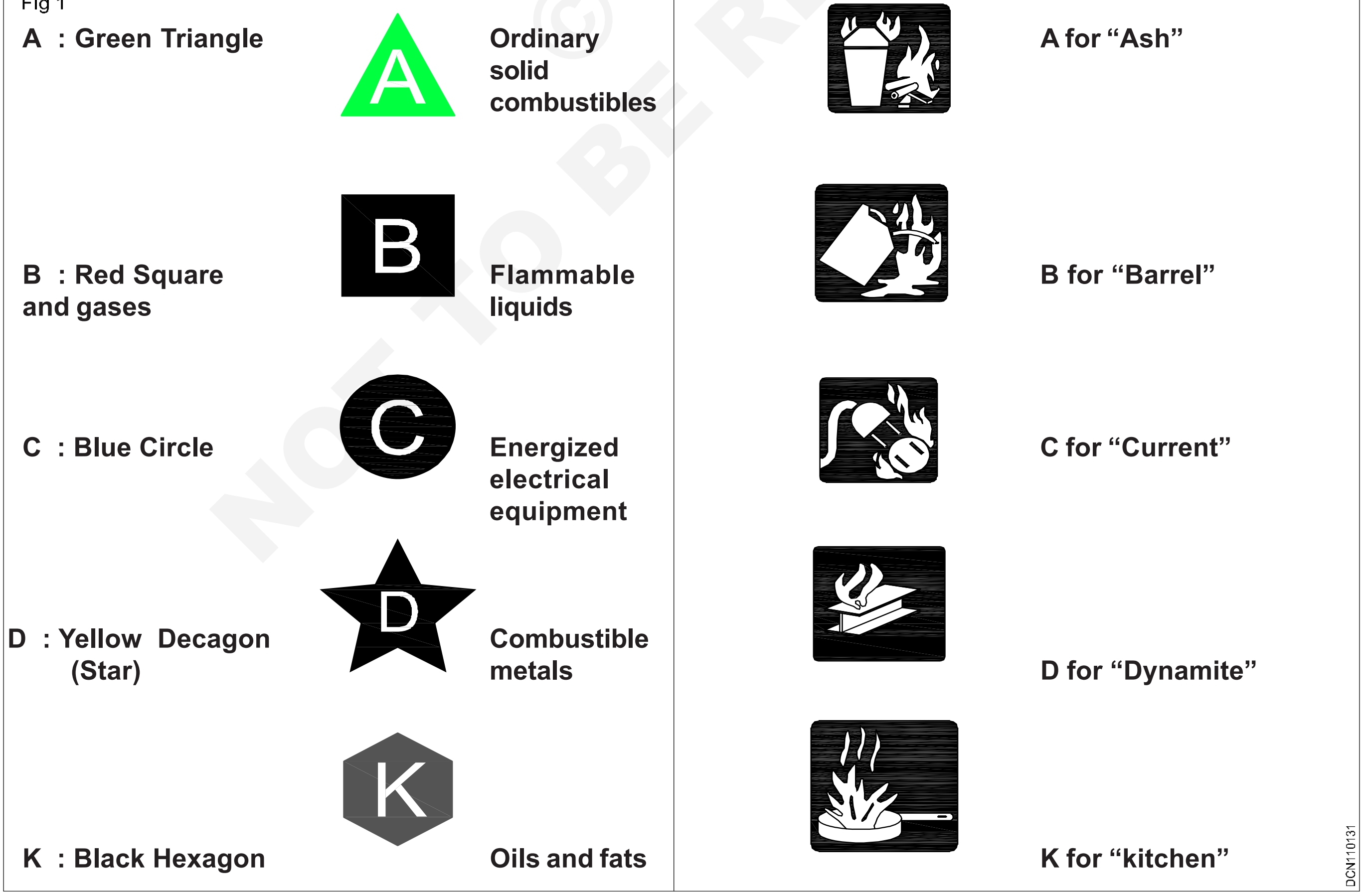
- Stored pressure
- Cartridge-operated.

In stored pressure units, the expellant is stored in the same chamber as the firefighting agent itself. Depending on the agent used, different propellants are used. With dry chemical extinguishers, nitrogen is typically used, water and foam extinguishers typically use air. Stored pressure fire extinguishers are the most common type.

Carbon-dioxide extinguishers contain the expellant gas in a separate cartridge that is punctured prior to discharge, exposing the propellant to the extinguishing agent. This type is not as common, used primarily in areas such as industrial facilities, where they receive higher-than-average use. They have the advantage of simple and prompt recharge, allowing an operator to discharge the extinguisher, recharge it and return to the fire in a reasonable amount of time. Unlike stored pressure types, these extinguishers use compressed carbon dioxide instead of nitrogen, although nitrogen cartridges are used on low temperature (-60 rated) models.

Cartridge operated extinguishers are available in dry chemical and dry powder and in water, wetting agent, foam, dry chemical (classes ABC and B.C.) and dry powder (class D) types in the rest of the world.

Fig 1



Class A : This is suitable for cloth, wood, rubber, paper, various plastics, and regular combustible fires. It is usually filled with 2 ½ gallons (9.46 liters) of pressurized water.

Class A fire extinguishers are designed to put out fires that have started from household items that are made out of materials that will quickly ignite. These materials include paper products and furniture made from wood. The Type A fire extinguisher contains water. The number on the canister represents how much water it contains. If there is a No. 1, the extinguisher will have a little more than I gallon of water. The higher the number, the more water it contains. The letter A stands for ash. A fire that burns from household items will leave ashes.

Class B : This is suitable for grease, gasoline or oil-based fire is usually filled with a dry chemical. Extinguishers smaller than 6lbs (2.72kg) are not recommended.

Class B fire extinguishers are used to put out fires that have started from highly flammable liquids. These liquids include any type of lacquer or oil-based paint products, paint thinners and lacquer thinners, oils and gasoline. According to the phoenix fire department, the letter B represents a barrel. Most of these chemicals are transported in a barrel-like container. The number on the extinguisher represents how many square feet it will cover. A 3 would represent 3 square feet, which is not a very large area. A larger fire could not be extinguished with this extinguisher.

Class C : This is suitable for electrical fires caused by appliances, tools and other plugged in gear. It can contain either halon or CO_2. Halon expensive and depletes the ozone layer and its use is restricted.

Class C : fire extinguishers are used to put out fires that have started from an electrical source. The source could be from appliances, lighting or your electrical system. This extinguisher uses carbon dioxide to put out the fire. Carbon dioxide will basically remove the oxygen from the air around the fire. Carbon dioxide is also used in some Type B extinguishers.

Class D : This is used for water-reactive metals such as burning magnesium and will be located in factories using such metals. It comes in the form of a powder that must cover the material to extinguish it.

Class D : Class D extinguishers are used to put out fires on metals that are capable of burning. These types of metals are found in the manufacturing industry only. This extinguisher uses a dry powder to put out the fire. You will not likely ever have a need for this type of extinguisher unless you work with titanium, sodium or magnesium.

Class K : This contains a special purpose wet chemical agent for use in kitchen fires and deep fryers to stop fires started by vegetable oils, animal fats, or other fats started in cooking appliances.

Class K : Many people have not heard of the Type K fire extinguisher. This extinguisher can be found in large kitchens. Many restaurants use large deep fryers full of cooking oils to deep fry foods. The typical Type B extinguisher would not be sufficient to put out a grease fire of this magnitude.

Fire fighting methods

Starvation/Blanketing	- Elimination of fuel
Smothering	- Limitation of oxygen
Cooling	- Removal of temperature

Accident & Safety

Objectives: At the end of this lesson you shall be able to
- **state the base principle for protective equipment**
- **state the accident prevention technique**
- **describe the controls of accidents & safety measures.**

Basic Principles for Protective Equipment (PPE)

Personal protective equipment, commonly referred to as "PPE", is a equipment worn to minimize exposure to serious workplace injuries and illnesses. (Fig 1) These injuries and illnesses may result from contact with chemical, radiological, physical, electrical, mechanical or other workplace hazards. Personal protective equipment may include items such as gloves, safety glasses and shoes, earplugs or muffs, hard hats, respirators or coveralls, vests and full body suits. (Fig 2 & Fig 3)

Use of personal protective equipment : All personal protective equipment should be of safe design and construction, and should be maintained in a clean and reliable fashion. It should fit well and be comfortable to wear, encouraging worker use. If the personal protective equipment does not fit properly, it can make the difference between being safely covered or dangerously exposed. When engineering, work practice and administrative controls are not feasible or do not provide sufficient protection, employers must provide personal protective equipment to their workers and ensure its proper use. Employers are also required to train each worker required to use personal protective equipment to know:

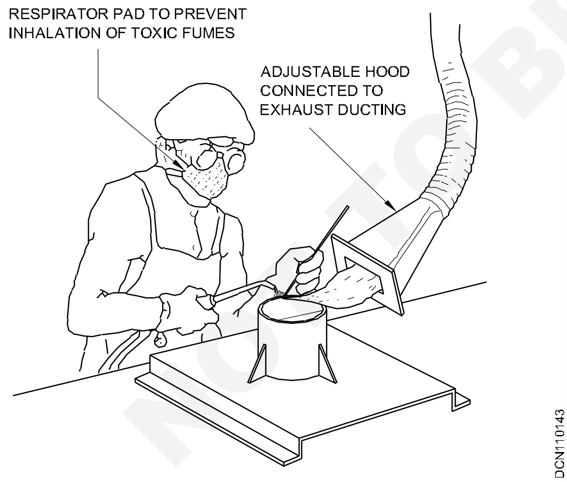
- When it is necessary?
- What kind is necessary?
- How to properly put it on, adjust, wear and take if off.
- The limitations of the equipment
- Proper care, maintenance, useful life and disposal of the equipment.

If PPE is to be used, a PPE program should be implemented. This program should address the hazards present; the selection, maintenance and use of PPE; the training of employees and monitoring of the program to ensure its ongoing effectiveness.

Fig 1

Fig 2

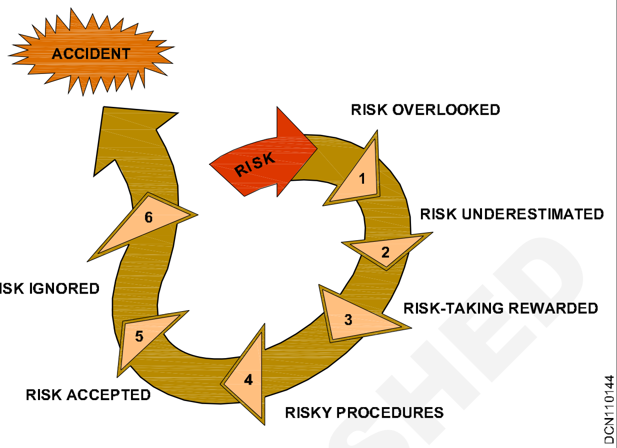
Fig 3



Accident prevention techniques-control of accidents and safety measures

Accident are unplanned, undesired event, not necessarily resulting in an injury or illness, but damaging property and/or interrupting the activity in process. Accident happen at all jobs. There are certain accidents that are common to a job. All employees should be trained and reminded how to do their job correctly to prevent unnecessary injuries while at work. An accident can occur when a machine malfunction or a person isn't paying attention to the work they are suppose to be doing. Even a small accident can cause major problems for an employee and their employer. The best practice to avoid all types of accidents is to teach and promote a safe and happy workplace. (Fig 4)

Fig 4



Accidents can happen anytime at any place they are more likely to happen when a person is participating in an unsafe act. That is why it is important to follow all safety rules and guidelines while working. If a taking a few more minutes to do the job safe is worth saving your life.

Overexertion in the workplace is a serious issue. Prevent damage to your back, knees and arms is very important. Train all employees on how to prevent overexertion by following safety rules and guidelines while completing workplace task.

Control of accidents are done by reducing exposure to a hazards through engineering, work practices, administration or protective equipment.

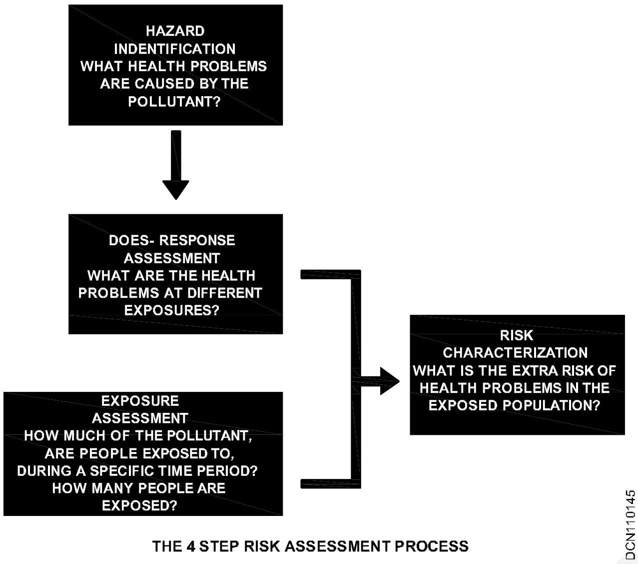
Responsibilities

At department level the supervisors are made to instruct their employees regarding the requirements of this program, effectively enforce compliance of this program's procedures, including the use of disciplinary action, for any violations or deviations from the procedures outlined in this program; assure that the equipment required for compliance with this program is in proper working order, inspected and tested as required, and made available for use to their employees, promptly investigate and report all on-the-job accidents or job related health problems. (Fig 5)

Recognizing and controlling hazards

Engineering controls minimize employee exposure by either reducing or removing the hazard at the source or isolating the worker from the hazard. Engineering controls include eliminating toxic chemical and substituting non-toxic chemicals, enclosing work processes or confining work operations, and the installation of general and local ventilation systems. Work practice controls alter the manner in which a task is performed. Some fundamental and easily implemented work practice, controls include changing existing work practices to follow proper procedures that minimize exposures. While operating production and control equipment, inspecting and maintaining process and control equipment on a regular basis, implementing good housekeeping procedures, providing good supervision and mandating that eating, drinking, smoking, chewing tobacco or gum, and applying cosmetics in regulated areas be prohibited.

Fig 5

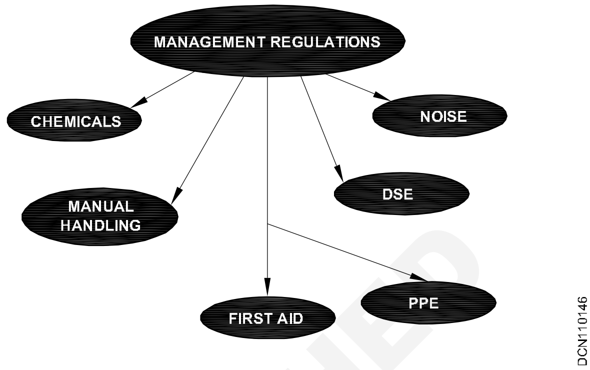


THE 4 STEP RISK ASSESSMENT PROCESS

Administrative controls, include controlling employees' exposure by scheduling production and tasks, or both, in ways the minimize exposure levels. (Fig 6) For example, the employer might schedule operations with the highest exposure potential during periods when the fewest employees are present. When effective work practices or engineering controls are not feasible or while such controls are being instituted, appropriate personal protective equipment must be used. Examples of personal protective equipment are gloves, safety goggles, helmets, safety shoes, protective clothing and respirators. To be effective, personal protective equipment must be individually selected, properly fitted and periodically refitted, consciously and properly worn, regularly maintained and replaced, as necessary.

Fig 6

RISE ASSESSMENT



The employees have to comply with the procedures of this program, consult with their supervisor, when they have questions regarding the safety and health conditions of their workplace, report any accidents or job related injuries or illnesses to their supervisor and seek prompt medical treatment, if necessary.

Employees are responsible for exercising appropriate care and good judgment in preventing injuries and illnesses, adhering to all safety and health rules, policies and procedures and reporting all unsafe conditions, malfunctioning or unsafe equipment, work related accidents, injuries and illnesses, and unsafe work practices to their immediate supervisor. If that is not feasible, a report should be made to the head of their department, the plant operations safety officer, or a member of the work safe/be well committee.

First Aid

Objectives: At the end of this lesson you shall be able to
- **explain how to take care of injured & sick persons at workplaces**
- **explain how to provide first aid & transportation to sick person**
- **state ABC of first aid**
- **state how to report an emergency.**

Purpose of First Aid

- To sustain life
- To prevent suffering
- To prevent secondary complications
- To promote speedy recovery
- To prepare for further medical treatment.

First aid is defined as the immediate care and support given to an acutely injured or ill person, primarily to save life, prevent further deterioration or injury, plan to shift the victims to safer places, provide best possible comfort and finally help them to reach the medical centre/hospital through all available means. It is an immediate life-saving procedure using all resources available within reach.

First-aid procedure often consists of a range of simple and basic life saving techniques that an individual performs with proper training and knowledge.

The key aims of first aid can be summarized in three key points :

- **Preserve life :** If the patient was breathing, a first aider would normally place them in the recovery position, with the patient leant over on their side, which also has the effect of clearing the tongue from the pharynx. It also avoids a common cause of death in unconscious patients, which is choking on regurgitated stomach contents. The airway can also become blocked through a foreign object becoming lodged in the pharynx or larynx, commonly called choking. The first aider will be taught to deal with this through a combination of 'back slaps' and 'abdominal thrusts'. Once the airway has been opened, the first aider would assess to see if the patient is breathing.

ASSESSING THE SICK OR INjURED

PRIMARY SURVEY

- Is an initial rapid assessment of a casualty to establish and treat conditions that are an immediate threat to life.

DANGER

RESPONSE

AIRWAY

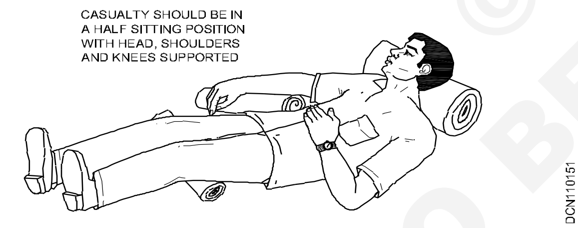
BREATHING

CIRCULATION

DR ABC

- **Prevent further harm :** also sometimes called prevent the condition from worsening, or danger of further injury, this covers both external factors, such as moving a patient away from any cause of harm, and applying first aid techniques to prevent worsening of the condition, such as applying pressure to stop a bleed becoming dangerous. Victim should be in half sitting position with head, shoulder & neck support. (Fig 1)

Fig 1



- **Promote recovery :** First aid also involves trying to start the recovery process from the illness or injury, and in some cases might involve completing a treatment, such as in the case of applying a plaster to a small wound.

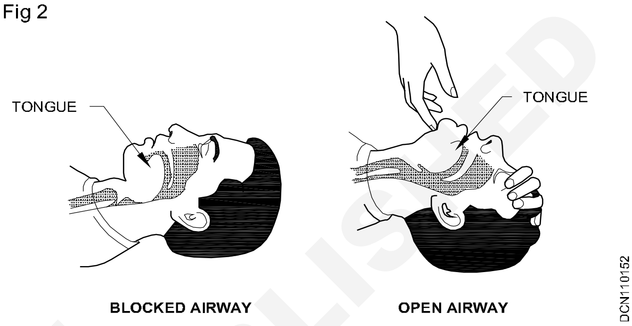
Training : Basic principles, such as knowing to use an adhesive bandage or applying direct pressure on a bleed, are often acquired passively through life experiences. However, to provide effective, life-saving first aid interventions requires instruction and practical training. This is especially true where it relates to potentially fatal illnesses and injuries, such as those that require Cardio Pulmonary Resuscitation (CPR), these procedures may be invasive and carry a risk of further injury to the patient and the provider. As with any training, it is more useful if it occurs before actual emergency, and in many countries, emergency ambulance dispatchers may give basic first aid instructions over the phone while the ambulance is on the way.

Training is generally provided by attending a course, typically leading to certification. Due to regular changes in procedures and protocols, based on updated clinical knowledge, and to maintain skill, attendance at regular refresher courses or re-certification is often necessary. First aid training is often available through community organizations such as the red cross and St. John ambulance.

ABC or First-aid : ABC stands for Airway, Breathing and Circulation

Airway : Attention must first be brought to the airway to ensure it is clear. Obstruction (choking) is a life-threatening emergency. (Fig 2)

Fig 2



Breathing : Breathing if stops, the victim may die soon. Hence means of providing support for breathing is an important next step. There are several methods practiced in first-aid.

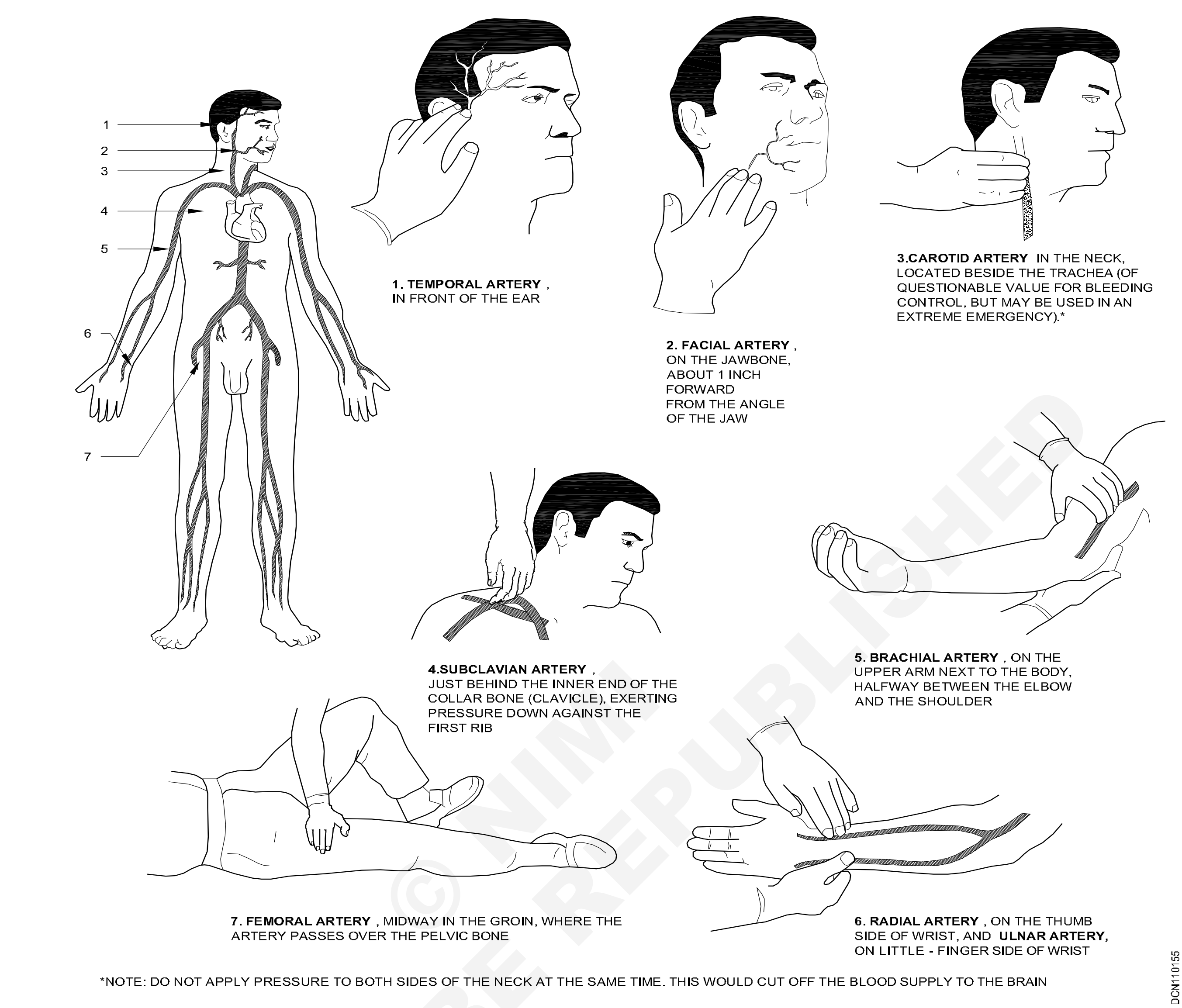
Circulation : Blood circulation is vital to keep person alive. The first aiders now trained to go straight to chest compressions through CPR methods. (Fig 3 & Fig 4)

Fig 3

Fig 4

When providing first aid one needs to follow some rule. There are certain basic norms in teaching and training students in the approach and administration of first-aid to sick and injured. (Fig 5)

Fig 5



Not to get panic : Panic is one emotion that can make the situation more worse. People often make mistake because they get panic. Panic clouds thinking and causes mistakes. First-aider need calm and collective approach. if the first-aider himself is in a state of fear and panic gross mistakes may result. It's far easier to help the suffering, when they know what they are doing, even if unprepared to encounter a situation. Emotional approach and response always lead to wrong doing and may cloud one to do wrong procedures. Hence be calm and focus on the given situation. Quick and confident approach can lessen the effect of injury.

Call medical emergencies : If the situation demands, quickly call for medical assistance. Prompt approach may save the life.

Surroundings play vital role : Different surrounding require different approach. Hence first-aider should study the surrounding carefully. In other words, one need to make sure that they are safe and are not in any danger as it would be of no help that the first aider himself get injured.

Do no harm : Most often, enthusiastically practiced First-Aid Viz. administering water when the victim is unconscious, wiping clotted blood (which acts as plug to reduce bleeding), correcting fractures, mishandling injured parts etc., would leads to more complication. Patients often die due to wrong FIRST-AID methods, who may otherwise easily survive. Do not move the injured person unless the situation demands. It is best to make him lie wherever he is because if the patient has back, head or neck injury, moving him would cause more harm.

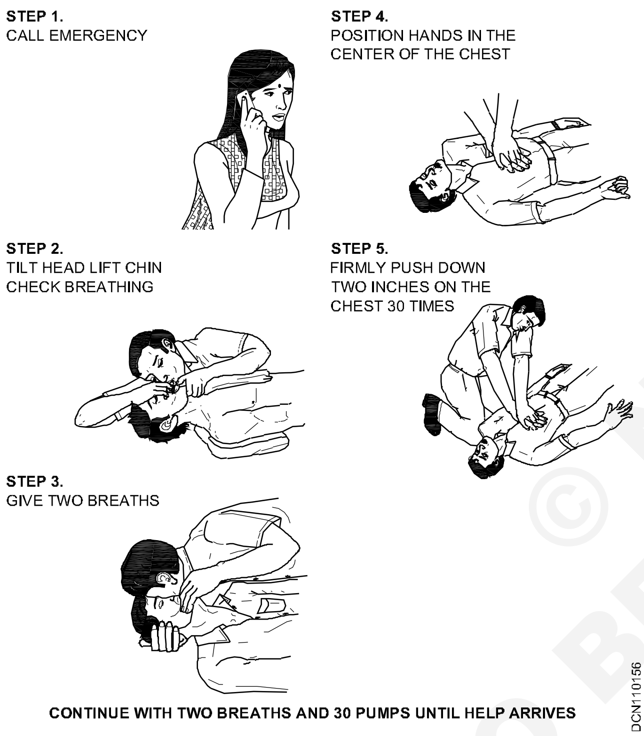
This does not mean do nothing. It mean to make sure that to do something the care givers feel confident through training would make matters safe. If the first-aider is not confident of correct handling it is better not to intervene of do it. Hence moving a trauma victim, especially an unconscious one, need very careful assessment. Removals of an embedded objects (like a knife, nail) from the wound may precipitate more harm (e.g., increased bleeding). Always it is better to call for help.

Reassurance : Reassure the victim by speaking encouragingly with him.

Stop the bleeding : If the victim is bleeding, try to stop the bleeding by applying pressure over the injured part.

Golden Hours : India have best of technology made available in hospitals to treat devastating medical problems viz. head injury, multiple trauma, heart attack, strokes etc, but patients often do poorly because they don't gain access to that technology in time. The risk of dying from these conditions, is greatest in the first 30 minutes, often instantly. This period is referred to as golden period. By the time the patient reach hospitals, they would have passed that critical period. First-aid care come handy to save lives. It helps to get to the nearest emergency room as quickly as possible through safe handling and transportation. The shorter that time, the more likely the best treatment applied. (Fig 6)

Fig 6



Maintain the hygiene : Most importantly, first-aider need to wash hands and dry before giving any first aid treatment to the patient or wear gloves in order to prevent infection.

Cleaning and Dressing (Fig 7) : Always clean the wound thoroughly before applying the bandage. Lightly wash the wound with clean water.

Fig 7

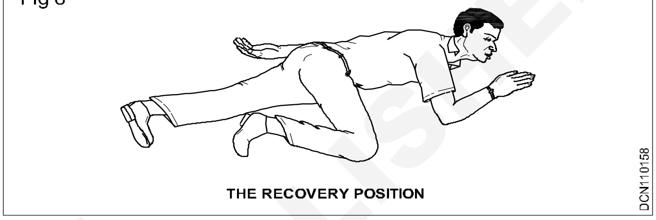
Not to use local medications on cuts or open wounds. They are more irritating to tissue than it is helpful. Simple dry cleaning or with water and some kind of bandage are best.

Stay with the victim until help arrives : Try to be a calming presence for the victim until assistance can arrive.

Unconsciousness

Loss of consciousness may threaten life if the person is on his back and the tongue has dropped to the back of the throat, blocking the airway. Make certain that the person is breathing before looking for the cause of unconsciousness. If the injuries permit, place the casualty in the recovery position with the neck extended.(Fig 8) Never give anything by mouth to an unconscious casualty. Unconscious also referred as **coma,** is a serious life threatening condition, when a person lie totally senseless and do not respond to calls, external stimulus. But the basic heart, breathing, blood circulation may be still intact, or they may also be failing if unattended it may lead to death.

Fig 8



The condition arises due to interruption of normal brain activity. The causes are too many.

- Shock (Cardiogenic, Neurogenic)
- Head injury (Concussion, Compression)
- Asphyxia (Obstruction to air passage)
- Extremes of Body temperature (Heat, Cold)
- Cardiac Arrest (Heart attack)
- Stroke (Cerebrovascular accident)
- Blood loss (Hemorrhage)
- Dehydration (Diarrhea & vomiting)
- Diabetes (Low or high sugar)
- Blood pressure (Very low or vey high)
- Over dose of alcohol, drugs
- Poisoning (Gas, pesticides, bites)
- Epileptic Fits (Fits)
- Hysteria (Emotional, Psychological)

The following symptoms may occur after a person has been unconscious : (Fig 9)

- Confusion
- Drowsiness
- Headache
- Inability to speak or move parts of his or her body (see stroke symptoms)
- Light headedness
- Loss of bowel or bladder control (incontinence)
- Rapid heartbeat (Palpitations)
- Stupor

First aid

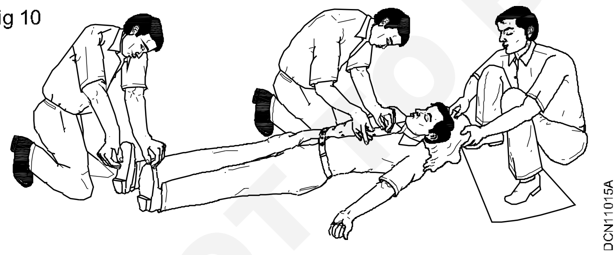
- Call emergency number.

Fig 9

FIRST AID : CONVULSIONS

- Check the person's airway, breathing and pulse frequently. If necessary, begin rescue breathing and CPR.
- If the person is breathing and lying on the back, and after ruling out spinal injury, carefully roll the person onto the side, preferably left side. Bend the top leg so both hip and knee are at right angles. Gently tilt the head back to keep the airway open. If breathing or pulse stops at any time, roll the person on to his back and begin CPR.
- If there is a spinal injury, the victims position may have to be carefully assessed. If the person vomits, roll the entire body at one time to the side. Support the neck and back to keep the head and body in the same position while you roll.
- Keep the person warm until medical help arrives.
- If you see a person fainting, try to prevent a fall. Lay the person flat on the floor and raise the level of feet above and support.
- If fainting is likely due to low blood sugar, give the person something sweet to eat or drink when they become conscious. (Fig 10)

Fig 10



Do Not

- Do not give an unconscious person any food or drink.
- Do not leave the person alone.
- Do not place a pillow under the head of an unconscious person.
- Do not slap an unconscious person's face or splash water on the face to try to revive him.

First-aid box

Small, medium and large dressings : These are sterile pads with bandages attached that can be used to control heavy bleeding and cover minor wounds. Triangular bandages - These are an extremely versatile piece of equipment. Folded into a pad, they can be used as a cold compress or as padding around a painful area. They can provide cover for burns or large scrapes and support broken bones.

Adhesive bandage (for small wounds), **Non-adhesive sterile dressings (various sizes), safety tape, adhesive tape and hypoallergenic tape.** Dressing can be cut to size and used to cover scrapes, burns and small wounds.

Gauze swabs : For use with water to clean wounds.

Ace bandages, compression bandages, tubular bandage : For use in providing support to sprains and strains.

Disposable gloves : For use in managing body fluids.

Blunt-ended scissors : tweezers.

Transport safety : Use one of the most safer methods.

CPR (Cardio-Pulmonary Resuscitation) : CPR can be life sustaining. If one is trained in CPR and the person is suffering from choking or finds difficulty in breathing, immediately begin CPR. However, if one is not trained in CPR, do not attempt as you can cause further injury. But most people do it wrong. This is a difficult procedure to do in a crowded area. Also there are many studies to suggest that no survival advantage when bystanders deliver breaths to victims compared to when they only do chest compressions. Second, it is very difficult to carry right maneuver in wrong places. But CPR, if carefully done by highly skilled first-aiders is a bridge that keeps vital organs oxygenated until medical team arrives.

Declaring death : It is not correct to declare the victim's death at the accident site. It has to be done by qualified medical doctors.

Call for emergency services if you believe that a situation is life-threatening or otherwise extremely disruptive.

- A crime, especially one that is currently in progress. If you're reporting a crime, give a physical description of the person committing the crime.
- A fire, if you're reporting a fire, describe how the fire started and where exactly it is located. If someone has already been injured or is missing, report that as well.

- A life-threatening medical emergency that requires immediate attention. If you're reporting a medical emergency, explain how the incident occurred and what symptoms the person currently displays.
- A car crash - Location, serious nature of injuries, vehicle's details and registration, number of people involved etc.

Call emergency services : The emergency number varies - 100 for Police & Fire, 108 for Ambulance.

Report your location : The first thing the emergency dispatcher will ask is where you are located, so the emergency services can get there as quickly as possible. Give the exact street address, if you're not sure of the exact address, give approximate information.

Give the dispatcher your phone number : This information is also imperative for the dispatcher to have, so he or she is able to call back if necessary.

Describe the nature of the emergency : Speak in a calm, clear voice and tell the dispatcher why you are calling. Give the most important details first, then answer the dispatcher's follow-up questions as best you can.

Do not hang up the phone until you are instructed to do so. Then follow the instructions you were given.

How to do basic first aid?

Basic first aid refers to the initial process of assessing and addressing the needs of someone who has been injured or is in physiological distress due to choking, a heart attack, allergic reactions, drugs or other medical emergencies. Basic first aid allows one to quickly determine a person's physical condition and the correct course of treatment.

Important guideline for first-aiders

Evaluate the situation (Are there things that might put the first-aider at risk)? When faced with accidents like fire, toxic, smoke, gases, an unstable building, live electrical wires or other dangerous scenario, the first-aider should be very careful not to rush into a situation, which may prove to be fatal.

If the person remains unresponsive, carefully roll them onto the side (recovery position) and open his airway.

- Keep head and neck aligned.
- Carefully roll them onto their back while holding his head.
- Open the airway by lifting the chin.

Look, listen and feel for signs of breathing : Look for the victim's chest to rise and fall, listen for sounds of breathing.

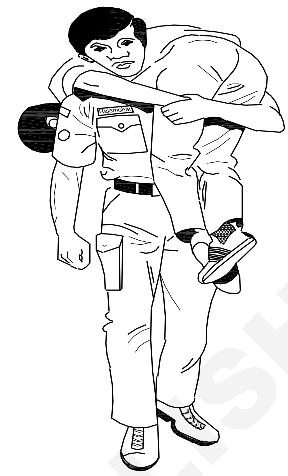
If the victim is not breathing, see the section below.

- If the victim is breathing, but unconscious, roll them onto their side, keeping the head and neck aligned with the body. This will help drain the mouth and prevent the tongue or vomit from blocking the airway.

Check the victim's circulation : Look at the victim's color and check their pulse (the carotid artery is a good option; it is located on either side of the neck, below the jawbone). if the victim does not have a pulse, start CPR.

Treat bleeding, shock and other problems as needed: After establishing that the victim is breathing and has a pulse, next priority should be, to control any bleeding. Particularly in the case of trauma, preventing shock is the priority. Some of the ways are mentioned in Fig 11, 12, 13 & 14 how to handle victims.

Fig 11



FIRE-MAN LIFT METHOD

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Fig 12

FORE AND AFT METHOD

DCN11015C

Fig 13

HAND SEAT METHOD

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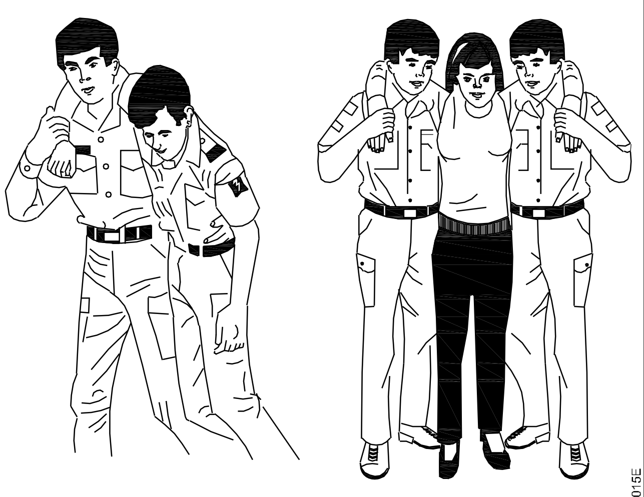
Fig 14



HUMAN-CRUTCH METHODS

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- **Stop bleeding :** Control of bleeding is one of the most important things to save a trauma victim. Use direct pressure on a wound before trying any other method of managing bleeding.
- **Treat shock :** Shock, a loss of blood flow to the body, frequently follows physical and occasionally psychological trauma. A person in shock will frequently have ice cold skin, be agitated or have an altered mental status, and have pale color to the skin around the face and lips. Untreated, shock can be fatal. Anyone who has suffered a severe injury or life-threatening situation is at risk for shock.
- **Choking victim :** Choking can cause death or permanent brain damage within minutes.
- **Treat a burn :** Treat first and second degree burns by immersing or flushing with cool water. Don't use creams, butter or other ointments, and do not pop blisters. Third degree burns should be covered with a damp cloth. Remove clothing and jewellery from the burn, but do not try to remove charred clothing that is stuck to burns.
- **Treat a concussion :** If the victim has suffered a blow to the head, look for signs of concussion. Common symptoms are; loss of consciousness following the injury, disorientation or memory impairment, vertigo, nausea and lethargy.
- **Treat a spinal injury victim :** If a spinal injury is suspected, it is especially critical, not move the victim's head, neck or back unless they are in immediate danger.

Basic provisions for OSH

Objectives: At the end of this lesson you shall be able to
- **state the basic provisions of safely, health, welfare under legislation of India.**

India has legislation on occupational health and safety for over 50 years. A safe and health work environment is the basic right of every worker. The constitutional provision for occupational safety and health under the Article 24 - No child below the age of fourteen years shall be employed to work in any factory or mine or engaged in other hazardous employment.

Article 39 (e & f) - The state shall in particular direct its policy towards securing.

e that the health and strength of workers, men and women, and the tender age of children are not abused and that citizens are not forced by economic necessity to enter vocations unsuited to their age and strength.

f That children are given opportunities and facilities to develop in healthy manner and in conditions of freedom and dignity and that childhood and youth are protected against exploitation and against moral and material abandonment.

Article 42 - The state shall make provision for securing just and human conditions of work and maternity relief.

National policy : Safety and health occupies a very significant position in India's constitution which prohibits employment of children under 14 in factories, mines and in hazardous occupations. Policy aims to protect the health and strength of all workers. It prevents employment in occupations unsuitable for the age and strength of the workers. It is the policy of the state to make provisions for securing just and humane conditions of work. The constitution provides a broad framework under which policies and programmes for occupational health and safety could be established.

National Legislation : Legislation provides an essential foundation for safety. To be meaningful and effective legislation should be reviewed and updated regularly as scientific knowledge develops.

The most important legislation cover occupational safety, health and welfare are :

- The Factories Act 1948. amended 1954, 1970, 1976, 1987.
- The Mines Act, 1952.
- The dock workers (safety, health and welfare) Act, 1986.
- The plantation labour Act, 1951.
- The Explosives Act, 1984.
- The Petroleum Act, 1934.
- The Insecticide Act, 1968.
- The Indian Boilers Act, 1923.
- The Indian Electricity Act, 1910.
- The Dangerous Machines (Regulations) Act, 1983.
- The Indian Atomic Energy Act, 1962.
- The Radiological Protection Rules, 1971.
- The Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989.

Environment

Objectives: At the end of this lesson you shall be able to
- **state the meaning and definition of environment**
- **list out and explain the components of environment**
- **explain atmosphere and its composition**
- **state the relationship between society and environment**
- **state the factors responsible for destruction and natural disasters.**

Environment Education is a process which makes the world community conscious about the problem of the environment. By this way we may understand the problem and find its solution and may also protect future problems.

Environmental Education (EE) can be linked with three main components

- Education about the environment (Knowledge).
- Education for the environment (Values, attitudes & positive actions).
- Education through the environment (A resource).

Meaning and definition of environment : In general, the word **environment** refers the cover of our surroundings, which includes our earth, soil, water and the atmosphere situated on it. The environment is the important system which covers all the living and non-living system. So it is necessary every layman and literate person to know its meaning.

The word environment is composed of two words- **'environ'** and **'ment'** their meaning is 'to surround' or 'to enwrap', which gives the meaning of sense of situation of the surroundings or cover.

The dictionary meaning of the environment is the "particular surroundings in which living and non-living things exist".

In universal encyclopedia, it is defined as "Environment is the sum of all those condition, systems and influences which influence the development life and death of organisms and their species. On **5th June** every year **world environment** day is celebrated.

Some eminent scholars defined the environment as follows:-

According to **E.J.Ross,** "Environment is an external force which influences us"

According to **Dr. D.H. Davis,** "In relation to man environment means all those physical forms spread all around man on land by which he is influenced continuously.

According to **Kovits,** "Environment is the sum of all those external conditions which influences the development cycle of the organisms on the surface of the earth.

Components of Environment : The components of environment can be classified as shown in the flow diagram.

Land, water, air, soil etc are important inanimate (or) abiotic components. Man, animal, plants and other organisms are biotic components.

Natural Environment : The natural environment is the environment, which comes into existence without interference of man.

Billion years ago earth had surroundings which were not suitable for the existence of any kind of life. Then a mass of gaseous-chemical with hot temperature in which the organisms cannot exist. Due to the process of action and reaction of these chemicals after millions of years, the suitable condition of environment came to exist.

Many components together co-ordinated to form a natural environment which helps in substance of life. The natural environment components can be classified into two

1 Abiotic components

2 Biotic components

1 Abiotic components

These components are not living but can support other living organisms. When these components became unbalanced and they cause for total to the living organisms. Some kinds of such organisms are given below:

i **Inorganic substances :** The elements which are taken up by the plants with the help of sunlight and converted into food. The examples of such inorganic elements are like nitrogen, calcium, phosphorus, hydrogen, carbon di-oxide and oxygen.

ii **Organic substances :** The substances which are taken in the form of inorganic materials from the food source and are again sent back to the environment after decomposition by decomposers. E.g. Carbohydrates, proteins, fats etc.

iii **Physical factors :** These factors have direct effect on living organisms, which are climatic conditions like temperature, rainfall, wind, humidity, soil and light energy which is used by the plants for the preparation of food.

iv **Lithosphere :** The outermost layer of the earth (i.e.) soil or land.

v **Hydrosphere :** Part of the earth having water resources like oceans, rivers, ponds and lakes.

vi **Atmosphere :** It is a cover around the earth composed by variety of gases which protects the living organisms from various harmful cosmic radiations.

2 Biotic components of environment

The area in which the life is possible is called as biosphere. All living organism in the biosphere depends upon one another and these organisms exist in the biosphere forming the following community.

i **Producers :** The green plants presents on earth surface which producers their own food only once by the process of photosynthesis in sunlight, water and carbon dioxide forms food for other organisms. E.g. Sugar, carbohydrates etc.

ii **Consumer :** This organisms directly (or) indirectly depends upon the green plants for the source of food. E.g. All animals including man.

iii **Decomposers :** These are micro organisms which decompose the complex compounds in the dead organic matter of plants and animals and again recycle the elements into the environment. E.g. Bacteria's and fungi.

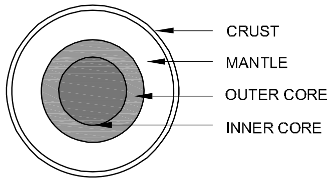
Man-made environment : The man is the highest of all creatures on this earth, who has started modifying the environment according to his own needs and its consequences which he faces every day. The recent developments in the under developed countries lead to more critical conditions.

The conditions of the villages are worse because there is no sewerage and sanitation system. The competition in the villagers for the increase in production of agricultural products leads to more and more use which ultimately spoils the environment and alter the composition of natural products.

Atmosphere : The earth is a dynamic planet. It is constantly undergoing changes inside and outside of the earth.

Just like onion, the earth is made up of several concentric layers with one inside (Fig 1)

Fig 1



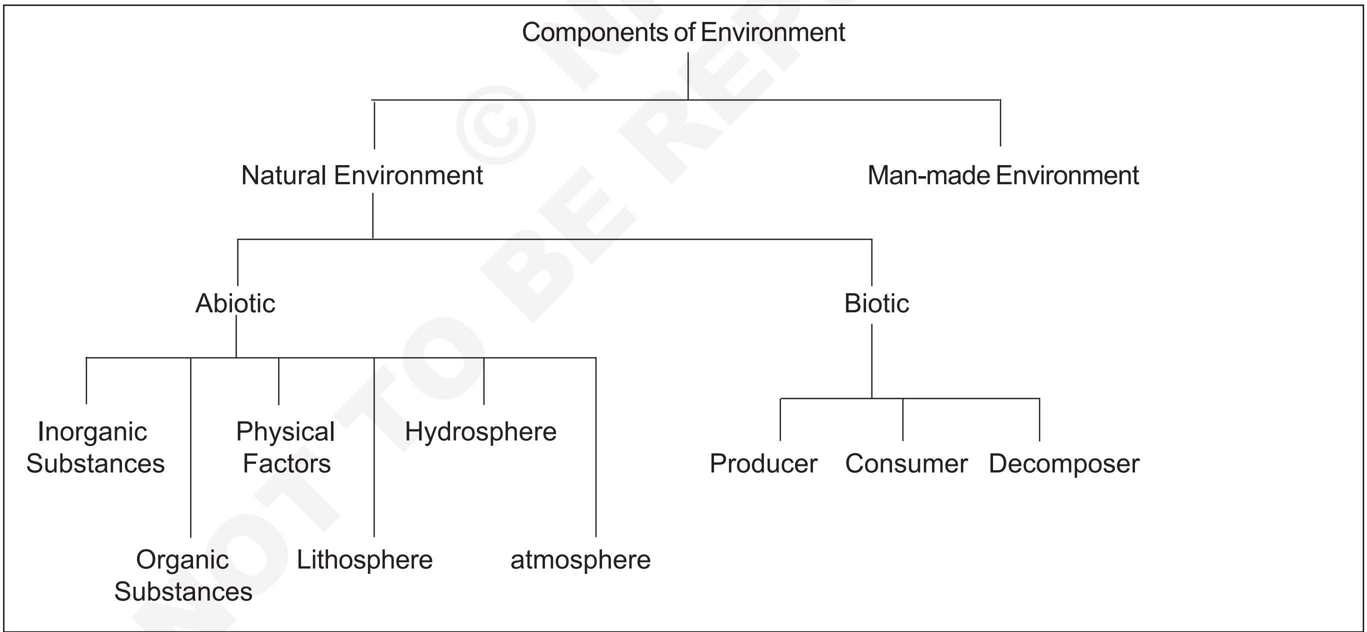
LAYERS OF THE EARTH

The uppermost layer over the earth's surface is called the 'crust'. It is the thinnest of all the layers and is about 35km on the continental masses and only 5km on the ocean floors. The main mineral constituents of the continental mass are the **'silica and alumina',** called as **'sial'.** The oceanic crust mainly consists of silica and magnesium, called as **'sima'.**

Just beneath the crust is the mantle which extends upto a depth of **2900km** below the crust.

The innermost layer is the **core** with a radius of about 350km. It is made up of nickel and iron and is called **'nife'.** The central core has very high temperature and pressure.

The earth is surrounded by a huge blanket of air called **atmosphere.** All living things on this earth depend on the atmosphere for their survival. It provides the air to breathe and protects from the harmful effects of the sun's rays. It is the mass of air that has made the temperature on the earth liveable.



Pollution and pollutants

Objectives: At the end of this lesson you shall be able to
- **define the meaning of pollution**
- **list out various kinds of environmental pollution**
- **define the meaning of pollutant**
- **state various type of hazardous waste management**
- **list out the causes of indoor environment pollution and suggestion to keep the environment safe.**

The quality of the environment has declined due to environmental pollution. In industrial and technological progress of man, the chemical and nuclear energy, poisonous gases and other industrial workers have polluted the environment by which the quality for the environment is affected.

Pollution : An undesirable change in the quality of physical, chemical and biotic substances, air, water and soil is called **pollution.** This change is harmful for the health and life of living things. The pollution brings a change in some aspect of the biosphere in a direct or an indirect manner, which leaves a bad effect on the living beings and the humans.

There are mainly two kinds of pollutions. They are

1 **Physical pollution :** A decline in physical elements of the environment caused by man's activities is called as **physical pollution.** It can be divided into three sub parts

   - Air pollution occurs when gases, dust particles, fumes (or smoke) or odour are introduced into the atmosphere in a way that makes it harmful to humans, animals and plant.

   - Air pollution can result from both human and natural actions. Natural events that pollute the air include forest fires, volcanic eruptions, wind erosion, pollen dispersal, evaporation of organic compounds and natural radioactivity.

Human activities that result in air pollution include

- **Emissions from industries and manufacturing activities :** Chimneys of manufacturing plant with lots of smoke and fumes coming out of it. Waste incinerators, Manufacturing industries and power plants emit high levels of carbon monoxide, organic compounds, and chemicals into the air. Petroleum refineries also release lots of hydrocarbons into the air.

- **Burning Fossil Fuels :** Cars, heavy duty trucks, trains, shipping vessels and airplanes all burn lots of fossil fuels to work. Fumes from car exhaust contain dangerous gases such as carbon monoxide, oxides of nitrogen, hydrocarbons and particulates. On their own, they cause great harm to people who breath them. Additionally, they react with environmental gases to create further toxic gases.

- **Household and Farming Chemicals :** Crop dusting, fumigating homes, household cleaning products or painting supplies, over the counter insect/pest killers, fertilizer dust emit harmful chemicals into the air and cause pollution. In many case, when we use these chemicals at home or offices with no or little ventilation, we may fall ill if we breathe them.

Air pollution prevention, monitoring and solution: Solution efforts on pollution are always a big problem. This is why prevention and interventions are always a better way of controlling air pollution. These prevention methods can either come from government (laws) or by individual actions. In many big cities, monitoring equipment has been installed at many points in the city. Authorities read them regularly to check the quality of air.

- **Government (or community) level prevention :** Governments throughout the world have already taken action against air pollution by introducing green energy. Some governments are investing in wind energy and solar energy, as well as other renewable energy, to minimize burning of fossil fuels, which cause heavy air pollution.

Governments are also forcing companies to be more responsible with their manufacturing activities.

Car manufacturing companies are also building more energy efficient cars, which pollute less than before.

- **Individual Level Prevention**

   - Encourage your family to use the bus, train or bike when commuting. If we all do this, there will be less cars on road and less fumes.

   - Use energy (light, water, boiler, kettle and fire woods) wisely. This is because lots of fossil fuels are burned to generate electricity, and so if we can cut down the use, we will also cut down the amount of pollution we create.

   - Recycle and re-use things. This will minimize the dependence of producing new things. Remember manufacturing industries create a lot of pollution, so if we can re-use things like shopping plastic bags, clothing, paper and bottles, it can help.

Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater), very often by human activities. Water pollution is very harmful to humans, animals and water life. The effects can be catastrophic, depending on the kind of chemicals, concentrations of the pollutants and where there are polluted. The effects of water pollution are varied and depend on what chemicals are dumped and in which locations.

Many water bodies near urban areas (cities and towns) are highly polluted. This is the result of both garbage dumped by individuals and dangerous chemicals legally or illegally dumped by manufacturing industries, health centres, schools and market places. Some of the effects of water pollution are:

- **Death of aquatic (water) animals :** The main problem caused by water pollution is that it kills life that depends on these water bodies. Dead fish, crabs, birds and sea gulls, dolphins, and many other animals often wind up on beaches, killed by pollutants in their habitat (living environment).

- **Disruption of food-chains :** Pollution disrupts the natural food chain as well. Pollutants such as lead and cadmium are eaten by tiny animals. Later, these animals are consumed by fish and shellfish, and the food chain continues to be disrupted at all higher levels.

- **Diseases :** Eventually, humans are affected by this process as well. People can get diseases such as hepatitis by eating seafood that has been poisoned. In many poor nations, there is always outbreak of cholera and diseases as a result of poor drinking water treatment from contaminated waters.

- **Destruction of ecosystems :** Ecosystems (the interaction of living things in a place, depending on each other for life) can be severely changed or destroyed by water pollution. Many areas are now being affected by careless human pollution, and this pollution is coming back to hurt humans in many ways.

Prevention of water pollution : Dealing with water pollution is something that everyone (including governments and local councils) needs to get involved with. Here are a few things we can do:

- Never throw rubbish away any where. Always look for the correct waste bin.
- Use water wisely. Do not keep the tap running when not in use.
- Do not throw chemicals, oils, paints and medicines down the sink drain, or the toilet.
- Buy more environmentally safe cleaning liquids for use at home and other public places. They are less dangerous to the environment.
- If you use chemicals and pesticides for your gardens and farms, be mindful not to overuse pesticides and fertilizers. This will reduce runoffs of the chemical into nearby water sources.
- If you live close to a water body, try to plant lots of trees and flowers around your home, so that when it rains, chemicals from your home does not easily drain into the water.

Land pollution is the deterioration (destruction) of the earth's land surfaces, often directly or indirectly as a result of man's activities and their misuse of land resources.

2 **Social pollution :** Accumulated happenings or crises have a country effect on the social aspects is called social pollution. It can be divided into three subgroups

- Population explosion (or) growth
- Social backwardness
- Economic pollution - poverty

Pollutant

The substance, which causes a decline in the quality of environment or produces pollution in the environment is called as a pollutant. It includes any solid, liquid or gaseous substance, which by its presence (or) excess in the environment is harmful effect on the living beings and man.

Pollutants are residues of the substance which are to be thrown away after use. Water or rivers get polluted by the wastes of the cities and sewage thrown into them.

Some pollutants of the environment are the cause to pollute the air, water and the solid and bring a decline in their quality.

Some of the main pollutants are given below

- Collected substances - dust, smoke, tar etc.
- Gases - Carbon dioxide, Nitrogen and sulphur dioxide.
- Solid wastes - which we thrown away after use
- Radioactive substances
- Noise - excessive noise of the vehicles
- Complex chemicals - ether, benzene, acid etc.
- Metals
- Fluorides
- Photo chemical oxides.
- Agricultural chemical substances

From the above examples the pollutants are broadly categorised into three types

- In the form of solid substances (or) matter
- In the form of liquid substances
- In the form of gases

According to the nature, pollutants can be classified into Non-degradable pollutants and Bio - degradable pollutants.

1 Non -degradable pollutants

Those pollutants which cannot be broken down into simpler, harmless substances in nature, are called non-biodegradable pollutants. DDT, plastics, polythene, bags, insecticides, pesticides, mercury, lead, arsenic, metal articles like aluminium cans, synthetic fibres, glass objects, iron products and silver foils are non-biodegradable pollutants. (Table1)

2 Bio-degradable pollutants

Hazardous waste

The waste that contains highly toxic and hazardous materials that injurious to all living things and environment are called as hazardous and toxic work.

Hazardous waste management

Following activities are to be followed for hazardous waste management. (Table 2)

- Reduce waste generation and choose less toxic materials. In Industries, manufacturing process can be altered to eliminate (or) reduce waste production.
- Recycle the solvent and acid to minimize the waste generation.
- Reuse the solvent and acids.

Handling methods of hazardous waste

The safest method to avoid hazardous waste problem is to cut down production of waste in the source itself. The methods of disposal of hazardous wastes are :

- **Physical process :** From this method, main aim is the volume reduction by Sedimentation, Absorption, Aeration, Osmosis, Ion exchange etc.
- **Chemical treatment :** In this method, chemicals are added to connect the hazardous waste into non-hazardous waste. This is suitable to the waste having corrosive and reactive proportion, and its aim to neutralize pH

Table 1

Sl. No.	Pollutant	Effect of human health
1	**Air pollution**	
	• Carbon monoxide	• Headache, hear stress
	• Lead	• Mental and physical improvement
	Water pollution	
	• Sewage pollutant	• Jaundice, cholera, typhoid
	• Methyl mercury	• Affects nerves system, lips and tongue deadness
	• Excess nitrate in drinking water	• Blue body syndrome
	Radioactive pollution	• Cancer, lung, breast, spot skin, genetic disorder
	Noise pollution	• Stress related diseases, eardrum may be damaged
	Ozone depletion	• Cataract, skin diseases, affecting immune system.

Table 2

Sl. No.	Source	Type of hazardous waste
1	Chemical Industries	Acids solvent base
2	Workshop (mechanical)	Metal paints, lead for lead acid battery
3	Leather Industries	Solvent, acid bases
4	Paper industry	Waste - inks, solvents
5	Construction	Waste paints - inflammable
6	Metal Industries	Paint waste, sludge's (containing heavy metals)
7	Electronic industries	Solvents, plating and slumping solutions
8	Nuclear power plants	Spent fuel, solvents, radio -active waste

- **Biological treatment :** This process is generally followed in municipal/corporation waste treatment plant. This process can be used, when the sludge contains high concentration of organic and low concentration of toxic substances.
- **Waste incineration :** This process is suitable if the waste is not subjected to complete decomposition and the waste is combusted for complete destruction.
- **OFF-site disposal :** The residue from thermal process or the untreated sludge have to be disposed in an environment, so that the soil and the ground water do not contaminate.

Indoor environment

Home or a house is such a place where family members live. Every person expects that the place should be pollution free so that he can live their conveniently. The increase in the technology and new domestic machineries and equipment is polluting the indoor environment.

A house has many such materials and appliances which cause pollutions in house environment and it affects out health badly but most of the people amongst us are ignorant of this environment.

Causes of the pollution of Indoor environment

There are many things in the house which cause a decline in the quality of the environment. The causes are follows

- Mica, plywood, new wood, varnish and chemical substances are harmful.
- Construction materials such as clay, lime, wood, cement, iron, concrete, plastic paints etc.
- Varnish, paints and fevicol etc. chemical substance used in making furniture's are poisonous and release poisonous gases in the indoor environment.
- The articles made of polythene and plastic has increased greatly, which pollute the air inside the soil.
- When chlorinated water is boiled it releases chlorine which leads pollution
- The kitchen is an important place in house. Where one or the other fuel is used for cooking food such as kerosene oil, petroleum gas etc. In the villages cow dung cakes and wood are burnt which produce harmful gases and smoke, mixer, indoor and juice and other application used in the kitchen also produce noise pollution.
- Many types of enjoyments are used at home which cause environmental pollution. CFC damages the ozone layer of the atmosphere due to which harmful and UV rays from the space and the sum come to the earth.

- Liquid waste water from bathing, working clothes and utensils, detergents, phenyls, disinfectant, geysers, heated up water etc. when chlorinated water is heated up, it forms chloroform which leads to suffocation and death.
- During technological advertisements various home gadgets also increase in number like. Cooler, heater, blower, refrigerator, washing machines, oven, air containers, VCRs computers, Fax, perfumes release CFCs which deplete the ozone layer of the atmosphere which reflects back to harmful radiations (UV) coming from the outer sphere and sun.

Today the science has given many things of comfort and luxury to man but they leave bad effect on health.

Suggestion for keeping the Indoor environmental safe : For keeping the indoor environment clean and pure following are the suggestion.

- While constructing a house it should be kept in mind that the house is spacious airy and well lighted.
- Methanol used in the construction should be of good quality.
- Materials of chemical composition must be avoided for the construction of houses.
- Synthetic and non-bio gradable materials should be avoided.
- Kitchen and bathrooms especially be airy and open.
- Waste from houses should be properly utilized.
- The sewage should not be sent to ground water by digging well.
- The electric appliances should be used in accordance with the introduction given on them.
- Proper disposal of excreting products.
- Traditional fuels should be avoided.
- Use of solar energy should be encouraged in houses.
- Elastic light appliance should not be installed in the house more than necessary.
- Excessive brightness should be avoided.
- The volume of various sources of entertainment like Television, tape recorder, stereo etc. should be kept in the house.
- Reduce the use of A.C. coolers, heaters etc. at home.
- The home should be well cleaned properly to avoid dust.
- The use of fragrant substances should be reduced.

5S Concept

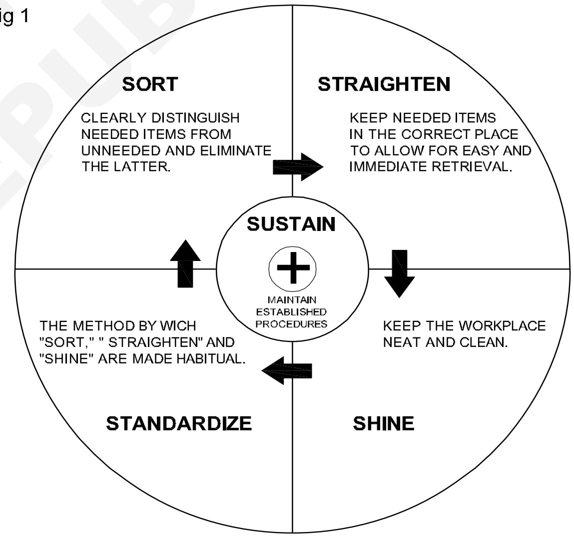
5S is a Japanese methodology for work place organization. In Japanese it stands for seiri (SORT), seition (SET), seiso (SHINE), seiketsu (STANDARDIZE), and shitsuke (SUSTAIN) . The list describes how to organize a work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order. The list describes how to organize a work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order.

5S Wheel (Fig 1)

The Benefits of the 5S system

- Increases in productivity
- Increases in quality
- Reduction in cost

Fig 1



5S WHEEL

DCN110181

Familiarisation and information about the institute and trade

Objectives: At the end of this lesson you shall be able to
- **state the general training system**
- **state the information about the trade**
- **state the rules and regulation of the institute and trade.**

Training system

General : The Directorate General of Training (DGT) under Ministry of Skill Development & Entrepreneurship offers range of vocational training courses catering to the need of different sectors of economy labour market. The vocational training programmes are delivered under aegis of National Council of Vocational Training (NCVT). Craftsman Training Scheme (CTS) and Apprenticeship Training Scheme (ATS) are two pioneer programmes of NCVT for propagating vocational training.

Draughtsman Civil trade under CTS is one of the popular courses delivered nationwide through network of ITIs. The course is of two years (04 semester) duration. It mainly consists of Domain area and Core area. In the Domain area-trade theory and practical impart professional skills and knowledge; while core area imparts workshop calculation and science, Engineering Drawing, and Employability Skills impart requisite core skills & knowledge and life skills. After passing out the training programme, the trainee is being awarded National Trade Certificate (NTC) by NCVT which are recognized worldwide.

Candidates broadly need to demonstrate that they are able to

- Read & interpret technical parameters /documentation, plan and organize work processes, identify necessary materials and tools.
- Perform work with due consideration to safety rules, Govt. Bye laws and environmental protection stipulations.
- Apply professional knowledge, core skills & employability skills while performing the work
- Check the work as per sketches and rectify errors
- Document the technical parameters related to the work undertaken.

About the trade

What do draftsman do?

Draftsmen, also called drafters, perform some of the same tasks as architects and often work with architects.

Draftsmen are responsible for creating technical drawings that accurately represent design ideas. Draftsmen use hand drawing and computer - aided drafting methods to generate precise drawings that meet given specifications and are used by manufacturers, builders and engineers.

Plan and organize assigned work and detect & resolve issues during execution. Demonstrate possible solutions and agree tasks with in the team. Communicate with required clarity and understand technical English. Sensitive to environment, self-learning and productivity.

Job duties and tasks for "Civil drafter"

1 Produce drawings using computer assisted drafting systems (CAD) or drafting machines or by hand using compasses, dividers, protractors, triangles and other drafting devices.

2 Draft plans and detailed drawings for structures, installations, and construction projects such as highways, sewage disposal systems, and dikes, working from sketches or notes.

3 Draw maps, diagrams, and profiles, using cross-sections and surveys, to represent elevations, topographical contours, subsurface formations and structures.

This course is meant for the candidates who aspire to;

1 Use and maintain in good condition -drawing instruments, slide rule, survey instrument, auto level, digital theodolite, total station, GPS, computer & drafting software, plotter & printer etc.

2 Plan and draw of residential buildings from given data.

3 Prepare working drawings of all types of buildings from line sketches in CAD.

4 Planning, drawing, estimating, and costing of civil work. Drawing plans by using CAD. Making of 3D models of civil work. Giving setting out of site, supervision of civil work etc.

5 Prepare proposals for drainages and water supply for a given building including preparation of detailed drawings.

6 Plot the longitudinal section and cross - section for a proposed road and calculate the earth work and materials for road work.

7 Draw the parts of R.C.C structures and steel sections. Prepare working drawing of R.C.C structures from the given field data.

8 Draw from sketches or specifications various types and cross - section of roads culverts, bridges, Railways & irrigation structures in CAD.

9 Carry out the surveying by using latest equipments (Auto level, Digital theodolite, total station, GPS).

N.C.O Code No. 3118.20 Draughtsman, Civil : Prepare drawings of buildings, stores, highways, dams, culverts, etc. from sketches, notes or data for purposes of construction or alternations. Takes instructions form Civil Engineer studies sketches and calculates dimensions from notes or data. Draws to given scale different elevations, plan, sectional views etc. of desired construction using drawing instruments. Draws detailed drawings of specific portions as required. Indicates types of materials to be used, artistic and structural features, etc. in drawing as nenessary. may do tracing and blue printing. May reduce or enlarge drawings. May prepare or check estimate schedules for cost of materials and labour. May prepare tender schedules and draft agreements. May work as draughtsman Architectural.

N.C.O. Code No.3118.50 Draughtsman, Structural : Prepares drawings of bridges, steel structures, roof tresses etc. from sketches, designs of data for purposes of construction, alteration orrepairs. Stuides sketches, data, notes etc. and receives instructions from Structural or Mechanical Engineers, regarding details and types of drawings to be made. Calculates dimensions as necessary from available notes, data etc and by application of standard formulae. Draws to scale detail, assembly and arrangement drawings showing sectional plan and other views as directed and prints (writes) necessary instructions regarding materials to be used, limits, assembly etc. to clearly indicate all aspects of structure to be manufactured. May prepare estimate and operation schedules for labour and material costs. May prepare tender schedule and draft agreements. May prepare tables showing requirements of bars, their numbers, sizes and shapes. May trace and make blue prints.

N.C.O Code No.3118.60 Draughtsman, topographical: Sketches topographical drawings to scale in different colours using blue print prepared from field plane tables. Carries out independently projection of small scale map to predetermined size, incorporating features covered in survey, producing total geographical effect by hill shading, giving contours, profile, cross sections, authorized symbols, etc. Uses grid tables, projection table compasses, pantograph, planimeter, etc.

Options for employment are : Employment opportunities for trainee from this trade as draftsman, surveyor and land surveyor shall be available in Central & State Government Departments.

Private sector opportunities shall be as Draftsman, Construction Supervisor with Architect, Civil Engineer, and Civil Contractor, Builders.

Options for Self- Employment are : The Trainee shall be able to independently undertake planning, drawing, estimation & costing and supervision of civil construction work. He can set up his own office for above work and also to supply Civil Construction materials.

Rules and regulation of the institute and trade

- The trainees who are all got admission in I.T.I has to follow same general rates stipulated by the institution, and those are given below
- The trainees who are all got admission in I.T.I has to follow same general rates stipulated by the institution, and those are given below
- He should try to earn good room from the institution
- The trainees should attend the institution to the correction in punctuality should be maintained.
- He should be very sincere and faithful not only to this instructor but also other instructors and staff the institute.
- He should attend were proper formal dress as specified by the institute.
- He should not wear loose clothes and this may be the cause for accident while crossing in shops floor.
- He should have good attitude and behave with good manner to all the staff members his fellow students and to this senior students.
- He should take part in the activities of the institute.
- He should maintain discipline of the class room and the institution.
- He should not spoil the environment of institute.

Note : The above rules and regulation are also compulsory for the Girl trainees to adhere

Overview of the subject to be taught in each semester

Objective: At the end of this lesson you shall be able to
- **state the subject to be learned in each semester.**

Overview of the subject to be taught for each semester : During the two years duration, a candidate is trained on subject viz. Professional Skill, Professional Knowledge, Workshop Science & Calculation and Employability Skills. In addition to this, a candidate is entrusted to undertake project work and Extra Curricular Activities to build up confidence. The practical skills are imparted in simple to complex manner & simultaneously theory subject is taught in the same fashion to apply cognitive knowledge while executing tasks. The practical part starts with simple geometrical drawing and finally ends with preparing sanction plan of Residential / Public building; drawing of roads, bridges, railway tracts, dams and Estimation and costing of civil works at the end of the course.

Job area after completion of training : After completion of this training trainees maybe able to earn their livelihood. Environment of I.T.I is differs from the schools education. In I.T.I we concentrate more time in practical training i.e he has to obtain good skill in the trade in which he trained. Hence we can say I.T.I.s are institutions which lay the carpet for self job opportunity and differ job opportunity in public sector and private sector.

There are so many departments in public sector and private sector which provides the job opportunity for the trade of Draughtsman Civil .

The name of some public sectors are given below

- Central public works department
- Central architect department
- Military Engineering service
- National High ways department
- Central geological department
- Survey of India
- Railways
- State P.W.D.
- Nagar palikas
- Private building construction companies

Now Government of India passed an order in parliament those are all trained in particular group of trades such as D'man Civil, D'man Mechanic and Mechanic shop group of trades, they can join in 2nd year of diploma courses in the respective states.

Subject to be taught in the trade of D'man Civil for each semester

Ist Year

- Occupational safety and health
- First Aid and introduction of PPF
- 5S concept
- Power failure, fire alarm
- Use of drawing instruments and equipment, their care and maintenance
- Layout of drawing sheets and following of different size of drawing sheets.
- Plane and solid geometrical figures
- Simple problems on projection of points, lines surfaces and solids.
- Drawing of sketches from models (Plan, sections and elevation)
- Conventional signs and symbolism drawing
- Read and use of plain, diagonal, comparative, diagonal, vernier and scale of chords.
- Arrangement of bricks in different types of bonds in building and in foundation
- To have to knowledge to prevent the structure from the dampness
- Various types of arches and lintels
- Chain surveying and preparation of site plan
- Observe the bearings of lines
- Traverse survey using compass
- Longitudinal and cross - sections for the given route using auto level.
- Calculation of reduced levels of various points.
- Preparation of contour map
- Traverse survey using theodolite
- Topographical map using theodolite and level
- Different type of doors and windows
- Different type of carpentry joints
- Electrical wiring system drawing
- Different ground floors
- Different types of roofs with all details
- Upper floors - General principles of construction
- Truss and stair cases.

IInd year

- Draw plan, section and elevation of a residential building (single story / and double story) with the help of sketches and line diagram.
- Practice an CAD- Explain method of giving commands -Explain drawing area setup - explain drawing and settings.
- Principles of planning local building by laws with ISI standards.
- Perspective view of building
- Inking - Lerroy set printing of letters- tracing- practice of blue prints.
- Create objects on 3D modeling and concept of CAD.
- Preparing detailed drawing of reinforced bars -indicating shape of bend, hook, details of cranks and development length.
- Draw details of R.C.C stair
- Preparation of bar bending schedule
- Draw reinforcement details of T-beam, inverted beam and cantilever
- Draw reinforcement details of R.C.C retaining wall
- Preparation of the reinforcement details of column with footing and continuous columns
- Draw the details of framed structures and portal frame.
- Draw the different types of steel sections.
- Draw the different types of rivets and bolts.
- Elevation and section of girders
- Draw roof trusses and stanchion
- Preparing the detailed drawing of various pipe joints
- Preparing the detailed drawing of the different types of sanitary fittings arrangements of man holes - details of septic tanks in plumbing system of new technology.
- Draw the details of R.C.C water tanks
- Draw the cross - sectional view of different types of roads showing component / parts.
- Draw the detailed longitudinal section of road showing its gradient.
- Typical plan showing curve.
- Details of different types of culverts and bridge.
- Draw the typical cross- section of rail sections, railway tracks in cutting and embankment
- Draw the detailed drawing of dam, barrages and weir.
- Draw the detailed sectional view of distributaries and head regulators.
- Preparing detailed drawing of different types of cross drainage works.
- Draw the schematic diagram of different structures of hydro electric project.
- Preparing the detailed estimate of a building - quantity of items required, rate analysis etc.
- Preparing the detailed estimate by using software.
- Transverse survey using total station.
- Use of GPS and application in survey work.

Engineering Drawing

Objectives: At the end of this lesson you shall be able to
- **state the importance of engineering drawing**
- **state the areas of civil engineering drawing.**

Introduction : The communication of ideas through the graphical language is probably the oldest form of communication among human. Engineering graphics is the study that required special equipment to form the images.

Engineering Drawing : It is the universal graphic language of engineers, spoken, read and written in its own way.

Engineering drawing also has its grammar in the theory of projections, its idioms in conventional practice, its punctuations in the types of lines, its abbreviations, symbols and its descriptions in the constructions. The shape of objects are established by different lines and size description are by symbols lettering and dimensioning.

In Civil Engineering, this is concerned with structural works. It is very broad with many subspecialties, including structural, geotechnical, water resource and transportation engineering. Structural engineers are concerned with the safe design and construction of structures.

Geometrical Drawing : It is the foundation of all engineering drawing. It is the art of representation of geometrical objects on a drawing sheet, which is difficult to learn or teach without the good aids. Accuracy, neatness and legibility are of great importance in engineering drawing.

Plane geometrical Drawing : It is the art of representation of objects having two dimensions, i.e. length and breadth such as, square, rectangle, etc. on a drawing sheet.

Solid Geometrical Drawing : It is the art of representation of objects having three dimensions, i.e. length and breadth and height such as, cube, cylinder, etc. on a drawing sheet.

The learning process is accomplished through traditional construction methods, may then only easily accomplished by the use of computer.

List of drawing instruments, equipments and materials to be used during training

Objectives: At the end of this lesson you shall be able to
- **state instruments, equipments and materials**
- **list out instrument, equipments and materials**
- **state the standard as per 962-1987**
- **to use different drawing instruments, equipments and materials**
- **follow Precautions in the use of instruments, equipments and materials.**

Introduction : Engineering Drawing is the language of engineers, the accuracy and neatness of the engineering Drawing depends on the quality of the instruments, equipments and material used. Hence, preference should be given to standard instruments and equipments and draughtsman should be able to use different drawing instruments.

List of instruments

- Drawing board
- Tee-square or Mini Drafter
- Set-square
- Scale
- Protractor
- French curves
- Stencil
- Drawing instruments box

List of equipments

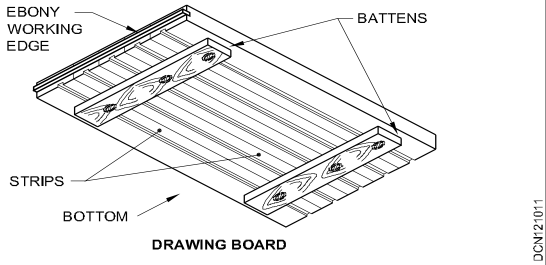
- Drafting machine
- Computer for Auto CAD. (Monitor UPS, CPU, key board, mouse, etc.)
- Plotter/Printer

List of materials

- Drawing papers
- Drawing pencils
- Rubber/ Eraser
- Drawing papers fasteners (Drawing pins, Cello tape)
- Tracing paper or tracing film

Drawing board (Fig 1) : The standard size should be as per IS: 1444-1963/1977 of Bureau of Indian Standards.

Fig 1



DRAWING BOARD

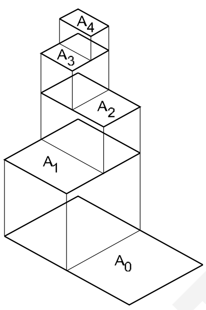
Sl. No.	Designation	Drawing Boards Sizes in mm (L x W x T)	Drawing sheets to be used with designation
1	B0	1500 x 1000 x 25	A0
2	B1	1000 x 700 x 25	A1
3	B2	700 x 500 x 15	A2
4	B3	500 x 350 x 15	A3

The following precaution may be taken in handling the drawing boards

- Always keep an extra sheet on the top surface of the drawing board.
- Do not keep anything on the top flat surface of the drawing board.
- Take sufficient care in up keeping the straightness of the ebony edge.

Drawing papers (Fig 2) : The standard size as per Bureau of Indian standard (B.I.S)

Fig 2



HALVING AND DOUBLING

Designation	Trimmed size (mm)	Untrimmed size (mm)
A0	841 x 1189	880 x 1230
A1	594 x 841	625 x 880
A2	420 x 594	450 x 625
A3	297 x 420	330 x 450
A4	210 x 297	240 x 330
A5	148 x 210	165 x 240

1 The size of the drawing sheets to be used depends on the size of the object to be drawn and the scale to be used.

2 The length of the drawing sheet can be horizontal or vertical while drawing.

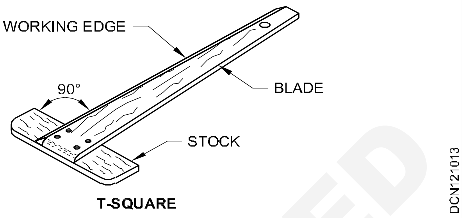
3 A2 size of drawing sheet is most convenient for drawing purposes in the class room.

4 The width to length ratio of drawing sheet is $1 : \sqrt{2}$

5 Area of A0 drawing sheet is 1.00 square metre.

T-square (Fig 3) : It consists of two parts, a long strip called blade and a short strip called head or stock. The blade is fitted with an ebony or plastic piece on its upper edge to form a working edge.

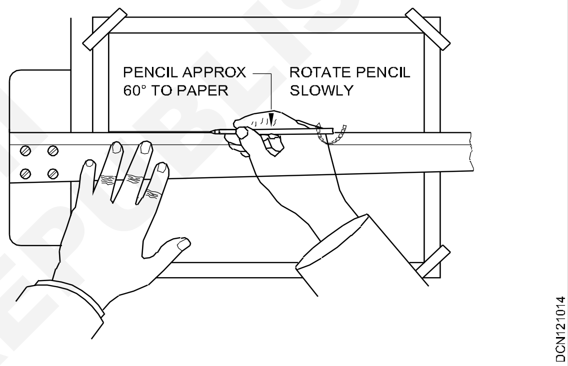
Fig 3



T-SQUARE

The following precautions may be taken in handling the T-square (Fig 4)

Fig 4



1 When not in use, T-square should be left flat on the drawing board or suspended from the hole at the end of the blade.

2 Clean the blade with moist cloth to remove lead particles.

3 Do not use T-square as a hammer to drive in the drawing pins etc.

4 Do not use the ebony edge as a straight edge for cutting paper with knife.

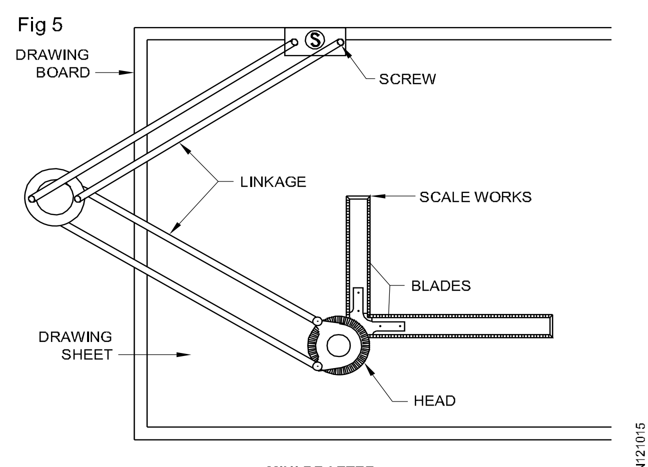
5 Ensure that the screw heads are tight.

T-square is used to draw only horizontal lines. Do not use lower edge of the T-square to draw horizontal lines. While drawing horizontal lines, the pencil should be slightly inclined towards the right. Vertical and inclined lines are drawn with the help of set squares.

Mini drafter(Fig 5)

It is a simple and small shaped instrument of the drafting machine. Now-a-days these are mostly used by the engineering students. All the working functions of T-Square, Set-Square, Protractor, Scales and their merits are co-ordinated in a Mini-Drafter.

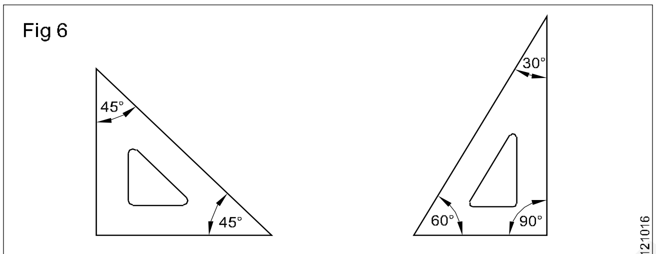
Fig 5



MINI DRAFTER

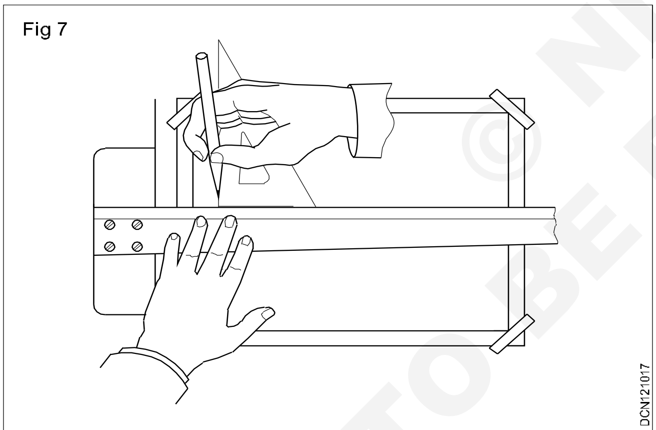
Set-square (Fig 6 and Fig 7) : It is made of transparent celluloid plastic in triangular shape They are available in two types, 30^0-60^0 and 45^0-45^0.

Fig 6



(a) 45° SET SQUARE (b) 30° - 60° SET SQUARE

Fig 7



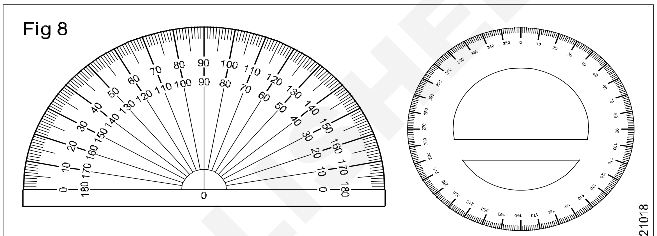
Engineer's scales (Table) : It is used to make full size, reduced size or enlarged size drawings conveniently, depending upon the size of the object and that of the drawing sheet. They are made of cardboard, plastic and as recommended by Bureau of Indian Standards, are available in set of eight scales. They are designated from M1 to M8.

Table

Designation	Description	Scales
M1	Full size	1:1
	50 cm to a metre	1:2
M2	40 cm to a metre	1:2.5
	20 cm to a metre	1:5
M3	10 cm to a metre	1:10
	05 cm to a metre	1:20
M4	02 cm to a metre	1:50
	01 cm to a metre	1:100
M5	5 mm to a metre	1:200
	2 mm to a metre	1:500
M6	3.3 mm to a metre	1:300
	1.66 mm to a metre	1:600
M7	2.5 mm to a metre	1:400
	1.25 mm to a metre	1:800
M8	1 mm to a metre	1:1000
	1.5 mm to a metre	1:2000

Protractor (Fig 8) : It is made of transparent celluloid plastic, available in semi circle or circle.

Fig 8

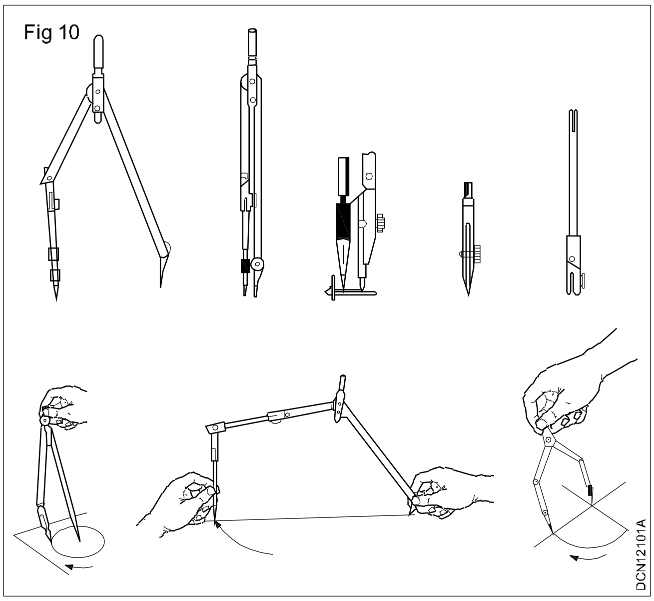


SEMI-CIRCULARPROTRACTOR CIRCULAR PROTRACTOR

Compass (Fig 9) : It is used for drawing circles both in pencil and in ink. It consists of two legs hinged at one end. One leg is attached with a steel needle by means of a screw while the other leg is provided with a socket to accommodate interchangeable attachments.

Dividers (Fig 10) : Dividers are similar to the compass and are made in square, flat and round forms. They are used for

Fig 10



1 Dividing curved or straight lines into any number of equal parts.

2 Transferring dimensions from one part of the drawing to another part.

3 Setting dimensions form the scale to the drawings.

Fig 9 a

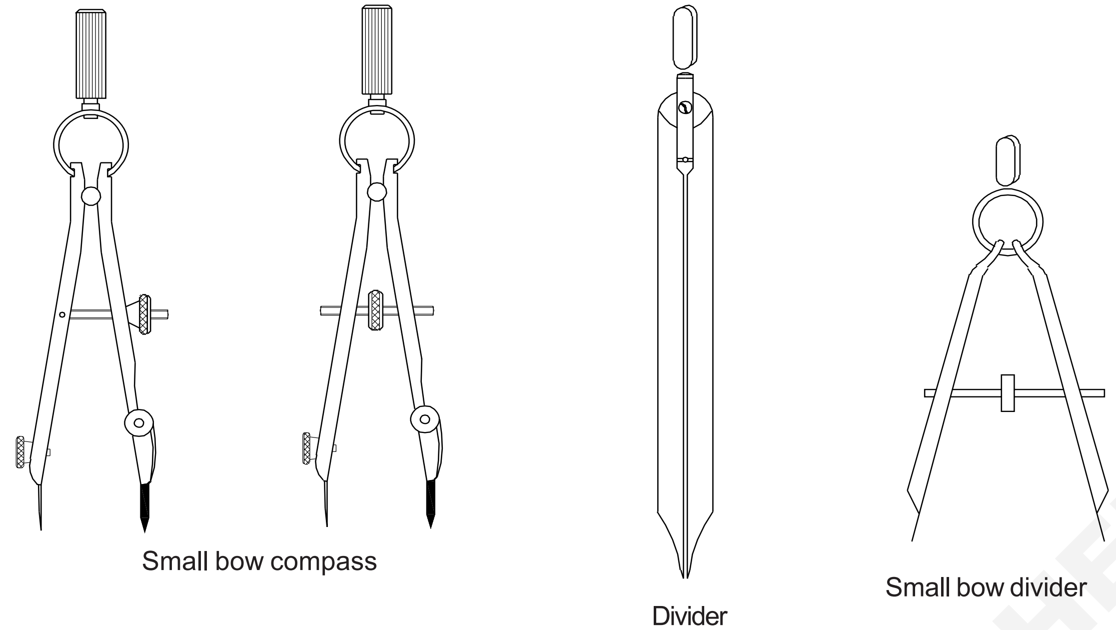
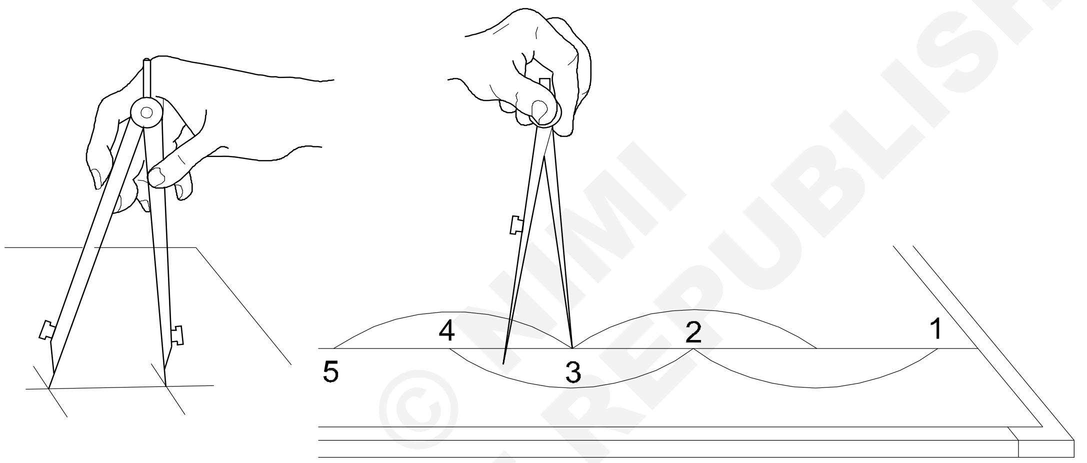
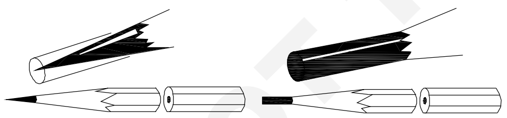


Fig 9 b



Drawing pencils (Fig 11) : These are in many grades. The grade HB denotes medium soft. The grade H denotes the degree of hardness in an increasing order. Similarly, grade B indicates the degree of softness in an increasing order.

Fig 11



The lead of the wood pencil may be sharpened in the following ways

1 Cylindrical

2 Conical

3 Wedge (Chisel edge)

4 Bevel

Mechanical clutch pencil is very common in use. This is very simple, easy to use, requires no sharpening time and even cheaper in long run. Hence, this type of pencil is preferred by professional draughtsman. Students using these types of pencils will save a lot of time.

1 Only a sharp pencil can make quality drawing and hence, sharpen the pencil as and when it is necessary.

2 Sharpen the pencil only where there is no grade mark.

3 In a compass H pencil sharpened to bevel point, having its wedge shaped side slopping outside, is used.

Selection

- HB- For free hand works
- H- For making drawing and lettering
- 2H- for drawing construction lines, dimensions lines, section lines and centre lines.
- 3H, 4H- For drawing minute details
- B- For shading

Eraser : Soft pencil erasers are ideal for erasing pencil marks. This eraser will not destroy the surface of the paper and hence drawing can be re-penciled.

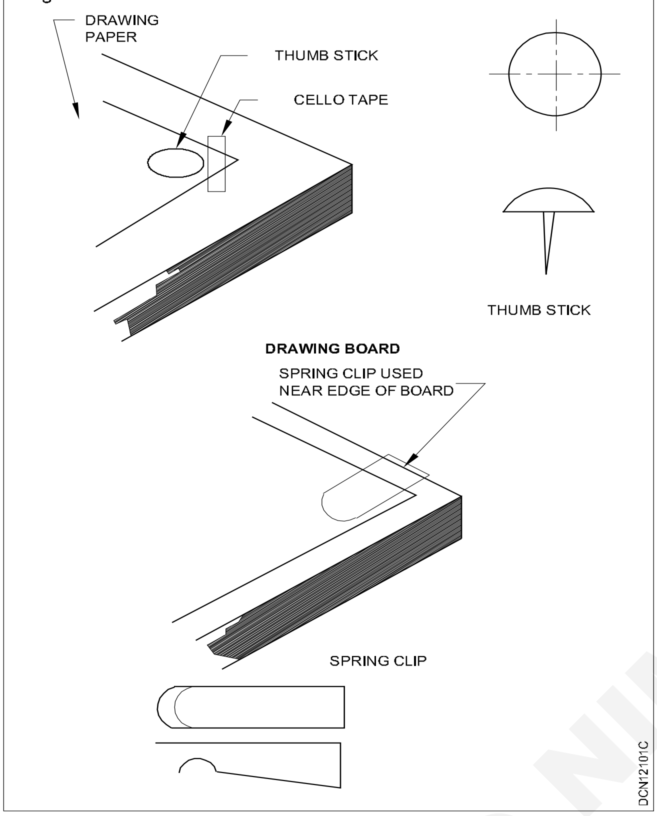
Fastener (Fig 12): Following materials are used to fix the drawing sheet on the drawing board.

- Thumb pins
- Cello tapes
- Fold back gap spring clips.

Template : Templates are available for drawing circles, arcs, ellipses, triangles, squares and other polygons. Also, symbols used by various engineering faculties, such as architectural, mechanical, electrical, chemical etc. are now available in the form of templates.

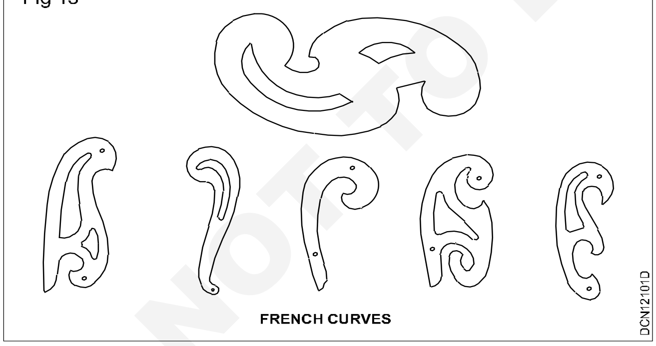
Stencils : Stencil is a thin flat piece of celluloid used to write letters and numerals. This helps the draftsmen to write neatly and uniformly and at a faster rate.

Fig 12



French curves (Fig 13) : A French curve is a curved ruler used for drawing irregular curves that are neither circles nor circular arcs. It is made of wood, plastic or transparent celluloid. There are different forms and sizes of French curves.

Fig 13



Flexible curve : Flexible curve is made out of materials having flexibility. It is made of lead bar enclosed in rubber and can be bent into any shape to form a curve. It helps to draw smooth curve passing through any given points. Flexible curves of various sizes are now available in the market.

Precautions in the use of instruments: Following precautions should be taken while doing the drawing works,

1 The lower edge opposite to the working edge of the Tee-Square should not be used for drawing horizontal lines.

2 T- Square should not be used as hammer to drive to drawing board pins.

3 Measuring scales should not be used as hammer to drive to drawing pins.

4 Drawing sheets should never be cut by blade or knife with the T-Square blade as the guide.

5 All the instruments and drawing sheet etc. Should be thoroughly dusted off and cleaned before starting the work.

6 No end of the pencil should be kept in mouth.

7 No oiling should be done to the joints of the instruments; otherwise, oil will give stains or spots on the drawing sheets.

8 Only required instruments should be kept on the drawing board. All extra instruments should be kept away in drawer.

9 Divider should not be used as pincer.

10 Soaking paper should not be used for drying the ink.

11 After completing the work all the instruments should be properly cleaned.

Conclusions

One should practice handling and using drawing instruments before attempting complex drawing problems. Developing correct drawing habits will enable to make continuous improvement in the quality of drawings. Each drawing will offer an opportunity for practice. Later on, good form in the use of instruments will become a natural habit.

Layout of drawing sheet

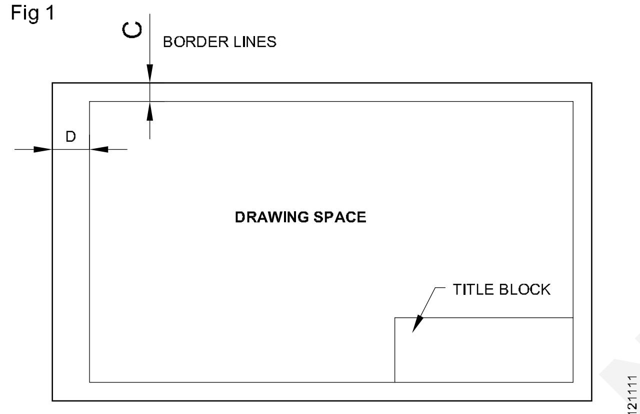
Objectives: At the end of this lesson you shall be able to
- **state the system of layout of drawing sheet**
- **list the different layout for designated drawing sheet**
- **explain the title block.**

Introduction

The details of layout showing frame with border lines, title block and margins around the frame as per Bureau of Indian Standards (B.I.S.) IS: 10711-1983 specifies the sizes and layout of drawing sheets.

Layout of drawing sheet (Fig 1)

Fig 1



LAYOUT OF DRAWING SHEET

After fixing drawing sheet on the drawing board, draw

- Border lines
- Title block

Border lines

All drawing requires a border. The standard line thickness of the border is 0.60 mm. The top, right and bottom margin should be 10mm and the left margin should be 20mm. This applies for all sheets sizes (A0, A1, A2, and A3). Notice that the left margins in larger to allow space for binding a drawing sheet. The title block place at right hand bottom of the sheet except A4 drawing sheet.

Borderline width : 0.60 mm

Top margin : 10 mm

Right margin : 10 mm

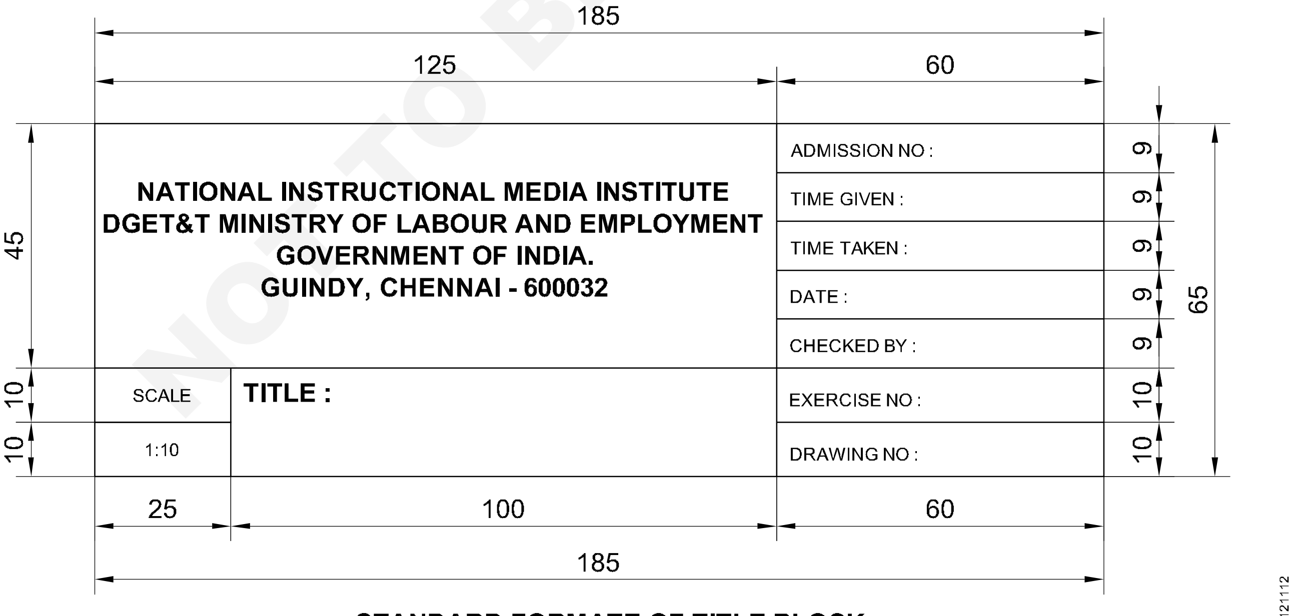
Bottom margin : 10 mm

Left margin : 20 mm

Title Block (Fig 2)

A rectangular of 185 mm x 65 mm is draw at the bottom of the right-hand side on drawing sheets of all sizes, to furnish the details, namely name of the firm/institute, name of the Draughtsman /trainee, Roll number, title of the Drawing, scale of drawing and checked by architect/ engineer/trainer.

Fig 2

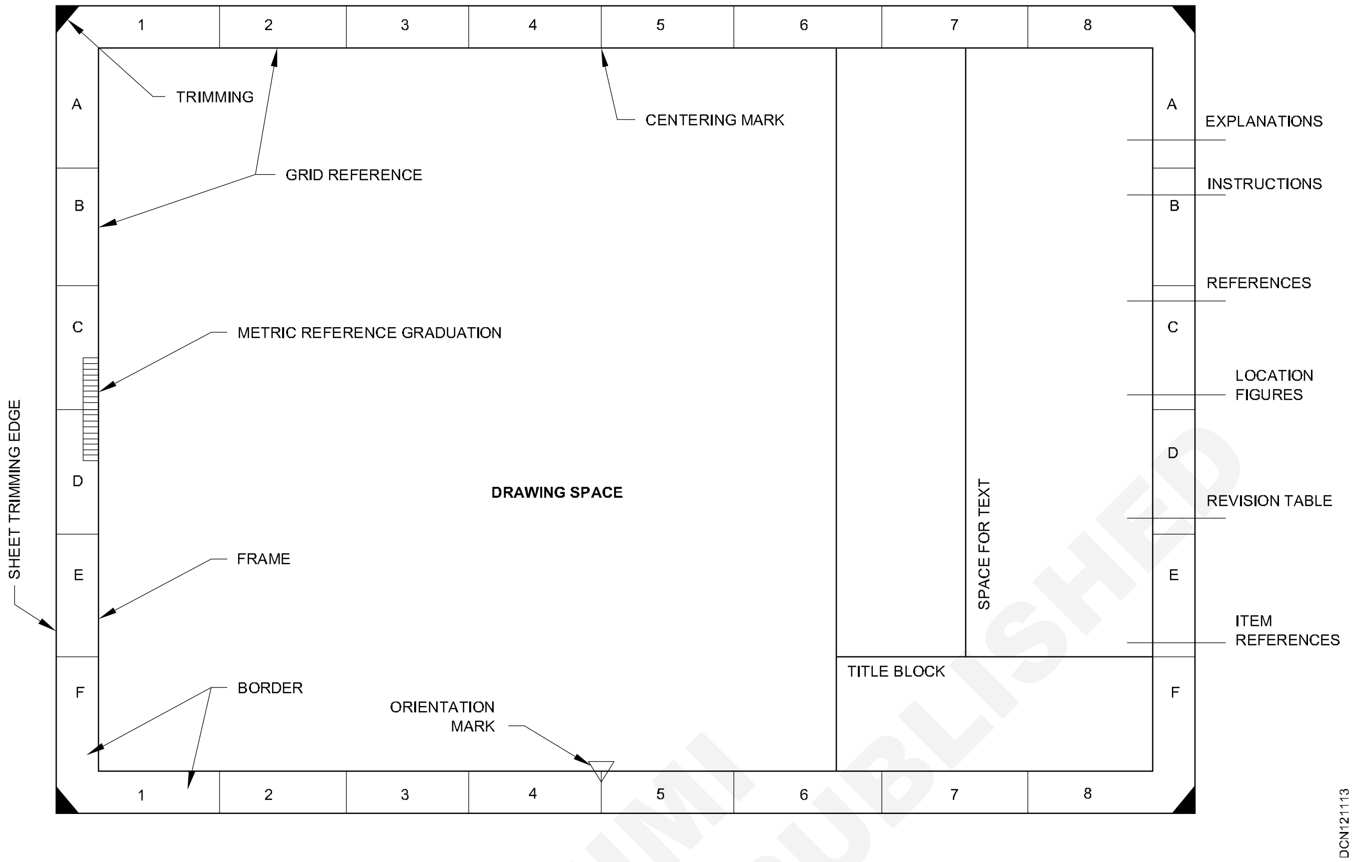


STANDARD FORMATE OF TITLE BLOCK

Spacing Drawing (Fig 3)

When only one figure is to be drawn on a sheet it should be drawn in the centre of the working space. For more than one figure, the space should be planned and divided into suitable bocks.

Fig 3



1
2
3
4
5
6
7
8
A
B
C
D
E
F
TRIMMING
CENTERING MARK
GRID REFERENCE
METRIC REFERENCE GRADUATION
SHEET TRIMMING EDGE
DRAWING SPACE
FRAME
BORDER
ORIENTATION MARK
TITLE BLOCK
SPACE FOR TEXT
EXPLANATIONS
INSTRUCTIONS
REFERENCES
LOCATION FIGURES
REVISION TABLE
ITEM REFERENCES
DCN121113

Folding of drawing sheets

Objectives: At the end of this lesson, you shall be able to
- **state the purpose of folding a drawing sheet**
- **explain the method of folding for drawing sheet.**

Introduction

After the completion of the drawing, the drawing should be folded properly according to IS: 11664-1986 recommended by Bureau of Indian Standards, and filed neatly for submission or for future revision / reference. All the maps and plans are folded to final size for convenience of record in office files.

The following procedure shall be adopted (Fig 1)

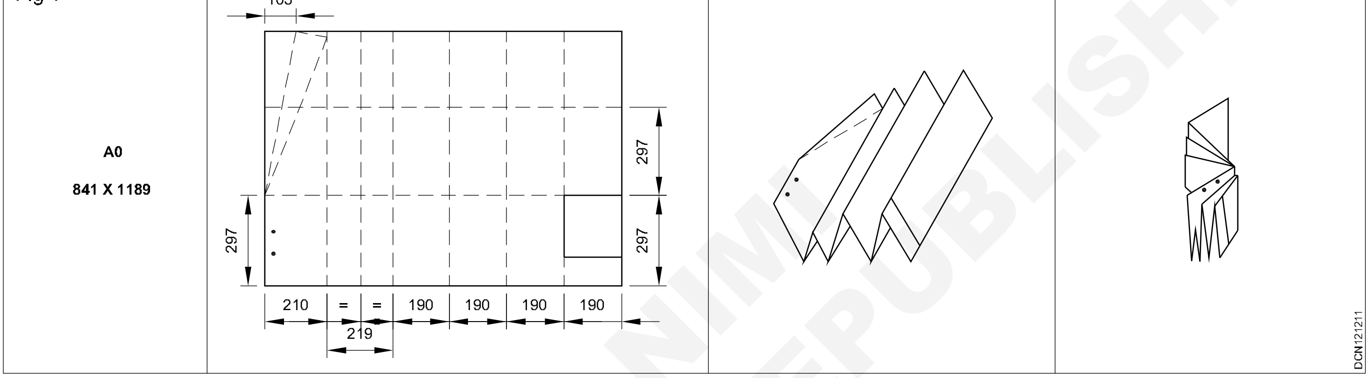
a Always fold vertically first,

b Fold horizontally next

c Folded drawing to be size of file, and

d It can see that the Title block of all the folded prints appears in topmost position for easy reference.

Fig 1



Free hand technical sketching of tools in civil work

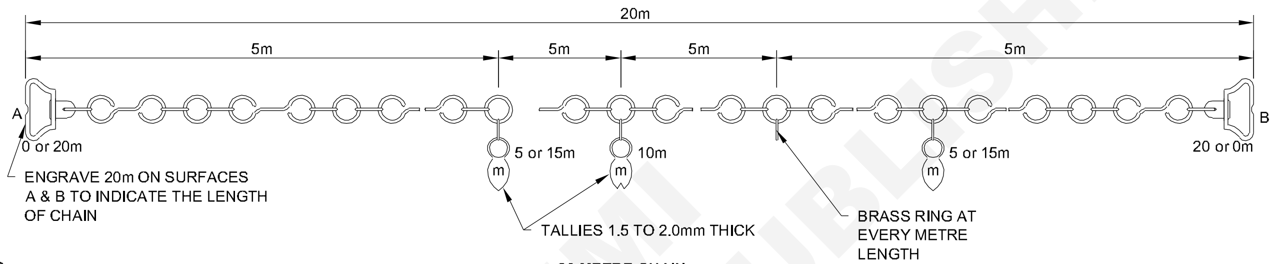
Objectives: At the end of this lesson you shall be able to
- **multi-views of the object/civil working tools.**

Importance of technical sketching: The importance of free hand sketching of machine parts and components in engineering field cannot be over estimated. Free hand technical sketching is a drawing drawn with/without the use of any drawing instruments and drawn not to scale.

The presentation of the views should be in good proportion to the extent possibility and by visual identification. Free hand technical sketching helps the designer in reflecting his thoughts and recording his ideas. Most original ideas and thoughts are expressed first through the medium of free hand sketching. For verbal explanation free hand sketching plays a very important role.

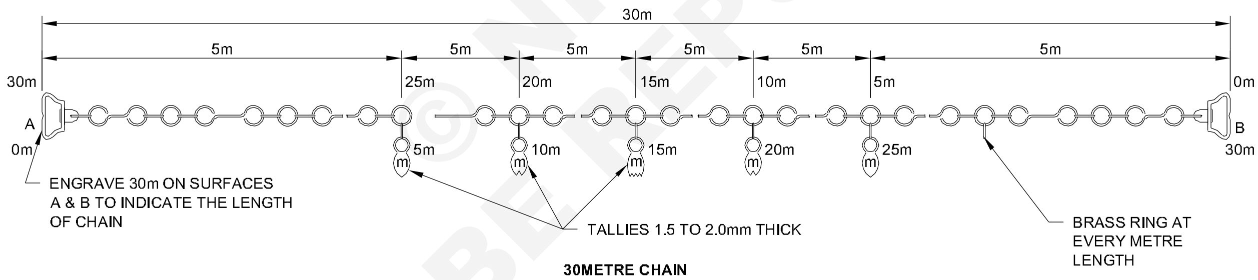
Free hand sketching contains all necessary details such as shape and size description.

Fig 1



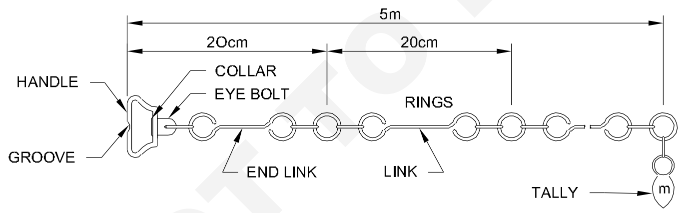
20 METRE CHAIN

Fig 2



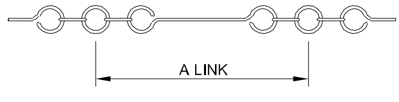
30METRE CHAIN

Fig 3



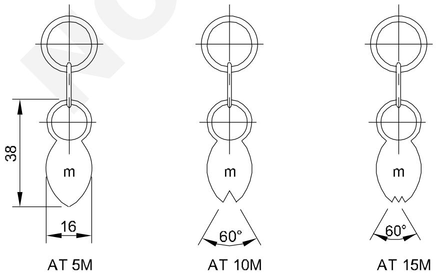
DETAILS OF A METRIC CHAIN

Fig 4



A LINK OF A CHAIN

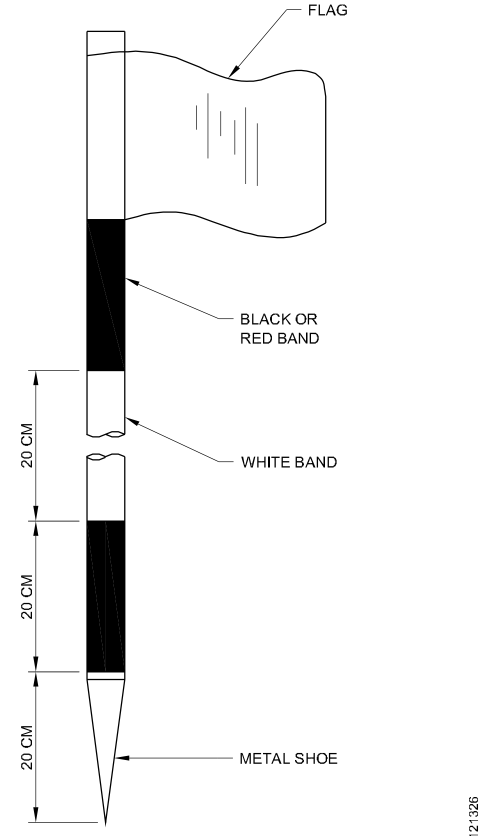
Fig 5



SHAPE OF TALLIES IN 30m METRIC CHAIN

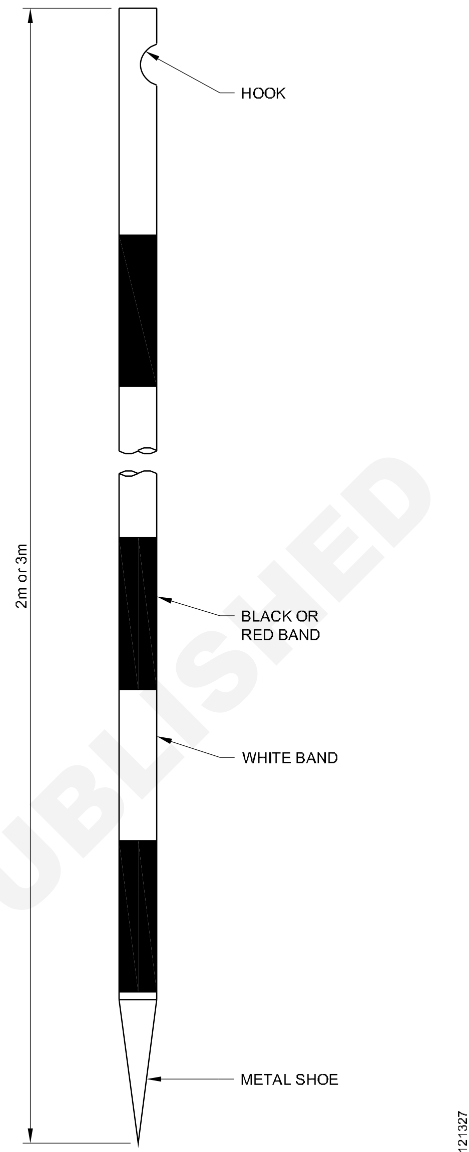
DCN121321

Fig 6



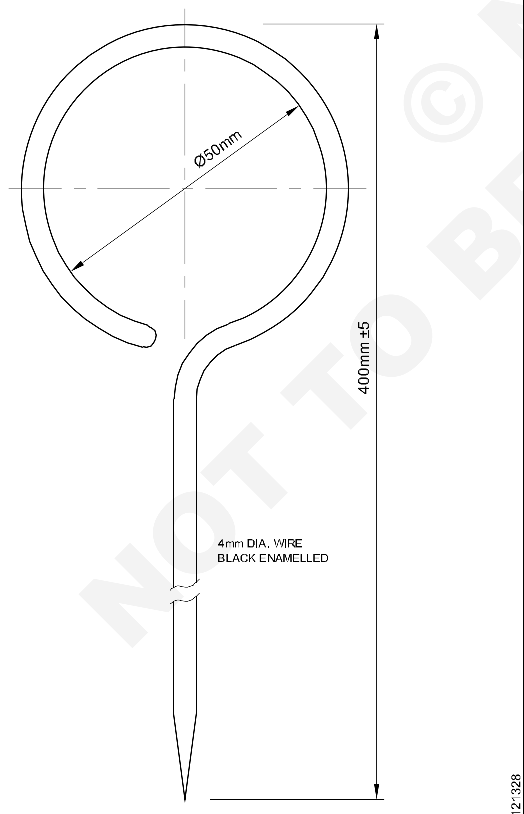
RANGING ROD

Fig 7



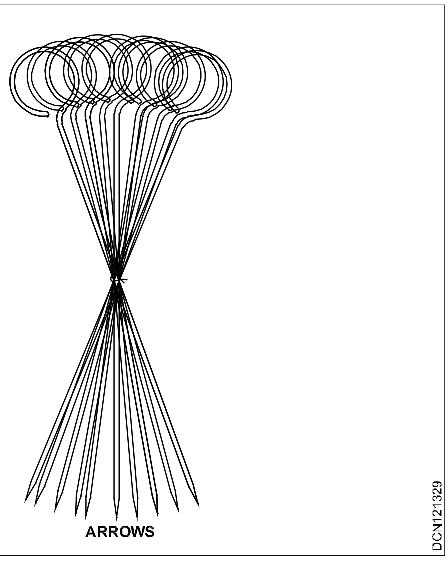
OFFSET ROD

Fig 8



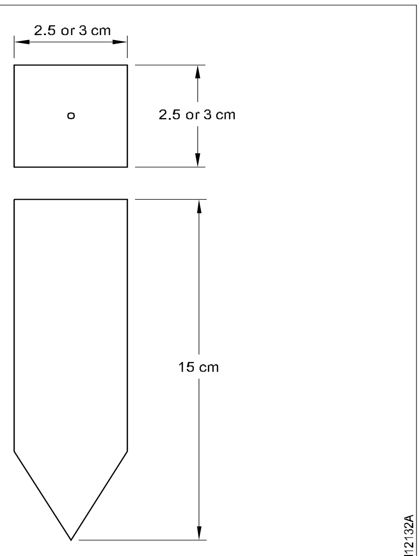
ARROW

Fig 9



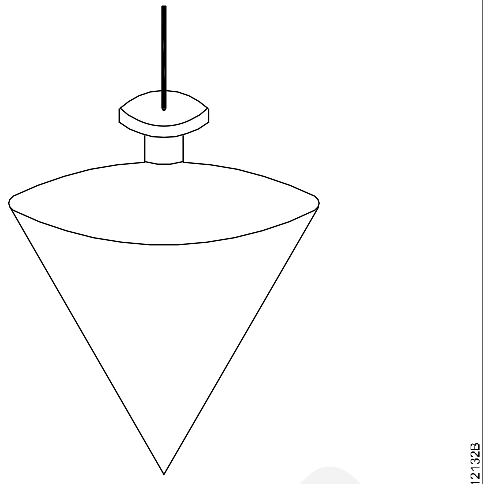
ARROWS

Fig 10



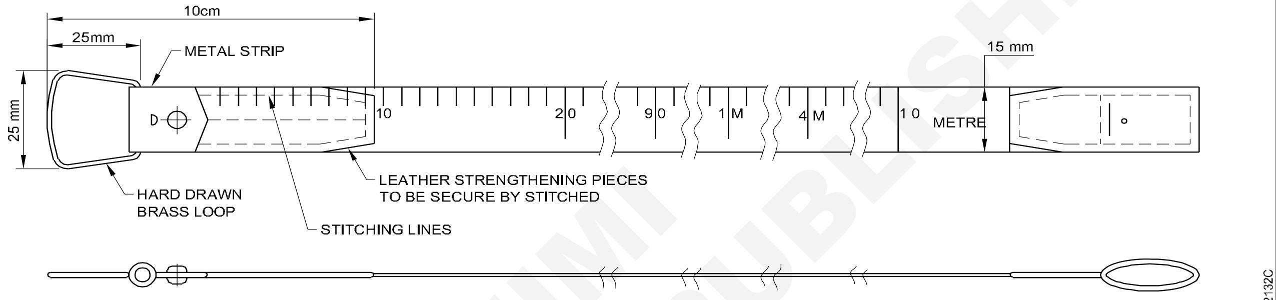
WOODEN PEG

Fig 11



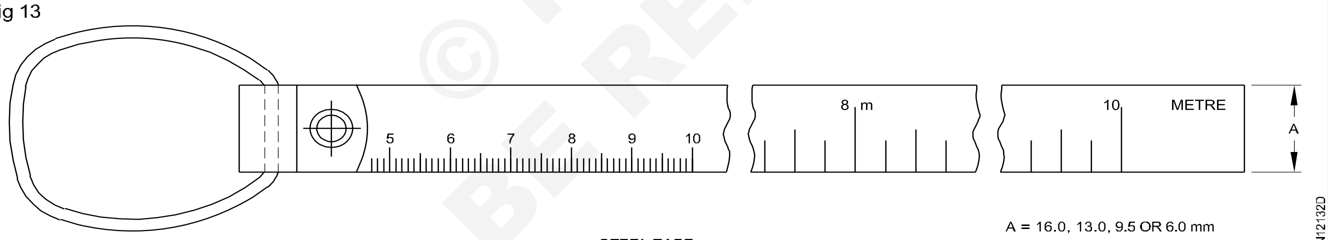
PLUMB BOB

Fig 12



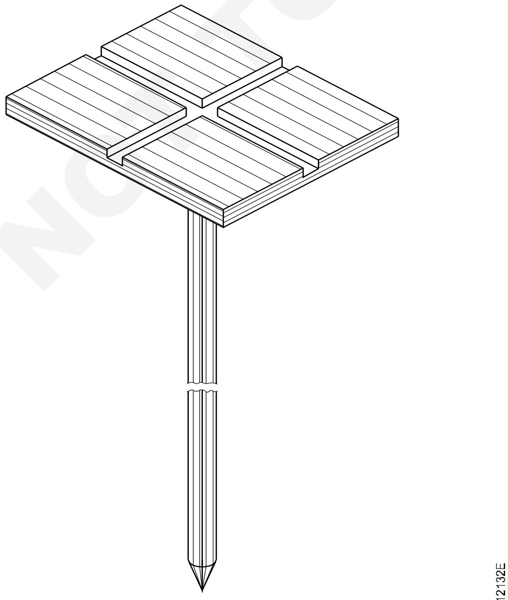
METALLIC TAPE

Fig 13



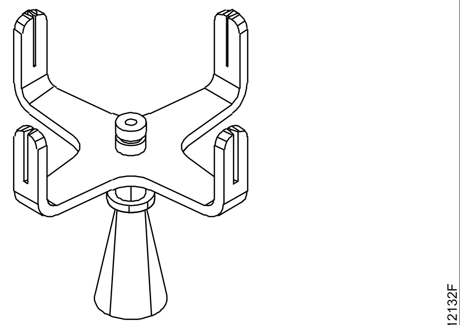
STEEL TAPE

Fig 14



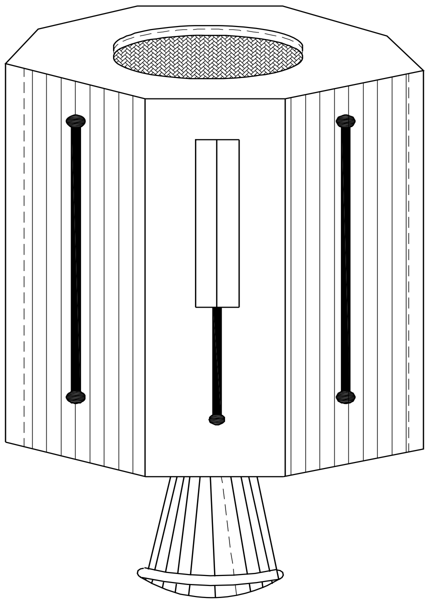
WOODEN CROSS STAFF

Fig 15



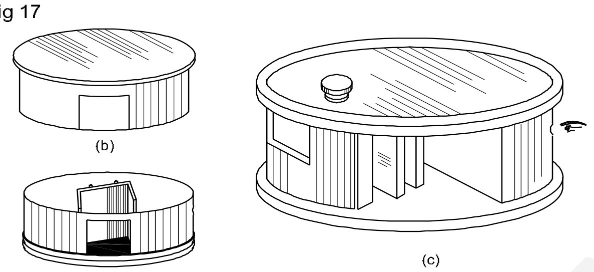
METAL ARM CROSS-STAFF

Fig 16



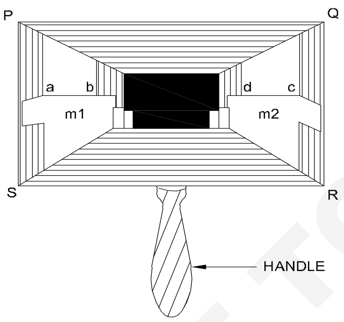
FRENCH CROSS-STAFF

Fig 17



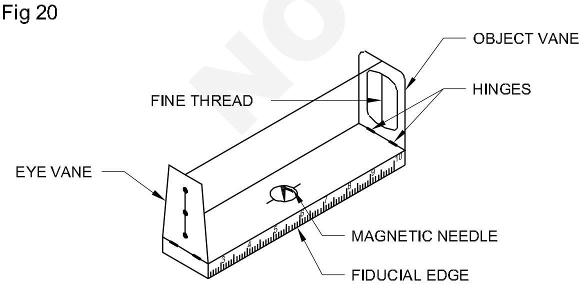
ROUND OR CYLINDERICAL OPTICAL SQUARE

Fig18



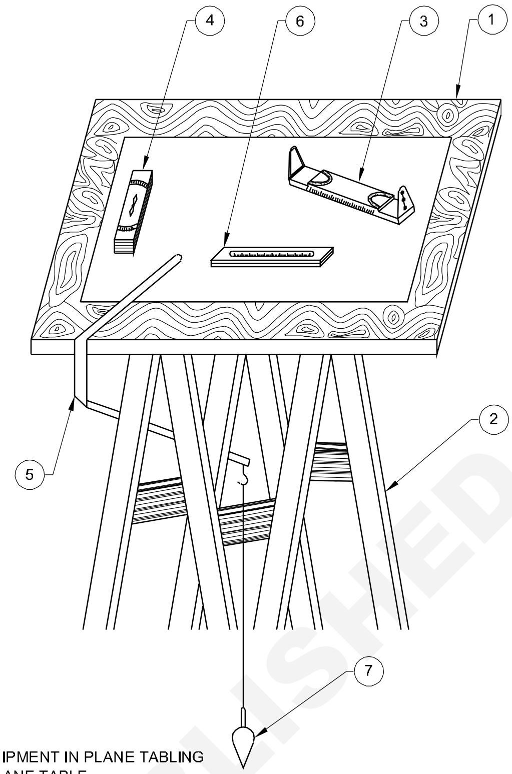
INDIAN OPTICAL SQUARE

Fig 20



A PLAIN ALIDADE

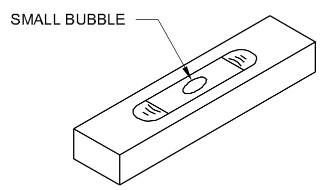
Fig 19



EQUIPMENT IN PLANE TABLING
1. PLANE TABLE
2. TRIPOD STAND
3. ALIDADE
4. TROUGH COMPASS
5. U-FRAME
6. SPIRIT LEVEL
7. PLUMB-BOB

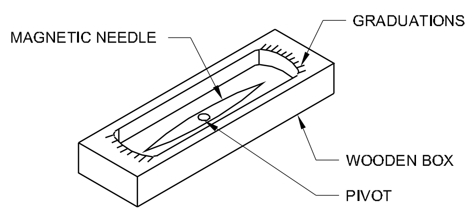
PLANE TABLE

Fig 21



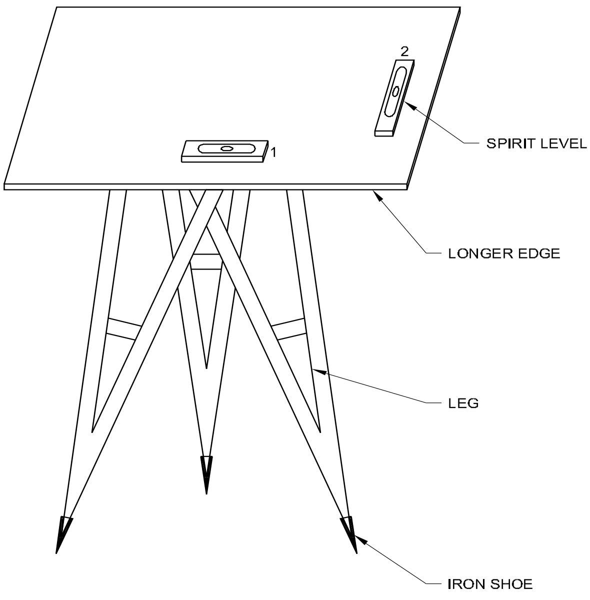
SPIRIT LEVEL

Fig 22



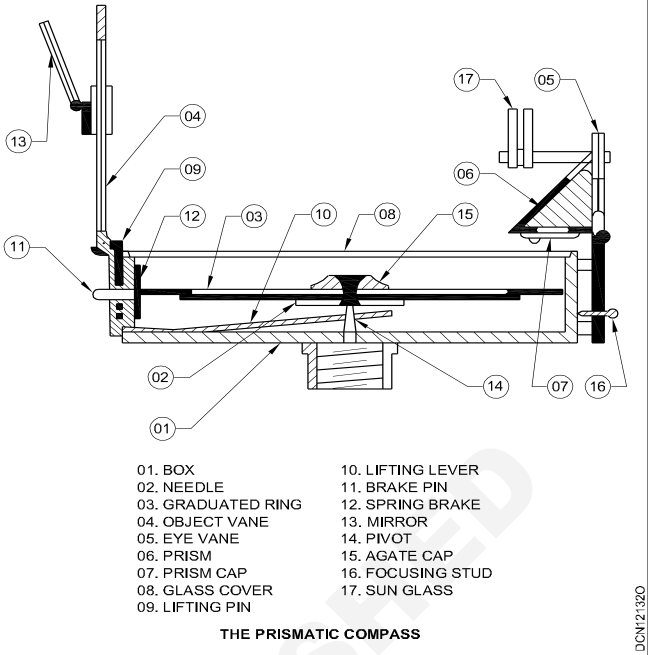
TROUGH COMPASS

Fig 23



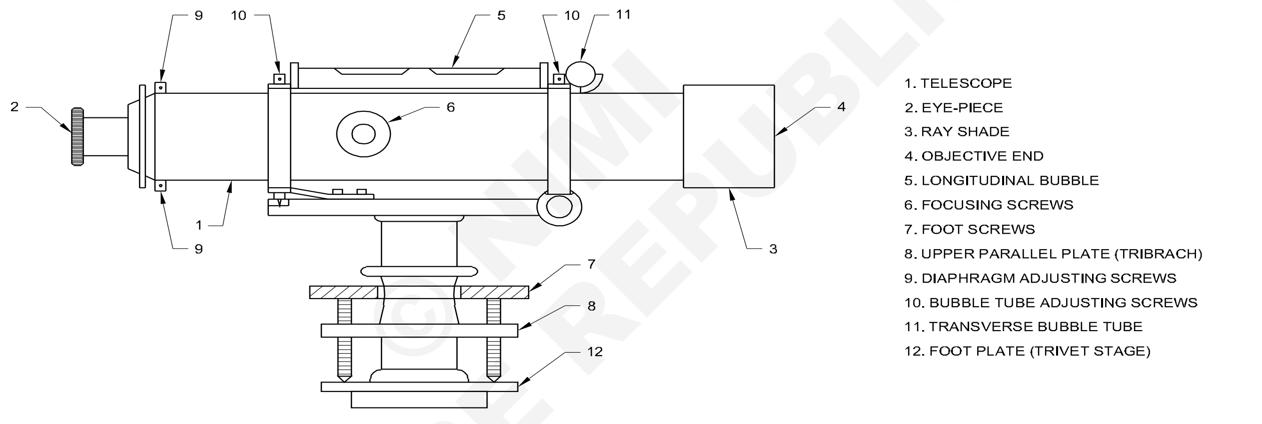
LEVELLING THE PLANE TABLE

Fig 24



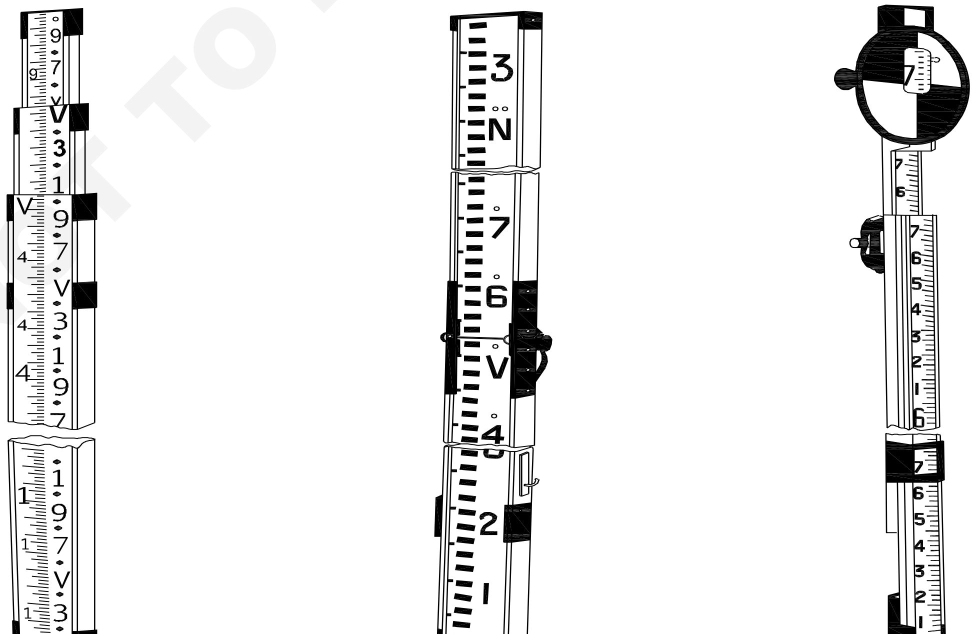
THE PRISMATIC COMPASS

Fig 25



DUMPY LEVEL

Fig 26



TELESCOPIC STAFF FOLDING STAFF TARGET STAFF

Symbols for architectural & building drawings (IS 962 - 1989) SP - 46 : 2003

Objectives: At the end of this lesson you shall be able to
- **identify the symbols for building plan- bath kitchen.**

Symbols for building plan- bath kitchen : Building plan- bath kitchen- ready made symbols for building plan

Ready -made symbols for building plan (Fig 1) : It is a fast and easy building plan software for creating great - looking office layout and commercial floor plans. It includes thousands of ready-made graphics that you simply stamp to create your drawing, including appliances, bath kitchen, building core, cabinets, electrical and telecom, furniture, garden accessories, wall shell and structure, cubicles, office accessories, office equipment, office furniture, planting, wall, door and window.

Fig 1

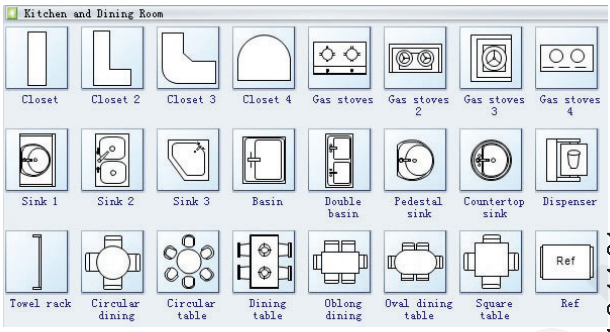


Fig 1.2.14.01

Home floor- bath kitchen : Free download building plan software and view all examples

Home plan & floor plan (Fig 2) : Home plan - used for kitchen and bathroom design, architectural and

Fig 2

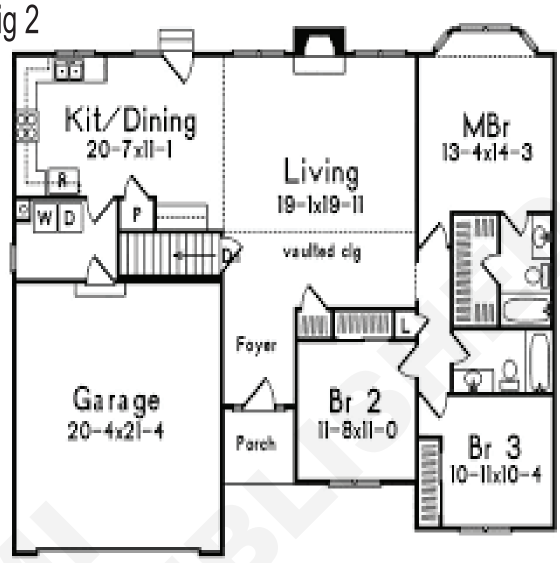


Fig 1.2.14.02

construction documents, space plans, remodeling and planning additions.

Floor plan - used for commercial building design, space plans, architectural layout, construction documents, structural diagrams and facility planning.

More kitchen and bathroom symbols (Fig 3) : The new version of symbols includes more kitchen and bathroom symbols for drawing floor plans.

Fig 3

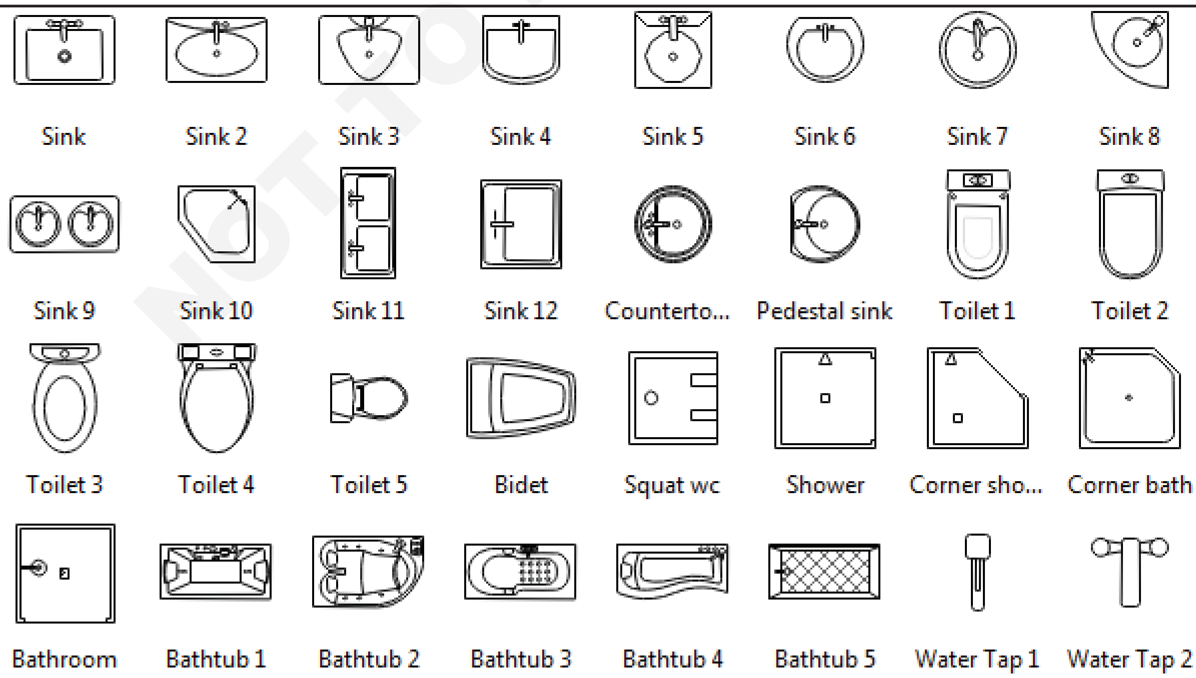
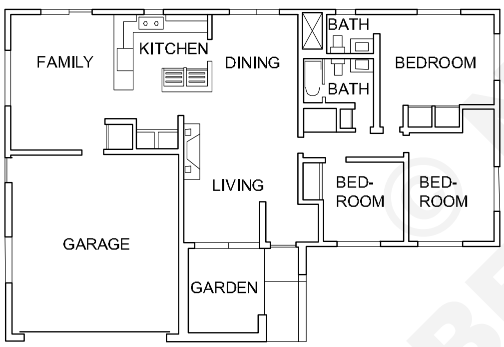


Fig 1.2.14.03

How to use appliances symbols for building plan : One of the obligatory documents that is included to design project of home, apartment, office center, or any other premise is the plan of arrangement of different appliances and home appliances. Creation the plan of such kind lets you to preplan the location of appliances, to make sure in convenience of their location and to envisage all nuances. Well though-out plan helps to avoid mistakes and future reworks, especially in relation to be location of major and large appliances. Concept draw PRO software extended with floor plans solution offers the perfect set of drawing tools, samples, examples, templates and ready-to-use vector objects that let you easily develop best layouts for your rooms, kitchen, bathroom, laundry etc. Ready-made symbols of appliances included to the appliances library are ideal and even indispensible for designing professional building plans and appliances layouts for homes, commercial and office premises. When designing your plans, you can make several variants and choose the best solution. (Figs 4 to 12)

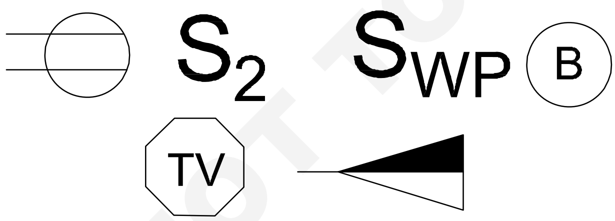
Hatching pattern can be used as a means to broadly indicate the material of the part /object to differentiate difference material is sectional views BIS laid out standards ((IS:11663) on conventional representations of the materials.

Fig 4



DCN121414

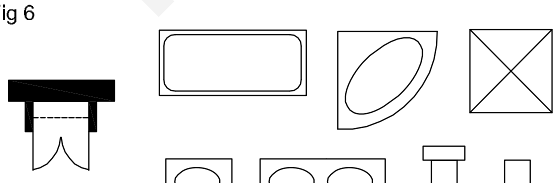
Fig 5



BLUEPRINT SYMBOLS

DCN121415

Fig 6



FLOOR PLAN SYMBOLS

DCN121416

Fig 8

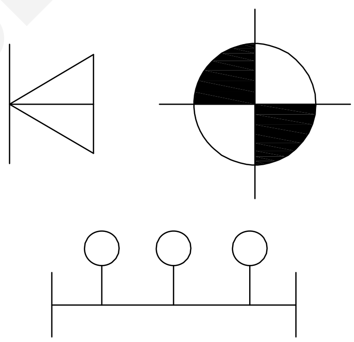
Free blueprint symbols

Fig 9

ELECTRIC SYMBOLS

ADN110519

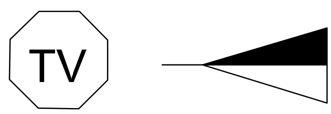
Fig 10



LIGHTING SYMBOLS

DCN12141A

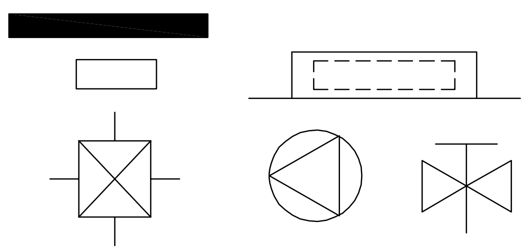
Fig 11



DATA / COMMS / TV SYMBOLS

DCN12141B

Fig 12

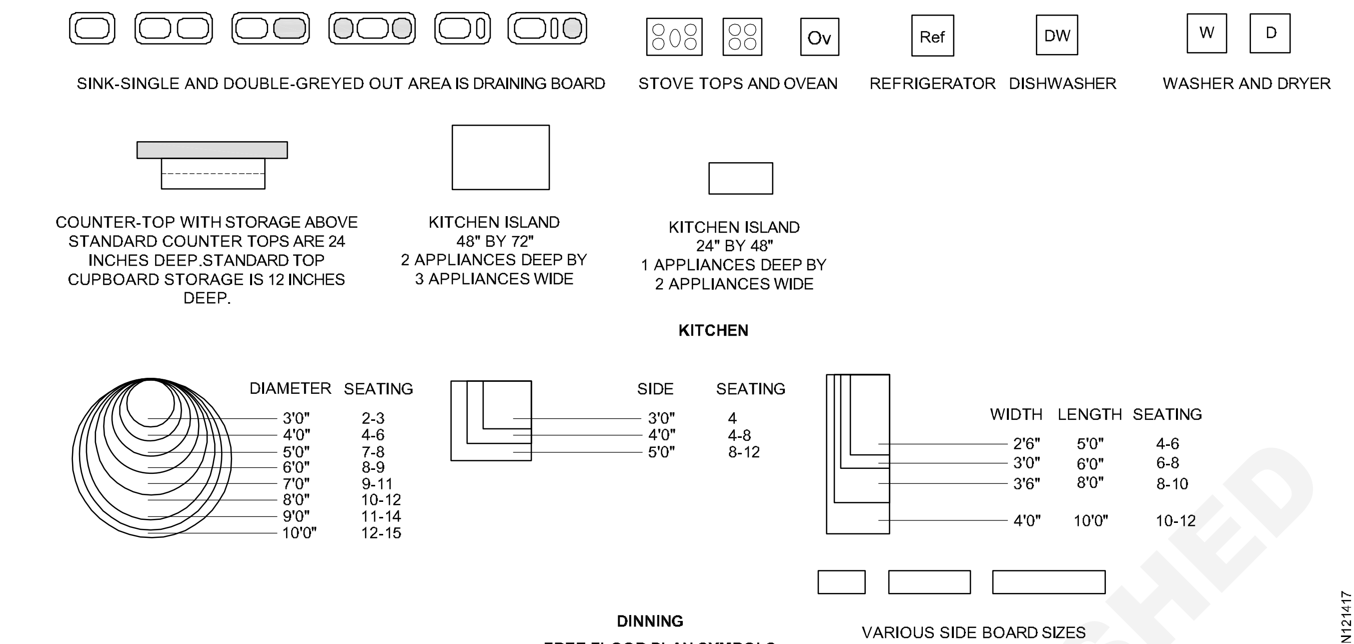


HVAC SYMBOLS

PLUMBING SYMBOLS

DCN12141C

Fig 7



FREE FLOOR PLAN SYMBOLS

Line

Objectives: At the end of this lesson you shall be able to
- **state the types of line**
- **explain the application of different types of lines.**

Introduction

The lines on engineering drawing differ in character and thickness to be read easily and to convey different appropriate messages to the trained eye.

Types of lines

Line	Description	General applications see figure and other relevant figure
A	Continuous thick	A1 Visible outlines A2 Visible edges
B	Continuous thin(straight or curved)	B1 Imaginary lines of intersection B2 Dimension lines B3 Projection lines or extension line B4 Leader lines B5 Hatching B6 Outline of revolved sections in place B7 Short centre lines B8 Thread lines B9 Diagonal line
C	Continuous thin free hand	C1 Limits of partial or interrupted views & sections, if the limit is not a chain thin
C		D1 Line (see figure)
D	Continuous thin (Straight) with zig-zags	
E	Dashed thick	E1 Hidden outlines E2 Hidden edges
F	Dashed thin	F1 Hidden outlines F2 Hidden edges
G	Chain thin	G1 Centre lines G2 Lines of symmetry G3 Trajectors
H	Chain thin, thick at ends & changes of direction	H1 Cutting planes
J	Chain thick	J1 Indication of lines or surfaces to which a special requirement applies
K	Chain thin double dashed	K1 Outlines of adacent parts K2 Alternative and extreme positions of movable parts K3 Centroidal lines K4 Initial outlines prior to forming K5 Parts situated in front of the cutting plane.

Lettering

Objectives: At the end of this lesson you shall be able to
- **state the lettering style**
- **designate the letters and numerals as per IS:962-1989.**

Introduction

1 An engineering drawing not only shows the shape of an object but also describes the size and other specifications necessary for its construction in the form of dimensions and notes.

2 Writing of titles, sub-titles, dimensions, scale and style, if it is in poor lettering, will spoil the appearance of an otherwise acceptable drawing.

3 'Practice makes a man perfect', Practice accompanied by continuous efforts would certainly improve the lettering skill and style

4 B.I. Standards (Bureau of Indian Standards) IS: 962-1989 (lettering for technical drawings) adopted from ISO: 3098/1-1974(E).

The essential features of lettering on engineering drawings are:

1 Legibility

2 Uniformity

3 Rapidity of execution

4 Suitability for micro filming, photographic, re-production, Xeroxing, ammonia printing, etc.

Since time is more important, the lettering should be in plain and simple style so that it can be done in freehand with speed. Single stroke letters satisfy the above requirements.

Letters and numerals are designated by their heights. However, actual sizes used depend upon the size of the drawing and the purpose for which it is intended.

Recommended sizes of letters and numerals

(Table - 6.01)

Items	Size Height in mm
Drawing number in title block and letters denoting cutting plane section	10,12
Title of drawing	6,8
Sub-title and heading	3,4,5,6
Notes, such as legends, schedules,materials list, dimensioning	3,4,5

The standard height for most lettering is 3 mm. For longer drawings a height of 5 mm to 6 mm is recommended. For special notes and title block information uniform lengths of 4 mm, 6 mm and 8 mm can be used.

Uniformity, size and spacing:

1 Lettering must appear neat and pleasing, like, uniformity in height, inclination, spacing and strength of line essential for good lettering. The lettering must be accurate, sharp, dark and easy to read.

2 Horizontal guidelines determine horizontal alignment, lettering height. It determines the spacing between lines of lettering.

3 Vertical guidelines serve to keep the verticality. It keeps proper inclination of freehand characters uniform.

4 In any drawing, only one kind of lettering style must be used. Lower case (small) letters are not generally used, except as symbols.

Dimensioning

Objectives: At the end of this lesson you shall be able to
- **to define Dimensioning.**
- **to dimension the drawings the drawings as per Indian Standard Specification.**

Introduction : It is the numerical representation engineering drawing

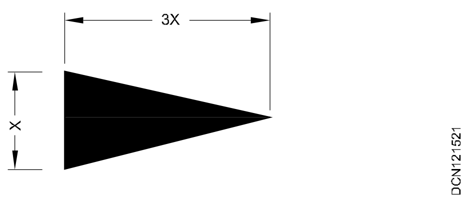
1 Dimensioning plays a predominant role in engineering drawing. It expresses the quantity, adds value and signifies relation to the parts of the diagram. This information is very vital. Without dimension, the meaning of the drawing is lost.

2 Dimensioning is provided in every part of the drawing to provide enough of details, to avoid misconception, confusion, leaving to chance and doubts etc.

3 Dimensioning must be clear and appear only once.

Arrow heads (Fig 1)

Fig 1



Arrowheads are marked at both ends of the dimension lines. The size of the arrowheads should be proportionate to the size of the drawing.

Fig 2

Oblique strike and origing indication

1 Where space is insufficient for arrowheads, oblique's stroke or dot may be used.

2 Oblique stroke is drawn as a short line inclined at 45 Degree. The origin indication is drawn as a small open circle of about 3mm Diameter.

Leader line is a line referring to a feature like dimension object and outline it continuous thin line.

1 If the leader line ends with in outline of an object, it should have a dot at the end.

2 It should have an arrowhead if it ends on the outline of an object.

3 It should terminate without dot or arrowhead if it ends on a dimension line.

Dimensioning method (IS: 11669-1986)

Method 1 (Aligned system) (Fig 2 and Fig 3)

1 The dimensions lines are drawn parallel to the object lines.

2 The dimensions values are placed above the dimensions lines and not by breaking the dimensions lines.

Fig 2

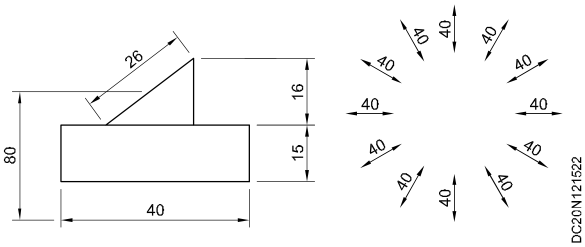
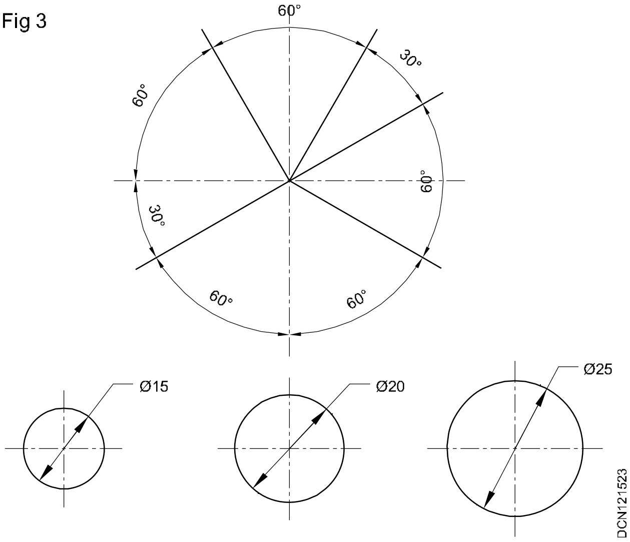


Fig 3



3 The dimensions values are placed near the middle and clear of the dimensions lines.

4 All dimensions are so placed that they can be read from the bottom or the right hand edge of the drawing sheet.

Method 2 (Unidirectional system) (Fig 4)

1 The dimensions lines are drawn parallel to the object lines.

2 The horizontal lines are dimensioned as in method-1

3 Vertical and inclined lines are dimensioned by writing the dimensions value in the gap left in the middle of the dimensions lines.

4 All dimensions are so placed that they can be read from the bottom of the drawing sheet.

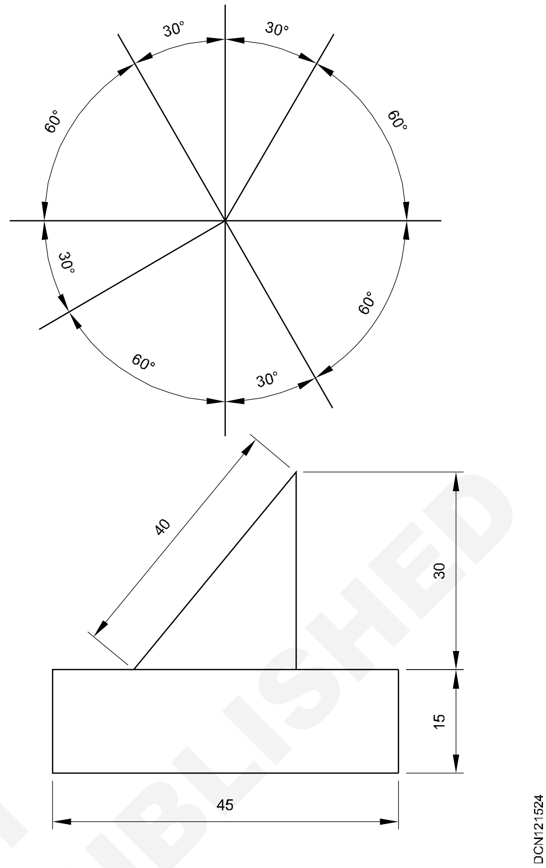
On any one drawing, use only one method of placing the dimensions.

Unit of dimensioning

1 The recommended unit of dimensioning is millimeters. There is no need to add the symbol for the unit e.g. a dimension value 40 means 40mm but a foot-note like "all dimensions in mm" is written in a prominent places.

2 When the dimension is less than 1, a zero should be placed before the decimal point such as 0.75.

Fig 4



Procedure to mark dimensions (Fig 5 and Fig 6)

1 Draw dimensions line parallel to the object line to be dimensioned at about 8 to 10mm from it.

2 Draw projection lines perpendiculars' to the object line. Where necessary, they may be drawn obliquely but parallel to each other.

3 Mark arrowheads at both end is of the dimensions line as per method-1 or method-2

Fig 5

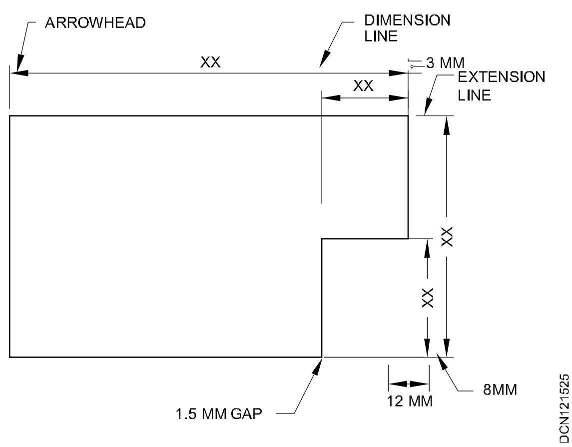
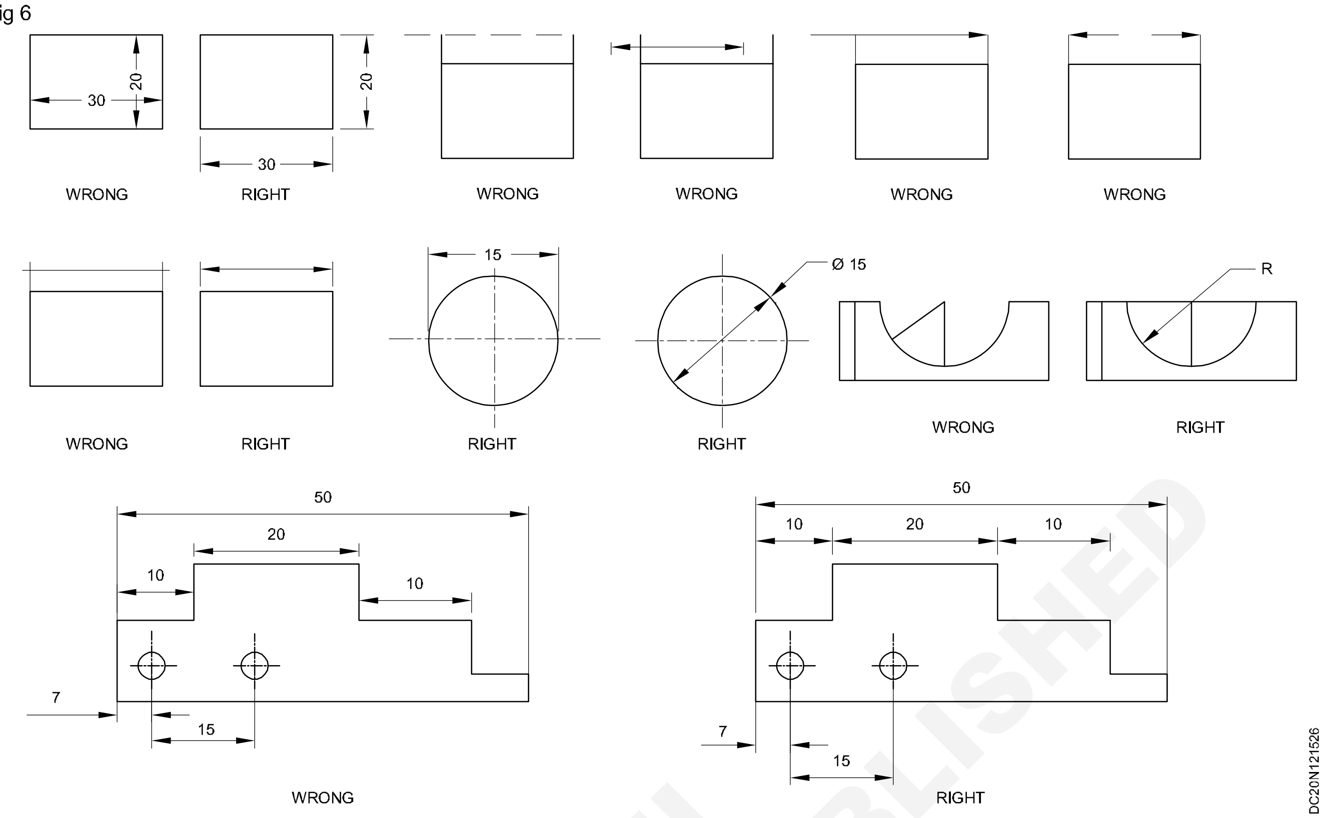


Fig 6



Plane Geometrical construction

Objectives: At the end of this lesson you shall be able to
- **define the terms of most commonly used geometrical shapes.**

Introduction

Geometry is the shape of the object represented as views, how the object will look when it is viewed from various angles, such as front, top, side, etc. Preparation of engineering drawings involves a numbers of geometrical constructions, which are mostly based on plane geometry. Knowledge of various geometrical shapes and their terms are essential, hence, it is necessary to study geometrical constructions.

Important geometrical terms

Triangles

Equilateral, Isosceles and Scalene. (A scalene triangle has three unequal sides).

Quadrilaterals

1 **Square-** All sides equal and all angles right angles.

2 **Rectangle or oblong-** Opposite sides equal and all angles right angle.

3 **Rhombus-** All sides equal, but angles are not right angles.

4 **Rhomboid**- Opposite sides equal and parallel, but angles are not right angles.

5 **Trapezoid**- Only two sides parallel.

6 **Trapezium**- No sides parallel, but may have two of its sides equal. When two of the sides are equal, it is called a trapezium or kite.

Polygons

Regular and irregular; when all sides are equal, it is a regular polygon, otherwise irregular.

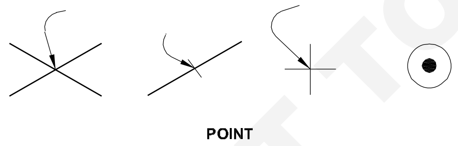
Pentagon- 5 sides; Hexagon- 6 sides; Heptagon- 7 sides; Octagon- 8 sides; Nonagon- 9 sides; Decagon- 10 sides;

Types of Lines and Angles

Objectives: At the end of this lesson you shall be able to
- **define points and lines**
- **state the classification of lines**
- **state the different types of angles**
- **explain the method of measuring angles.**

A point represents a location in space, having no width or height. It is represented by drawing intersection of lines or a dot. (Fig 1)

Fig 1



Line is the path of a point when it moves. It has no thickness and are of two types:

- Straight line
- Curved line

Straight line: It is the path of a point when it is moving in a particular direction. It has only length and no width. (Fig 2) Also a straight line is the shortest distance between two points. Straight line, depending on its orientation are classified as Horizontal, Vertical and Inclined or Oblique line.

Horizontal line (Fig 2)**:** Horizontal lines are those which are parallel to a horizontal plane. Example of horizontal plane is the surface of a still water. (Fig 3)

Fig 2

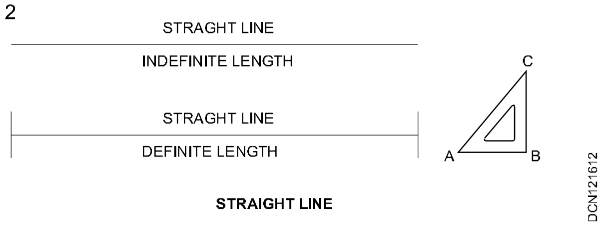
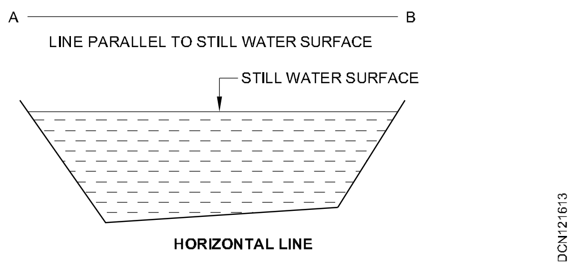


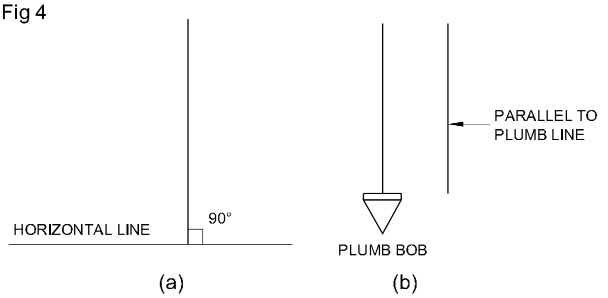
Fig 3



Vertical line (Fig 4a)**:** Lines which are perpendicular to horizontal lines are called vertical lines. It can be treated as a line along the plumb line of the plumb bob or parallel to a plumb line. (Fig 4b)

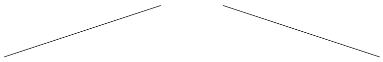
Inclined line or Oblique line: A straight line which is neither horizontal nor vertical is called an inclined line. (Fig 5)

Fig 4



VERTICAL LINE

Fig 5



INCLINED OR OBLIQUE LINE

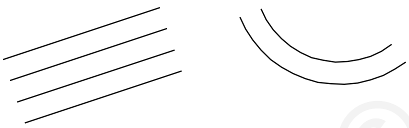
Curved line: It is the path of a point which always changes its direction. Examples of curved lines are shown in Fig 6.

Fig 6

CURVED LINES

Parallel lines: They are the lines with same distance between them. They may be straight lines or curved lines. Parallel lines do not meet when extended. (Fig 7)

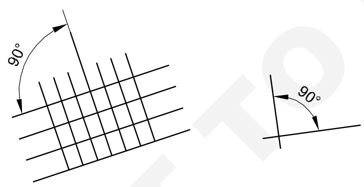
Fig 7



PARALLEL LINES

Perpendicular lines: When two lines meet at 90^{o}, the two lines are said to be perpendicular to each other. One of this line is called as reference line. (Fig 8)

Fig 8



PERPENDICULAR LINES

Angles: Angle is the inclination between two straight lines meeting at a point or meet when extended. AB and BC are two straight lines meeting at B. The inclination between them is called an angle. The angle is expressed in degrees or radians.

Concept of a degree: When the circumference of a circle is divided into 360 equal parts and radial lines are drawn through these points, the inclination between the two adjacent radial lines is defined as one degree. Thus a circle is said to contain 360^{o}. (Fig 9)

Acute angle: If an angle which is less than 90^{o} is called an acute angle. (Fig 10)

Right angle: Angle between a reference line and a perpendicular line is called right angle. (Fig 11)

Fig 9

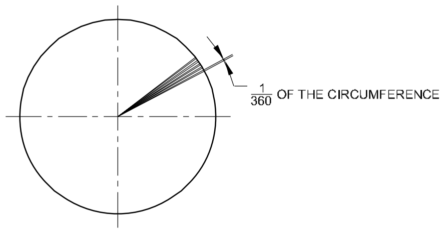
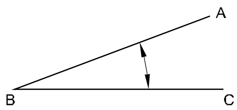
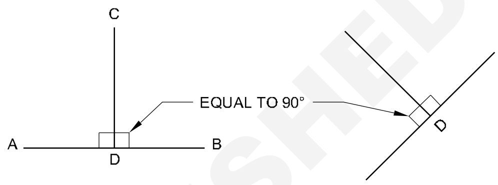


Fig 10



ACUTE ANGLE

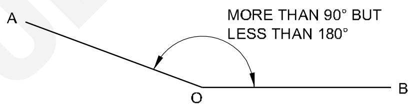
Fig 11



RIGHT ANGLE

Obtuse angle: This refer to an angle between 90^{o} and 180^{o}. (Fig 12)

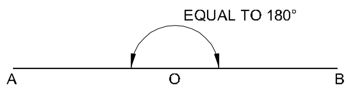
Fig 12



OBTUSE ANGLE

Straight angle: This refers to an angle of 180^{o}. This is also called as the angle of a straight line. (Fig 13)

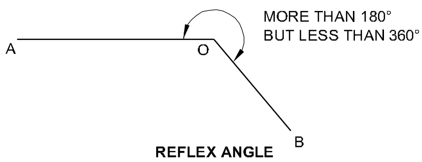
Fig 13



STRAIGHT ANGLE

Reflex angle: It is the angle which is more than 180^{o}. (Fig 14)

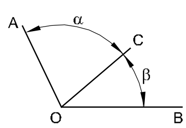
Fig 14



REFLEX ANGLE

Adjacent angles: These are the angles lying on either side of a line. (Fig 15)

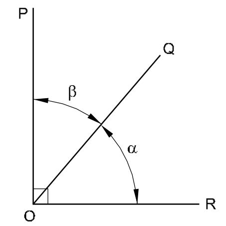
Fig 15



ADJACENT ANGLES

Complementary angles: When the sum of the two angles is equal to 90°, angle POQ + angle QOR = 90° angle POQ and angle QOR are complementary angles to each other. (Fig 16)

Fig 16

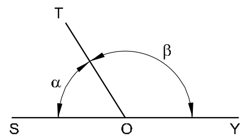


COMPLEMENTARY ANGLES

Supplementary angle: When the sum of the two adjacent angles is equal to 180°, example angle SOT + angle TOY = 180°, angle SOT and angle TOY are supplementary angles to each other. (Fig 17)

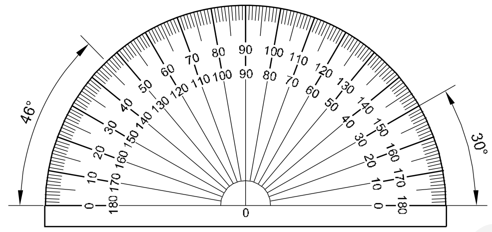
Protractor: Protractor is an instrument for measuring angles. It is semi-circular or circular in shapes and is made of flat celluloid sheet. The details of graduation in a semi-circular protractor is shown in figure 18.

Fig 17



SUPPLEMENTARY ANGLES

Fig 18



The angles can be set or measured from both sides, aligning the reference line and point `0' with the corner point of the angle.

Figure 18 shows how to read or set the angle. Protractor can also be used to divide a circle or drawing sectors.

Triangles and their types

Objectives: At the end of this lesson you shall be able to
- **define triangles**
- **name the different types of triangles and state their properties.**

Triangle is a closed plane figure having three sides and three angles. The sum of the three angles always equals to 180°.

To define a triangle, we need to have a minimum of three measurements as follows:

– 3 sides or

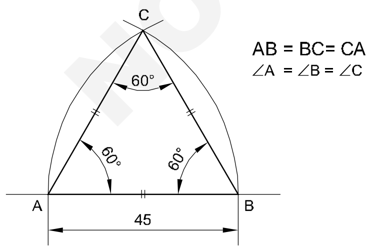
– 2 sides and one angle or

– 2 angles and one side

Types of triangles

– **Equilateral triangle** is a triangle having all the three sides equal. Also all the three angles are equal (60°) (Fig 1)

Fig 1



– **Isosceles triangle** has two of its sides equal. The angles opposite to the two equal sides are also equal. (Fig 2)

– **Scalene triangle** has all the three sides unequal in lengths. All the three angles are also unequal. (Fig 3)

Fig 2

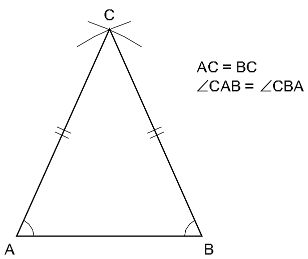
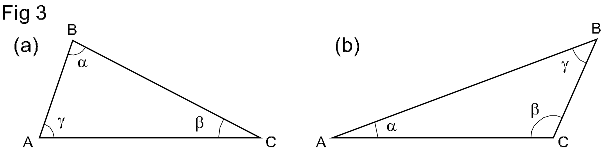
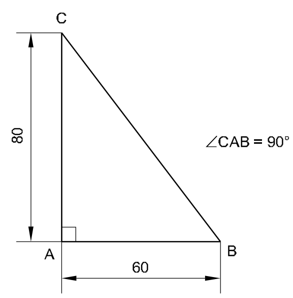


Fig 3



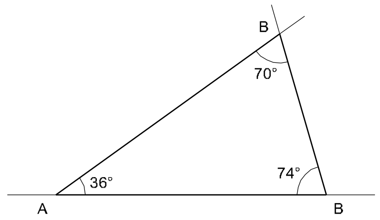
– **Right angled triangle** is one in which one of the angles is equal to 90° (Right angle). The side opposite to right angle is called hypotenuse. (Fig 4)

Fig 4



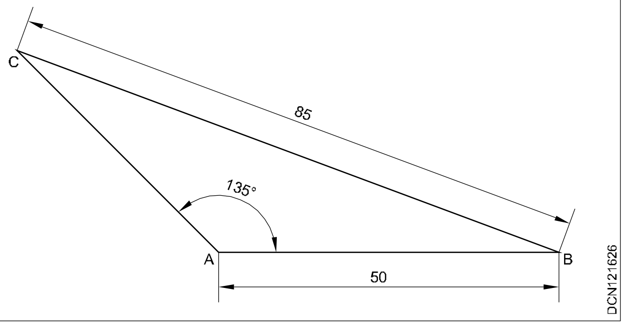
– **Acute angled triangle** is one in which all the three angles are less than 90°. (Fig 5)

Fig 5



– **Obtuse angled triangle** has one of the angles more than 90°. (Fig 6)

Fig 6



The sum of the three angles in any triangle is equal to 180°.

The sum of any two sides is more than the third side.

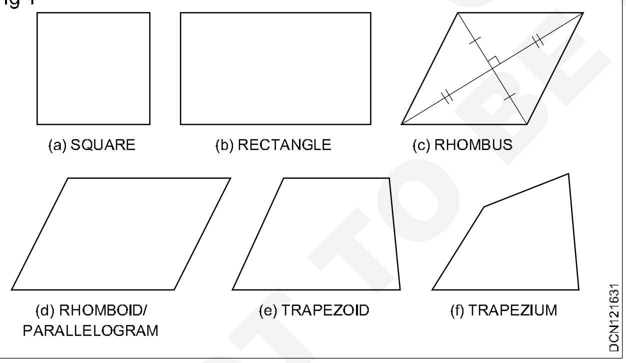
Quadrilaterals and their properties

Objectives: At the end of this lesson you shall be able to
- **define a quadrilateral**
- **name the quadrilaterals**
- **state the properties of quadrilaterals.**

Quadrilateral is a plane figure bounded by four sides and four angles. Sum of the four angles in a quadrilateral is of interior angles is equal to 360°. The side joining opposite corners is called diagonal. To construct a quadrilateral out of four sides, four angles and two diagonals a minimum of five dimensions are required of which two must be sides. Quadrilaterals are also referred as Trapezoid.

Types of quadrilaterals. (Fig 1)

Fig 1



– Square
– Rectangle
– Rhombus
– Rhomboid/Parallelogram
– Trapezoid
– Trapezium

Square : In a square all the four sides are equal and its four angles are right angles. The two diagonals are equal and perpendicular to each other.

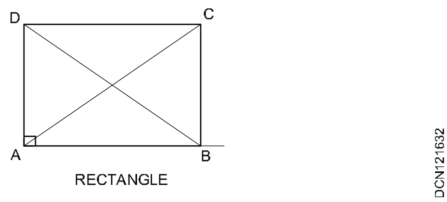
To construct a square we need to know (a) length of the side or (b) length of the diagonal.

Rectangle (Fig 2)**:** In a rectangle, opposite sides are equal and parallel and all four angles are right angles.

To construct a rectangle we need to know the length (a) two adjacent sides or (b) diagonal and one side.

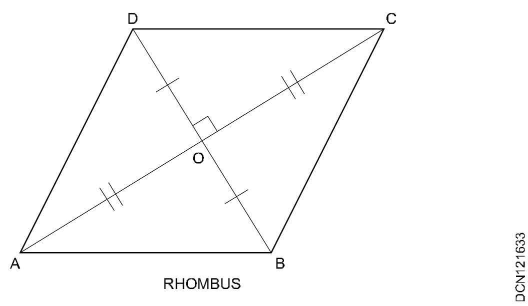
Fig 2 shows a rectangle ABCD. Sides AB = DC and BC = AD. Diagonals AC and BD are equal, bisect but not at right angles.

Fig 2



Rhombus (Fig 3)**:** In rhombus all the four sides are equal, but only the opposite angles are equal. ABCD is the rhombus where AB = BC = CD = AD.

Fig 3



Angle ABC = Angle ADC and Angle BAD = Angle BCD.

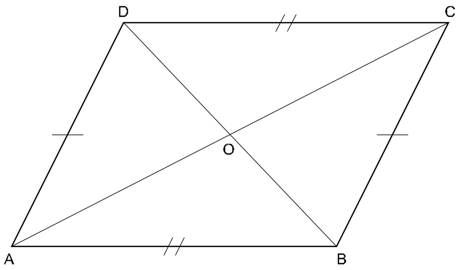
Diagonals AC and BD are not equal but bisecting at right angles.

AO = OC and BO = OD.

To construct a rhombus we need to know (a) two diagonals (b) one diagonal and an opposite angle or (c) one side and its adjacent angle.

Rhomboid/Parallelogram (Fig 4)**:** In a parallelogram opposite sides are equal and parallel. Opposite angles are also equal. Diagonals are not equal but bisect each other.

Fig 4



RHOMBOID / PARALLELOGRAM

Parallelogram is also known as rhomboid. To construct a parallelogram we need (a) two adjacent sides and angle between them or (b) one side, diagonal, and angle between them or (c) two adjacent sides and perpendicular distance between the opposite sides.

In the parallelogram ABCD, AB = DC; AD = BC

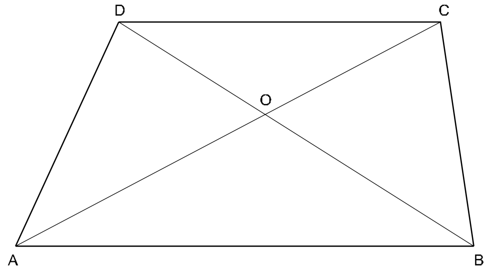
Angle DAB = angle DCB, angle ABC = angle ADC

Sides AB,CD and AD, BC are parallel.

Diagonals AC and BD are not equal but bisect at 0.

Trapezoid (Fig 5)**:** It is a quadrilateral, all the four sides are different and only two sides are parallel, all the four angles are different. The diagonals do not bisect at right angles.

Fig 5



TRAPEZOID

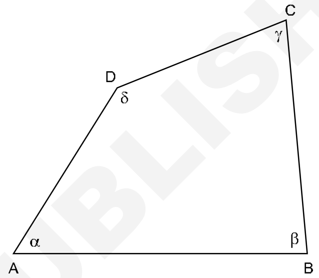
ABCD is a trapezoid, sides AB and DC are parallel but not equal.

Diagonals AC and BD and AO = OC need not be equal.

Sides AD and BC may sometimes equal.

Trapezium (Fig 6)**:** It is a plane figure of 4 sides, and any two sides equals to each other.

Fig 6



TRAPEZIUM

Polygon and their properties

Objectives: At the end of this lesson you shall be able to
- **define a polygon**
- **name the polygon in terms of the number of sides**
- **state the properties of polygon.**

Polygon is a plane figure bounded by many (usually five or more) straight lines. When all the sides and included angles are equal, it is called as a regular polygon.

Names of polygons: Polygons are named in terms of their number of sides as given below: (Fig 2)

Name	No. of sides
Pentagon	Five sides
Hexagon	Six sides
Heptagon	Seven sides
Octagon	Eight sides
Nonagon	Nine sides
Decagon	Ten sides
Undecagon	Eleven sides
Dadecagon	Twelve sides

Fig 1

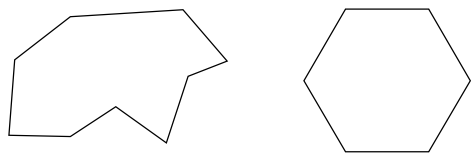
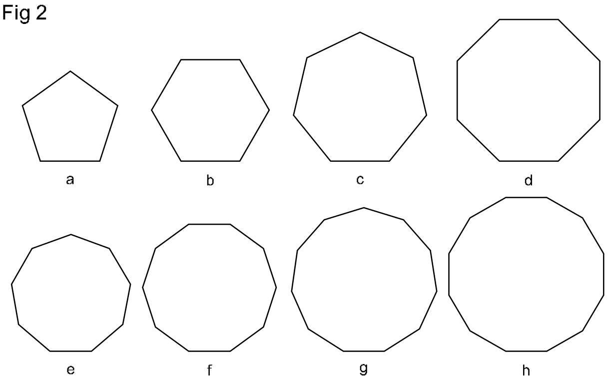


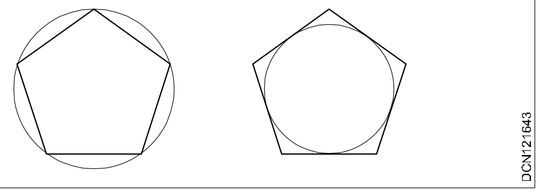
Fig 2



Properties of polygon

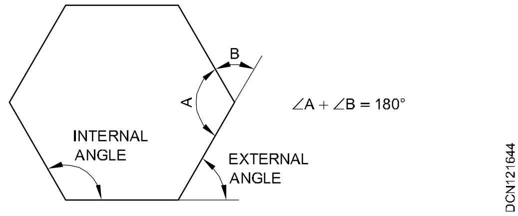
- All corners of a regular polygon lie on the circle. The sides of a regular polygon will be tangential to the circle drawn in side. (Fig 3)

Fig 3



- The sum of the interior angles of a polygon is equal to (2 x n - 4) x rt angle, where n is the number of sides.
- The sum of exterior angles of a polygon is equal to 360°.
- The sum of the interior angle and the corresponding external angle is 180°. (Fig 4)

Fig 4



Circles

Objectives: At the end of this lesson you shall be able to
- **state what is a circle**
- **name its elements**
- **state the function of a compass**
- **explain concentric and eccentric circles.**

Circle: Circle is a plane figure bound by a curve, formed by the locus of a point which moves so that it is always at a fixed distance from a stationery point the "Centre".

Radius: The distance from the centre to any point on the circle is called the "Radius".

Diameter: The length of a straight line between two points on the curve, passing through the centre is called the "Diameter", D: Dia or d. It is twice the radius.

Circumference: It is the linear length of the entire curve, equal to πD

Arc: A part of the circle between any two points on the circumference or periphery is called an 'Arc'.

Chord: A straight line joining the ends of an arc is called the chord. (Longest chord of the circle is the diameter)

Segment: A part of the circle or area bound by the arc and chord is the segment of the circle.

Sector: It is the part of a circle bounded by two radii (plural of radius) meeting at an angle and an arc.

Quadrant: Part of a circle with radii making 90° with each other is a quadrant (one fourth of the circle).

Half of the circle is called as semi-circle.

Tangent of a circle is a straight line just touching the circle at a point. It does not cut or pass through the circle when extended. The point where the tangent touches the circle is called the "point of tangency". The angle between the line joining the centre to the point of tangency and the tangent is always 90°.

Fig 1 shows all the above elements.

Concentric circles: When two or more circles (drawn) having common centre, they are called concentric circles. Ball bearing is the best example of concentric circles. (Fig 2)

Fig 1

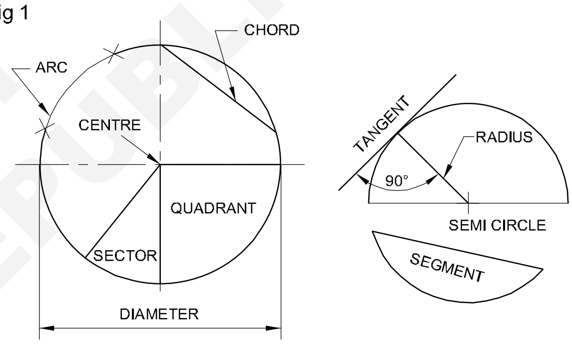
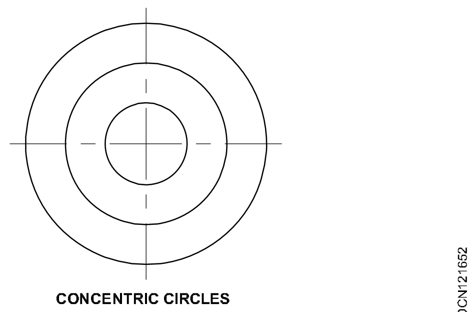


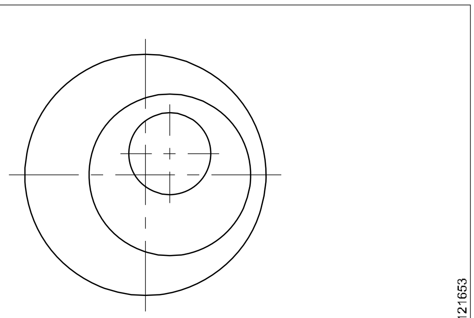
Fig 2



CONCENTRIC CIRCLES

Eccentric circles: Circles within a circle but with different centres are called eccentric circles. (Fig 3)

Fig 3



ECCENTRIC CIRCLES

Types of scales

Objectives: At the end of this lesson you shall be able to
- **state the necessity of scales**
- **explain representative fraction (RF)**
- **list the types of scales**
- **explain plain, comparative scales, scale of chords, diagonal scale and vernier scale.**

Inroduction : The drawings prepared proportionately to the smaller or larger size than the actual size, are said to be made to a scale. Scale of a drawing may be defined as the ratio of linear dimension of the same object. Scales used in engineering practice are available in sets of 8 or 12 scales. Same times the required scale will not be available. Then, it is necessary to construct a new scale. So the scales are used to prepare a drawing at a full size, reduced size or enlarged size.

Representative fraction : Representative fraction may be defined as the ratio of the distance between any two points of the object on a drawing to the actual distance between the same points of the object and it is abbreviated as R.F.

Mathematically,

R.F= distance on drawing/Distance on object

Reducing scale

An actual length of 5m of a room is represented by 25 mm length on drawing. Then,

R.F= distance on drawing/Distance on object

= 25mm/5m

=

= 1/200

Scale of drawing is 1:200

Enlarging scale

An actual length of a typical terminal strip of 10mm is represented by 50mm length on drawing. Then,

R.F. = Distance on drawings / Distance on object

= 50mm/10mm

$25/5 \times 100 \times 10$

= 5/1

Scale of drawing is 5:1.

Full scale

An actual length of an electrical switch board of length 30 mm, is represented by a 30mm length on drawing. Then,

R.F.= Distance on drawing/Distance on object

= 30mm/30mm

= 1/1

Scale of drawing is 1:1.

Scales used to scale drawn large parts in engineering drawings and architecture

1:40 1:100

1:50 1:150

1:65 1:200

1:80

Typical scales for site plan. Units in m.

1:500 1:5000

1:1000 1:10000

1:2000 1:20000

Scales used in surveys. Units in m.

1:50000 1:200000

1:100000 1:50000

Scale used in maps. Units in m.

1:1000000

Recommended scales

Scales recommended for use on engineering drawings are given below-

Full Scale	Reduced scale	Enlarged Scale
1:1	1:2	10:1
	1:2.5	5:1
	1:5	2:1
	1:10	
	1:20	
	1:50	
	1:100	
	1:200	

Civil Engineers and Architects generally use reduced scales while Mechanical and Electrical Engineers use both reduced and enlarged scales according to the need of the problems.

Metric measurements

10 millimeters (mm)	1 centimeter (cm)
10 centimeters (cm)	1 decimeter (dm)
10 decimeters (dm)	1 meter (m)

10 meters (m)	1 decameter (dam)
10 decameters (dam)	1 hectometer (hm)
10 hectometers (hm)	1 kilometer (km)

Types of scales

- Plain scale
- Diagonal scale
- Vernier scale
- Comparative scale
- Scale of chords (for angles)

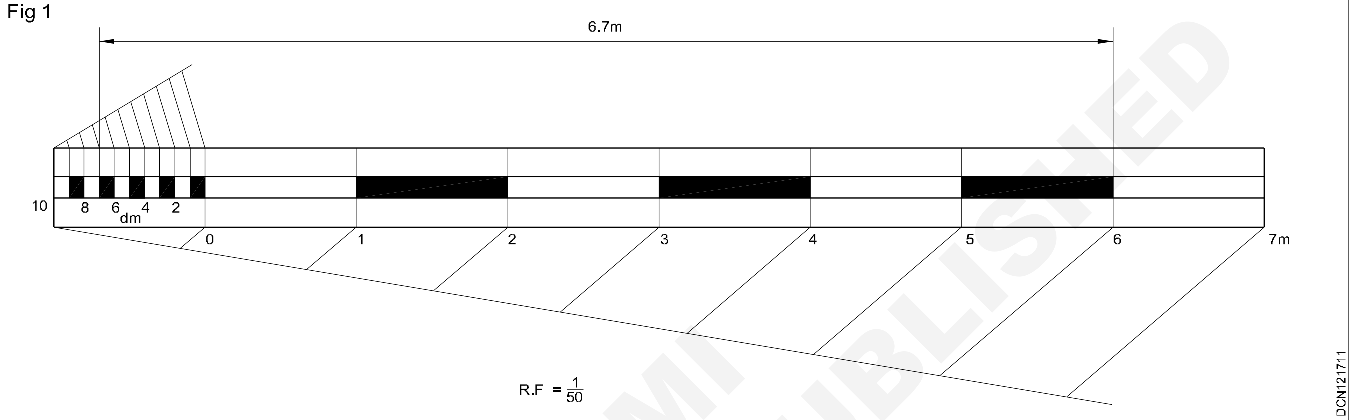
To construct a scale the following information is essential

RF of the scale

- Units which it must represent example mm, cm, m, ft inches etc.
- the maximum length it must show
- Minimum length of the scale = RF x the maximum length required to be measured.

Plain scales (Fig 1)**:** Scales are drawn in the form of rectangle, of length 15 cm (can be upto 30 cm) and width 5 mm. It is divided into suitable number of parts. The first part of the line is sub-divided into smaller units as required.

Fig 1



Every scale should have the following salient features:

- The zero of the scale is placed at the end of the first division from left side.
- From zero, mark further divisions are numbered towards right.
- Sub-divisions are marked in the first division from zero to left side.
- Names of units of main divisions and sub divisions should be stated/printed below or at the end of the divisions.
- Indicate the `RF' of the scale.

Example of construction of a plain scale to measure metres and decimetres. RF = $\frac{1}{50}$ and to measure upto 8 metres. Minimum standard length of scale = 15 cm.

The length of the scale = RF x maximum length to be measured = $\frac{1}{50} \times 8 \times 100\text{ CM} = 16\text{ CM}.$

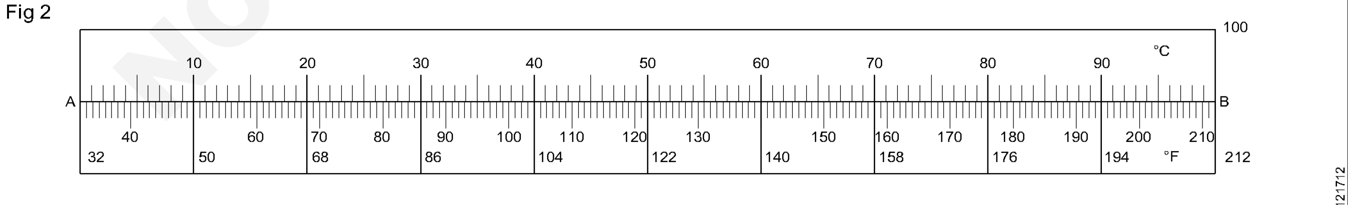
Length of 16 cm is divided into 8 equal parts or major divisions each representing one metre. If each major division is divided into 10 sub-divisions each sub-division will represents one decimetre.

A distance of 6.7 m will be shown as in the Fig 1.

Comparative scales (Fig 2)**:** Comparative scale is a graphical device to compare or convert one variable into another. It compares two similar units in different systems. For example meters, yards, kilometers, miles, temperature in degrees, centigrades and Fahrenheit etc.

Fig 2 shows the construction of a comparative scale to convert Fahrenheit (F) into Celsius (Centigrade-C) and Celsius into Fahrenheit.

Fig 2



COMPARATIVE SCALE

- The line AB (15 cm) is divided equally into 10 equal parts.
- Division on the top side of the scale is divided into 10 equal sub-divisions. Each sub-division is representing 1°C.
- Division on the bottom side of the scale is divided into 18 equal sub-divisions. Each sub-division is called 1°F.
- Datum of 'F' side scale is starting with 32°F instead of 0.

- Conversion from °C to F or vice-versa can be found out directly from the scale.

  10°C equivalent reading of F scale = 50°F

  25°C equivalent reading of F scale = 77°F

For the verification of the conversion using the scale use the following formulae.

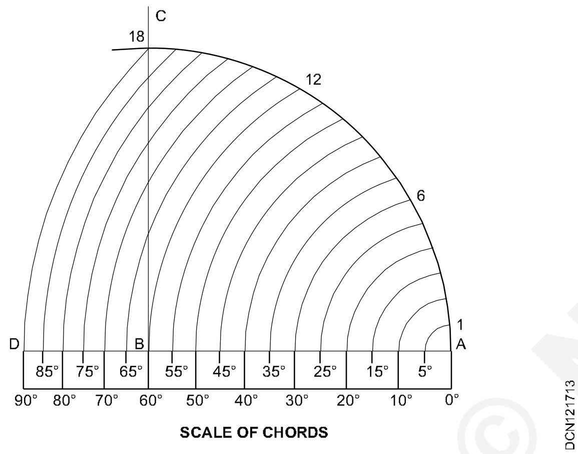
$C = (F - 32) \times \frac{5}{9}$

$F = (C \times \frac{9}{5}) + 32$

Scale of chords (Fig 3)**:** It is different from conventional linear scales. It is used to construct angles in the absence of a protractor, so called as a scale to measure or set angles or degrees. There is no rigid length of scale, so any convenient length can be taken to construct it.

Fig 3 shows the method of constructing the scale of chords.

Fig 3



- Draw a quadrant ABC and extend AB.
- A as centre, AC as radius, draw an arc CD.
- AD is the chord of arc AC.
- Divide the arc AC into 18 equal parts and each part is 5°.

– A as centre, draw arcs with radius. A1, A2, A3.....A18 to intersect line DA and mark them 5°, 10°.....90°.

Diagonal scale: Plain scales cannot be used for taking smaller measurement. The distance between the consecutive divisions on a plain scale, at best can only be 0.5 mm. In other words, the smallest measurement that can be taken. Using a plain scale of RF 1:1 is 0.5 mm. If the RF of a plain scale is 1:5, the smallest measurement such a scale can take is 2.5 mm (0.5 mm x 5).

To overcome this limitation two different types of scales are employed. They are

- Diagonal scale
- Vernier scale

Principle of diagonal scale: Diagonal scale relies on a "diagonal" to divide a small distance into further equal parts.

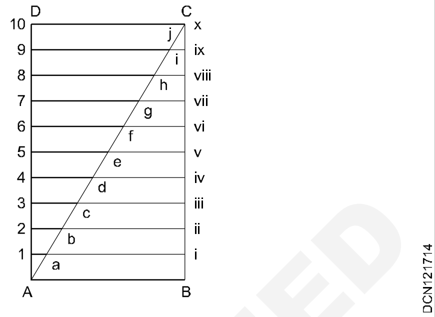
Principle of diagonal scale is based on the principle of similar triangles.

***Example*:** A small distance AB is to be divided into 10 equal parts using diagonal scale.

AB is the line to be divided into 10 equal parts.

Diagonal scale is shown in the Figure 4.

Fig 4



Side AD is the line to be divided into 10 equal parts 1 to 10. Parallel lines are drawn to AB from points 1,2.....10.

Join one of the diagonal AC.

Join parallel line cuts the diagonal at a,b.....j.

Distance 1 - a is $\frac{1^{th}}{10}$ of AB = 0.1 AB

Distance 2 - b is $\frac{2^{th}}{10}$ of AB = 0.2 AB

Distance a - i is $\frac{9^{th}}{10}$ of AB = 0.9 AB

Distance b - ii is $\frac{8^{th}}{10}$ of AB = 0.8 AB

If AB is 1 mm then 1 - a will be 0.1 mm and 2 - b will be 0.2 mm.

Similarly a - i will be 0.9 mm and c - iii will be 0.7 mm.

Parallel lines on both sides of the diagonal can be considered for measurement.

Vernier scale (Fig 5)**:** As stated earlier vernier scales are yet another means of dividing a small dimension into a number of equal parts so as to facilitate taking smaller measurements than is possible by plain scales.

Vernier scale consists of two parts - secondary scale or vernier scale (VS) and primary scale or main scale (MS).

The smallest measurement that can be taken on the main scale is called main scale division (MSD).

Least count of the vernier scale is the fraction of the main scale division upto which the measurement can be taken.

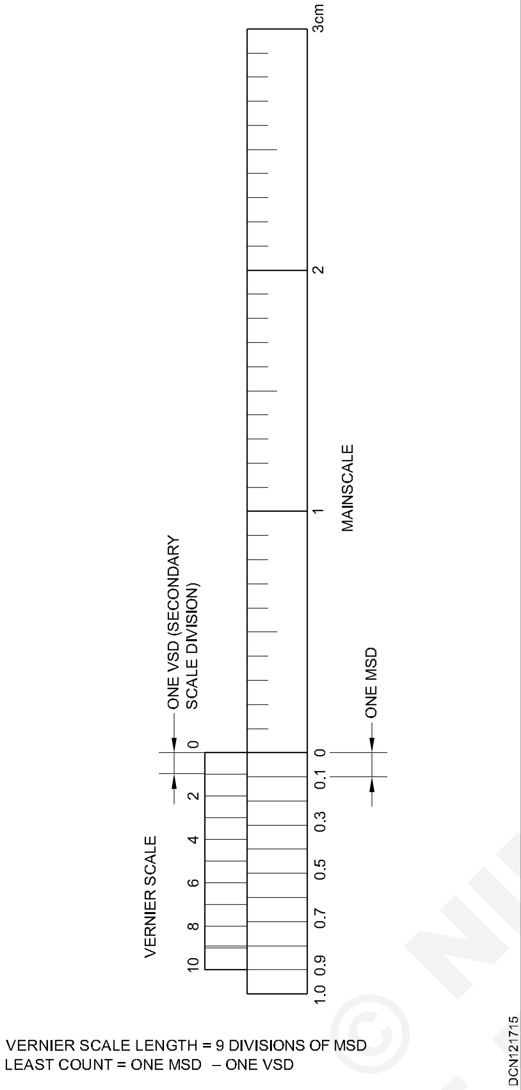
To arrive at the fraction of MSD, imaginarily MSD is divided into a number of equal parts (n)

$$n = \frac{\text{MSD}}{\text{Fractional part of msd}}$$

The length of the secondary scale depend upon the MSD and number of divisions (n) we have decided to make.

If one MSD is to be divided into 'n' parts, the length of the secondary scale (vernier) will be equal to the length of either (n-1) or (n + 1) parts of MSD.

Fig 5



Length of the secondary scale is divided into 'n' equal parts.

Thereby one secondary scale (vernier) division is equal to $\frac{(n-)\,MDC}{N}$ OR $\frac{(n+1)MSD}{N}$ as the case may be.

Direct or forward vernier: Vernier scale is the scale constructed having n - 1 numbers of MSD as the secondary scale (vernier) length. (Fig 6)

Fig 6

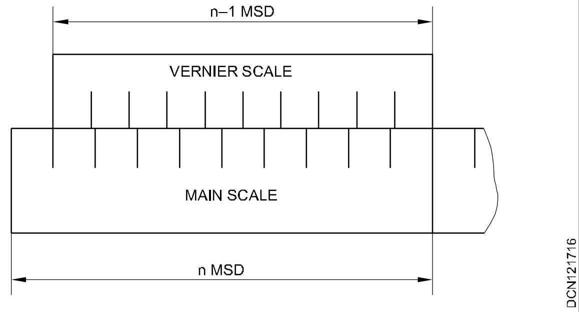
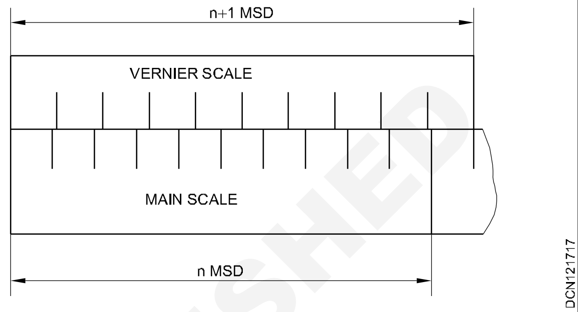


Fig 7



Retrograde or backward vernier: Vernier scale is the scale having n + 1 numbers of MSD as the secondary scale (vernier) length. (Fig 7)

According to Direct reading vernier

1 Main scale division - 1Secondary scale division (vernier) $= \frac{1}{n}$MSD

1 cm - $\frac{9}{10}$ $= \frac{1}{10}$CM

According to backward reading vernier

1 Secondary division (vernier) - 1 Main scale division $= \frac{1}{n}$MSD

1.1 cm - 1.0 cm $= \frac{1}{10}$CM

MSD is the least count of the vernier scale

Example on direct reading vernier scale : Construct a directing reading scale with one MSD = 2 mm, Least count = 0.25 mm.

Building stones

Objectives: At the end of this lesson you shall be able to
- **define rock and building stone**
- **explain the characteristics of good building stones**
- **classify the rocks**
- **identify type of stones available in India**
- **explain testing of stone.**

Definition: The soldified definite portion of earth's surface has not definite chemical composition and shape is called rock.

The quarried pieces of rock which is using for engineering purpose are called stone.

Characteristics of a good stone : To find the suitability of stones under different conditions, the following characteristics should be considered.

Appearance and colour: Have the ability to receive good polish, a pleasing colour and be free from cracks and spots.

Weight: A heavy stone possesses more compactness and less porosity.

Porosity and absorption: If it present in greater extent it makes the unsuitable for building construction.

Fineness of grain: Fine grained stone are suitable for molding works.

Compactness: Compact stone can with stand the effects of external agencies effectively.Durability of stone is decided by their compactness or density of composition.

Resistance to fire: Should have homogeneous composition and be free from calcium carbonate or oxide of iron.

Electrical resistance: The stone must be non-absorbent like slate.

Hardness and toughness: To resist wear and tear, the stone must be adequately hard and tough. Hardness may be tested by scratching with a pen knife and toughness tested by hammer.

Strength: The crushing strength of stone should be greater them 100N/mm2. All igneous rocks have around 100N/mm2and same of the metamorphic rocks also satisfy this requirement. Sedimentary rock has a low strength.

Specific gravity: For docks, harbors, gravity dams etc stones should have a high specify gravity, not less 2.6.The more specify gravity; more will be the weight of the stone for a given volume.

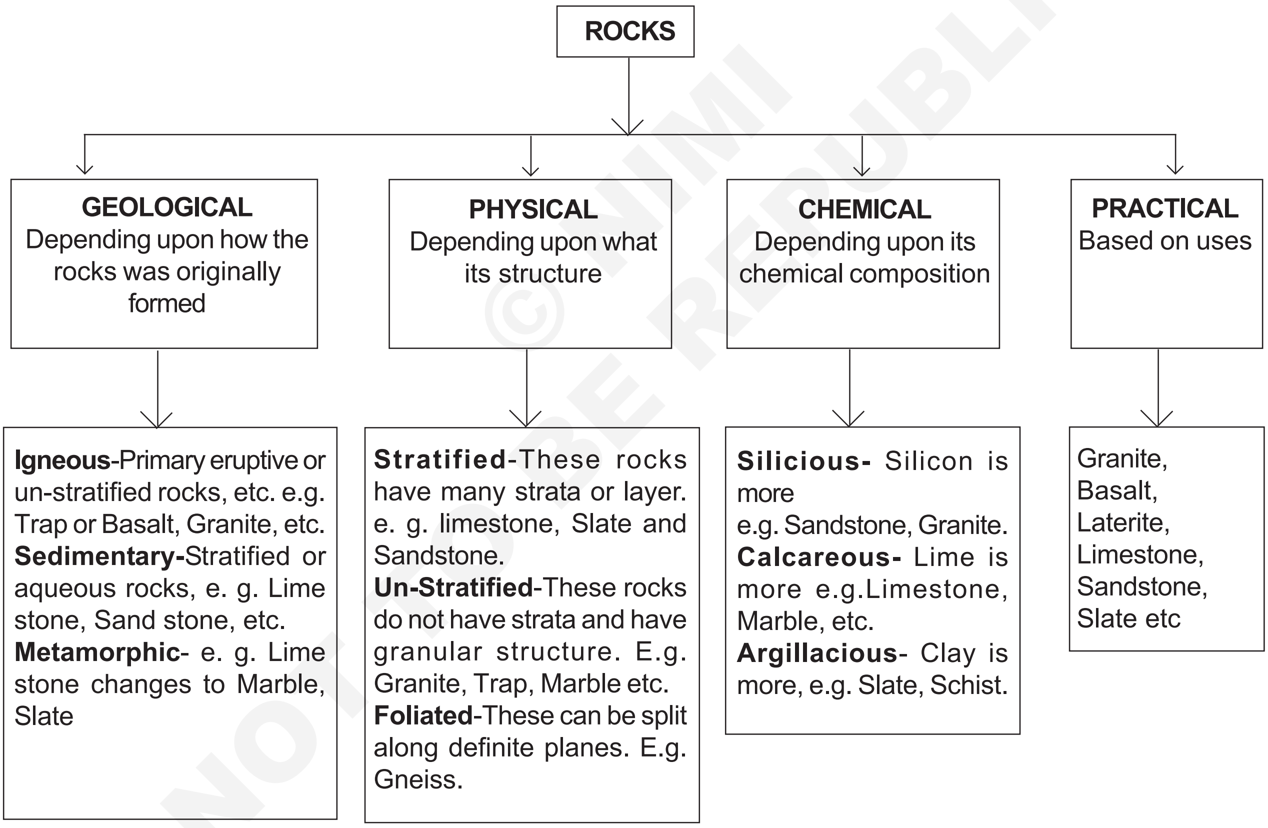
Durability: A stone is more durable, if it is compact, homogeneous and free from any Materials affected, also have negligible water absorption.

Dressing: Stone should possess uniform texture and softness if it is to hard, finish will be poor and dressing uneconomical

Cost: An important consideration in the selection of building stone.

Seasoning: Stone must be free from quarry sap, after quarrying and dressing, stone should be left for a period of 6-12 months for proper seasoning.

Classification of rocks



Types of Rocks : Rocks may be classified in the following three ways:

1 Geological 2 Physical 3 Chemical

Geological Classification : Based on their origin of formation stones are classified into three main groups- igneous, sedimentary and metamorphoic rocks.

Igneous rocks: These rocks are formed by cooling and solidifying of the rock masses from their molten magmatic condition of the material of the earth. Generally igneous rocks are strong and durable. Granite, trap and basalt are the rocks belonging to this category, Granites are formed by slow cooling of the lava under thick cover on the top. Hence they have crystalline surface. The cooling of lava at the top surface of earth results into non-crystalline and glassy texture. Trap and basalt belong to this category.

Sedimentary rocks : Due to weathering action of water, wind and frost existing rocks disintegrates. The disintegrated material is carried by wind and water, the water being most powerful medium. Flowing water deposits its suspended Materials at some points of obstacles to its flow. These deposited layers of Materials get consolidated under pressure and by heat. Chemical agents also contribute to the cementing of the deposits. The rocks thus formed are more uniform, fine grained and compact in their nature.

They represent a bedded or startified structure in general. Sand stones, lime stones, mud stones etc. belongs to this class of rock.

Metamorphic rocks: previously formed igneous and sedimentary rocks under go changes due to metamorphic action of pressure and interanl heat. For example due to metamorphic action grainte becomes gneiss, trap and basalt changes to schist and laterite, lime stone changes to marble, sand stone becomes quartizite and mud stone becomes slate.

Physical Classification

Based on the structure, the rocks may be classified as:

1. Stratified rocks 2. Unstratified rocks

Stratified rocks : These rocks are having layered structure. They posses planes of stratification or cleavage. They can be easily split along these planes. Sand stones, slate etc. are the examples of this class of stones.

Unstratified rocks: These rocks are not stratified. They possess crystalline and compact grains. They cannot be split in to thin slab. Granite, trap, marble etc, are the examples of this type of rocks.

Foliated Rocks : These rocks have a tendency to split along a definite direction only. The direction need not be parallel to each other as in case of stratified rocks.

Chemical classification

On the basis of their chemical composition engineers prefer to classify rocks as:

Silicious rocks, Argillaceous rocks and Calcareous rocks

Silicious rocks : The main content of these rocks is silica. They are hard and durable. Examples of such rocks are granite,, traps and quartzines etc.

Argillaceous rocks: The main constituent of these rocks is argil i.e., clay. These stones are hard and durable but they are brittle. They cannot withstand shock. Slates and laterites are examples of this type of rocks.

Calcareous rocks: The main constituent of these rocks is calcium carbonate. Limestone is a calcareous rock of sedimentary origin while marble is a calcareous rock of metamorphic origin.

Table

Common building stones of India

Stones	Rocks	Charactistics	Uses	Places
Basalt and Trap	Igneous	Hard and tough; difficult to work Its sp. gravity is 3 and compressive strength varies from 1530 to 1890 kg/cm^2. Its weight varies from 1800 to 2900 kg/m^3	Road metal, for rubble masonry, foundation work, etc.	Maharashtra, Bihar, Gujarat, Bengal. And M.P.
Chalk	Sedimentary	Pure white limestone soft and easy to from powder.	In preparing glazier's putty: as colouring material in manufacture of Portland cement.	Maharashtra, Bihar, Gujarat, Bengal. Punjab, Rajasthan, M.P, Andaman- Island U.P.& H.P.
Gneiss	Metamorphic	Splits into thin slabs easy to work .Its sp. Gravity is 2.69 and compressive strength is 2100kg/cm^2.	Street paving, rough stone masonry work, etc.	Madras, Mysore, Bihar, A.P, Maharashtra, Bengal, Kerala, Gujarat
Granite	Igneous	Hard, durable and available in different colours, highly resistant to natural forces, can take nice polish. Its Sp. gravity Varies from 2.6 to 2.7 and compressive strength varies from 770 to 1300 kg/cm^2. Its weight is about 2600 to 2700 kg/m^3.	Steps, sills, facing walls work bridge piers, columns, road metal, ballast, etc. It is unsuitable for carving.	Kashmir, Madras, Punjab, Rajasthan, U.P, M.P, Mysore, Assam, Bengal, Bihar, Orissa, Kerala, & Gujarat.
Kankar	Sedimentary	Impure limestone	Road metal, manufacture of hydraulic lime, etc.	North & central India.

	Metamorphic	Porous and spongy structure, easily quarried in blocks. Contains high percentage of Oxide of iron; available in different colours. Its compressive strength various from 18 to 32 kg/cm^2.	Building stone, road metal, rough stone, masonry work. etc.	Bihar, Orissa, Mysore, M.P., Maharashtra, Kerala, A.P., & Madras.
Lime Stone	Sedimentary	Consist of carbonate of lime easy to work Its Sp. gravity various from 2.00 to 2.75 and compressive strength is 550 kg/cm^2.	Floors steps , walls, road metal,manufacture of lime in blast furnace etc.	Maharashtra, Bihar, Gujarat, Bengal. Punjab, Rajasthan, M.P, Andaman- Island U.P.& H.P.
Marble	Metamorphic	Can take nice polish and available in different coloures. Its Sp. gravity is 2.65 and compressive strength is 720 kg/cm^2. and carved.	Flooring, facing work, Columns, steps, ornamental works etc. It can take nice poise It can easily be shown	Maharashtra, Gujarat, Rajasthan, M.P, Mysore, U.P and A.P.
Moorum	Metamorphic	Decomposed laterite, deep brown or red in colours.	Blindage for metal roads,for fancy paths and garden walls .	Bihar, Orissa, Mysore, M.P, Mah., Kerala, A.P., & Madras
Quartzite	Metamorphic	Hard, brittle, crystalline, and compact, difficult to work and dress.	Retaining wall, road metal, concrete, aggregate, pitching, rubble masonry,facing building etc.	Madras, Punjab, U.P, Mysore, Bengal, Gujarat. Rajasthan, A.P.
Sand stone	Sedimentary	Consists of quartz and other minerals, easy to work &dress and available in different colours. It is Sp.gravity various from 2.65 to 2.95 and compressive strength is 650 kg/cm^2. Its weight is about 2000 to 2200 kg/ cm^3.	Steps, facing work columns, flooring walls, road metal,ornamental work etc .	Maharashtra, Bihar, Gujarat, Bengal, Punjab, Rajasthan, M.P, Andaman Island, U.P, H.P, A.P, Kashmir, Madras .
Slate	Metamorphic	Black colour and splits along natural bedding planes, non-absorbent. Its Sp. gravity is 2.89 and compressive strength varies from 75 to 207 N/mm².	Roofing work, sills, damp proof courses, etc.	U.P., M.P., Bihar, Madras, Mysore and Rajasthan.

Bricks

Objectives: At the end of this lesson you shall be able to
- **define clay products**
- **compare stone and brick**
- **explain composition of brick earth**
- **describe the method of manufacturing of bricks**
- **explain the qualities of good bricks**
- **classify the bricks**
- **state testing of bricks**
- **list out the special bricks.**

Bricks: Moulded clay in rectangular block of uniform size, shape as per standard, which is dried and burned for the purposes of masonry work, is called brick.

Brick earth:(IS: 2117-1975) : A good brick earth should be such that it can be easily moulded and dried without cracking and wrapping.

Comparision of stone and brick

S.No.	Stone	Brick
1	It is heavier than brick	It is lighter than stone.
2	It is obtained from rock	It is made from clay.
3	Free from clay holes and flaws.	Free from lumps, flaws and cracks.
4	Hard and tough	Hard and sound
5	It absorbs heat more than a brick.	It absorbs less heat comparatively.
6	Water absorption <5%	Water absorption <16%
7	It is uniform in colour and can beShaped to the desired size.	Uniform in colour, shape and size.
8	It has high durability.	It is durability is less than that of stone.
9	Suitable for industrial area as it is acid and smoke proof.	Acid and smoke resistance is good but Less than that of stone.
10	Dressing, transporting costly.	Overall cost of manufacturing is less.
11	Labour cost for laying is more.	Labour cost is less

Requirements of good brick earth

1 It must have proper proportions of sand, silt and clay.

2 It must be homogeneous.

3 It should have sufficient plasticity.

4 It must be free from lumps of lime or kankar.

5 It must be free from earth containing alkaline salts, kankar.

6 It must be free from pebbles, grits and lumps of earth.

7 It must not contain vegetable and organic matter.

8 It should not mix with salty water.

Composition of brick earth

1 Alumina (or) clay = 20-30% by weight

2 Silica or Sand = 35-50%by weight

3 Silt = 20-25% by weight

4 i. Iron oxide

ii. Magnesia

iii. Lime (CaO)

iv. Sodium potash = 1.2% by weight

Total water- soluble material not more than 1%.

Lime + magnesia not more than 1% for alluvial soil

Not more than 15 for others.

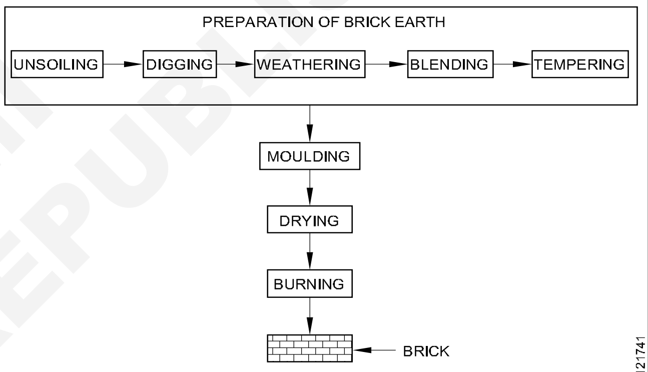
Manufacturing of clay bricks (IS: 2117-1975) (Fig 1) : The process of manufacture can be described the following steps:

Selection of site, (selection and un-soiling)

Preparation of clay, (digging & cleaning, weathering)& blending and tempering

Preparation of clay: The clay for bricks is prepared in the following order

Fig 1



OPERATIONS INVOLVED IN MANUFACTURING OF CLAY BRICKS

i unsoiling ii digging

iii cleaning iv weathering

v blending vi tempering

Unsoiling: The top layer of soil about 20cm in depth is taken out and thrown away. The clay in top soil is full of impurities and hence, it is to be rejected for the purpose of preparing bricks.

Digging : The clay is then dug out from the ground. It is spread on the levelled ground just a little deeper than the general level of ground. The height of heaps of clay is about 60cm to 120cm

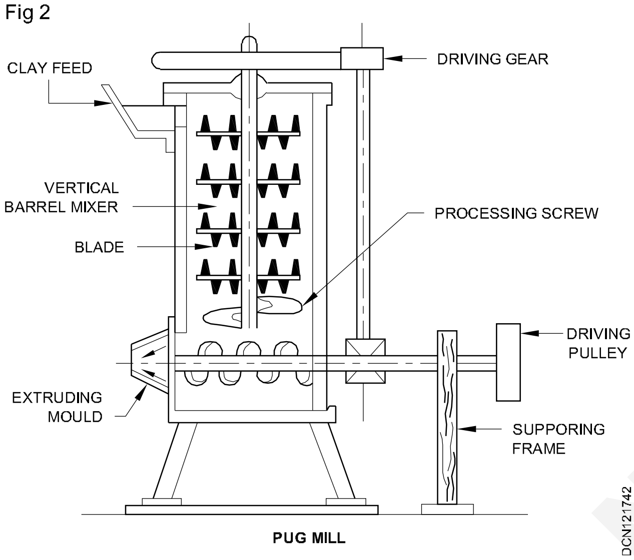
Cleaning: The clay as obtained in the process of digging, should be cleaned of stones, pebbles, vegetables matter, etc. If these particles are in excess the clay is to be washed and screened. Such a process naturally will prove to be troublesome and expensive. The lumps of clay should be converted into powder form in the earth crushing roller.

Weathering: The clay is then exposed to atmosphere for softening or mellowing the period of exposure varies from few weeks to full for a large project the clay is dug out just before the monsoon is allowed to weather throughout the monsoon.

Blending: The clay is made loose and any ingredient to be added to it, is spread out at its top. The blending indicates intimate or hormonious mixing. It is carried out by taking small portion of every time and by turning it up and in vertical direction. Blending makes clay fit for next stage of tempering.

Tempering: In the process of tempering, the clay is brought to a proper degree of hardness and it is made fit for the next operation . The water in required quantity is mass of clay added to clay and whole mass is kneaded or pressed under the feet of men or the tempering should be done exhaustively to obtain homogeneous uniform character. (Fig 2)

Fig 2



Moulding : The clay which is prepared as above is then sent for the next operation of moulding. Following are the two ways of moulding:

Bricks

1 Hand moulding 2 Machine moulding

Hand moulding : In hand moulding the bricks are mould by hand ie manually. It is adoped where man power is cheap and is readily available for the manufacturing process of brick on a small scale. The moulds are rectangular boxes which a open at top and bottom. They may be of wood or steel.

Ground moulded bricks : The ground is first made level and fine sand is sprinkled over it. The mould is dipped in water and placed over the ground the lump of tempered clay is taken and it is dashed in the mould. the clay is pressed or forced in a mould in such a way that it fills all the corners of mould. The extra or surplus clay is removed either by wooden strike or metal strike or frame with wire . A strike is a piece of wood or metal with sharp edge. It is to be dipped in water every time. The mould is then lifted up and raw brick is left on the ground. The mould is dipped in water and it is placed just near the previous brick to prepare another brick. The process is repeated till the ground is covered with raw bricks. A brick moulder can mould about 750 bricks per day with working period of 8 hours. When such bricks become sufficiently dry, they are carried and placed in the drying sheds.

Table moulded bricks: The process of moulding these bricks is just similar as above. But in this case the moulder stands near a table of size about 2m X 1m. The clay mould water pots stock bard strkies and pallet boards are placed for the further process of drying. However the efficiency of moulder decreases gradually because of standing at the same place for long duration. The cost of brick moulding also increases when table moulding is adopted.

Machine moulding : The moulding may also be achieved by machines. It proves to be economical when bricks in large quantity are to be manufactured at the same pot in a short time. It is also helpful for moulding hard and strong clay. These machine are broadly classified in two categories:

1 Plastic clay machines

2 Dry clay machines

Plastic clay machines: Such machines contain a rectangular opening of size equal to length and width of a brick. The pugged clay is placed in the machine and as it comes out through the opening it is cut into strips by wires fixed in frames. The arrangements is made in such a way that strips of thickness equal to that of the brick are obtained. As the bricks are cut by wire, they are also known as wire cut bricks.

Dry clay machines: In these machines, the strong clay is first converted into powder form. A small quantity of water is then added to form a stiff plastic paste. Such paste is placed in mould and pressed by machine to form hard and well shaped bricks. These bricks are known as pressed bricks and they do not practically require drying. They can be sent directly for the process of buring.

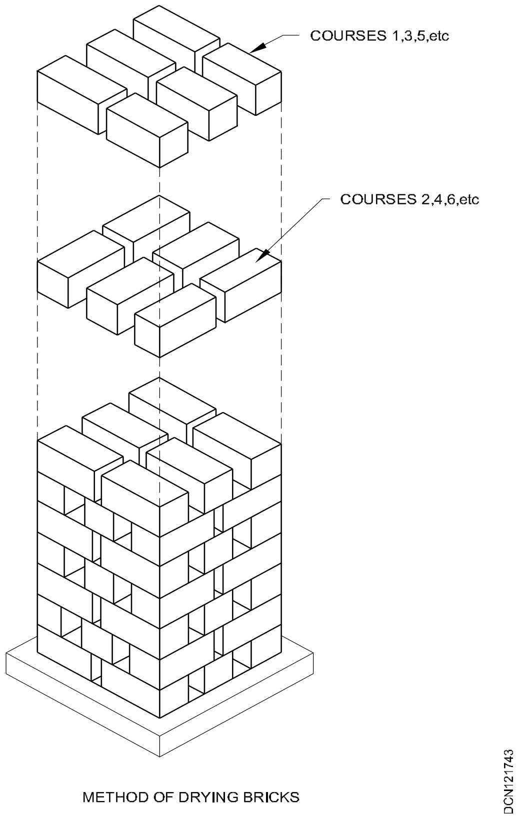
The wire cut and pressed bricks have regular shape, sharp edges and corners. They have smooth external surface.They are heavier and stronger than ordinary hand moulded bricks. They carry distinct frogs and exhibit uniform dense texture.

Drying : The damp bricks, if burns are likely to be cracked and distorted. Hence the moulded bricks are dried before they are taken for the next operation of buring. For drying the bricks are laid longitudinally in stacks of width equal to two bricks. A stack consists of eight or ten tiers. The bricks are laid along and across the stock in alternate layers. All bricks are placed on edge. The bricks should be allowed to dry till they become leather hard or bone-dry with moisture content of about 2 per cent or so (Fig 3).

The important facts to be remembered in connections with drying of bricks are as follows:

Artificial drying : The bricks are generally dried by natural process. But when bricks are to be rapidly dired on a large scale, the artificial drying may be adopted. In such a case, the moulded bricks are allowed to pass through special dryers which are in the form of tunnels or hot channels or floors. Such dryers are heated with the help of special furnaces or by hot flue gases. The tunnel dryers are more economical than hot floor dryers and they may be either periodic or continuous.

Fig 3



METHOD OF DRYING BRICKS

Circulation of Air: The bricks in stacks should be arranged in such a way that sufficient air space is left between them for free circulation of air.

Drying yard: For the drying purposes, special drying yards should be prepared. It should be slightly on a higher level and it is desirable to cover it with sand. Such an arrangement would prevent the accumulation of rain water.

Period for drying: The time required by moulded bricks to dry depends on prevailing weather conditions.Usually it takes about 3 to 10 days for bricks to become dry.

Screens: It is to be seen that bricks are not directly exposed to wind or sun for drying. Suitable screens, if necessary may be provided to avoid such situations.

Burning : This is a very important operation in the manufacturing of bricks. It imparts hardness and strength to bricks and makes them dense and durable. The bricks should be burnt properly. If bricks are overburnt, they will be brittle and hence break easily, if they are underburnt, they will be soft and hence, cannot carry loads.

When the temperature of dull red heat, about 650^{0}C is attained, the organic matter contained in the brick is oxidized and also the water of crystallization in driven away.

When the temperatrue of about 1100^{0}C is reached, the particles of two important constituents of brick clay, namely alumina and sand bind themselves together resulting in the increases of strength and density of bricks.

The burning of bricks, is done either in clamps or in kilns.

Clamps: The clamps are temporary structures and they are adopted to manufacture bricks on a small scale to serve a local demand or a specific purpose. The kilns are permanent structure and they are adopted to manufacture bricks on a large scale.

Kilns: A kiln is large oven which is used to burn brick. The kilns which are used in the manufacture of bricks are of the following two types

Intermittent kilns

Continuous kilns

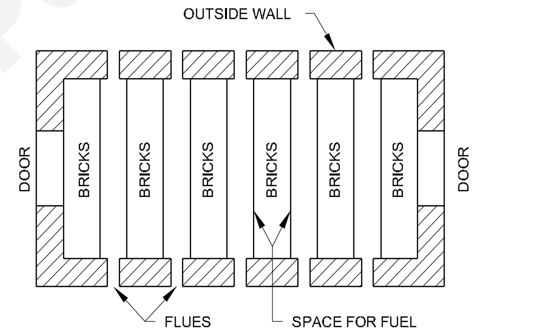
Intermittent kilns : These kilns are intermittent in operation which means that they are loaded, fired, cooled and unloaded. Such kilns may be either rectangular or circular in plan. They may be overground or underground. They are classified in two ways:

Intermittent up draught kilns

Intermittent down-draught kilns

Intermittent up draught kilns : These kilns are in the form of rectangular structures with thick outside walls. The wide doors are provided at each end for loading and unloading of kilns. The flues are channels or passages which are provided to carry flames or hot gases through the body of kiln. A temporary roof may be installed of any light material. Such roof gives protection to raw bricks from rain while they are being placed in position. This roof is to be removed when the kiln is fired. Fig 4 shows the plan of a typical intermittent up-draught kiln.

Fig 4



Intermittent up draught kiln

The kiln is allowed to cool down gradually for at least 7days and the bricks are taken out.

The procedure is then repeated for the next burning of bricks.

Intermittent down-draught kilns: These kilns are rectangular or circular in shape. They are provided with permanent walls and closed light roof. The floor of the kiln through flues. The working of this kiln is more or less similar to the up-draught kiln. But it is so arranged in this kiln that hot gases are carried through vertical flues up to level of roof and they are then released. These hot gases move downward by the chimney draught and in doing so, they burn the bricks.

Continuous kilns: This means that loading, firing, cooling and uploading are carried out simultaneously in these kilns. There are various types of the continuous kilns. Following three varieties of continuous kilns will be discussed:

Bull's trench kiln

Hoffman's kiln

Tunnel kiln

Bull's trench kiln: This kiln may be of rectangular circular or oval shape in plan. Fig 6 shows a typical bulls kiln of oval shape in plan. As the name suggest the kiln is constructed in a trench excavated in ground. In latter case, the ramps of earth should be provided on outside walls. The outer and inner walls are to be constructed of bricks. The opening are generally provided in the outer walls to act as flue holes. The dampers are in the form of iron plates and they are used to divide the kilns in suitable sections. This is most widely used kiln in India and it gives continuously supply of bricks.

Section 1 - Loading

Section 2 - Empty

Section 3 - Unloading

Section 4 - Cooling

Section 5 - Burning

Section 6 - Heating

Hoffman's kiln: This kiln is constructed overground and hence, it is sometimes known as flame kiln. Its shape is circular in plan and it is divided into a number of compartments or chambers. As a permanent roof is provided the kiln can even function during rainy season.

A radial flue connected with a central chimney and fuel holes with covers to drop fuel, which may be in the form of powdered coal, into burning chambers.

In this type of kiln each chamber performs various functions in succession, namely loading drying burning cooling and unloading. As an illustration 12 chambers shown in Fig 7 may be functioning as follows:

Chamber 1	-	loading
Chamber 2 to 5	-	drying and pre-heating
Chamber 6 and 7	-	Burning
Chamber 8 and 11	-	Cooling
Chamber 12	-	Unloading

Qualities of good bricks

The good brick which are to be used for construction of important engineering structure should possess the following qualities

1 Size and shape

2 Color

3 Structural

4 Hardness

5 Soundness

6 Porosity

7 Strength

8 Resistance of fire

9 Efflorescence

10 Durability

Example

1 Colour: Uniform copper red colour.

2 Shape: Rectangular 19 x 9 x 9 cm Standard.

3 Sound: Sound proof, clear ringing sound when struck with each other.

4 Absorption: It should not<20% for I Class <22% for II Class When socked in cold water for 24hrs

5 Toughness: Should not be break when dropped from an height of 1 meter.

6 Crushing Strength: 3-5 N/mm square. Minimum.

7 Specific gravity: 2-2.6

Classification of brick: The brick can broadly be dividing into two categories as following:

1 Unburnt bricks: These brick are dried with the help of sun heat only.

2 Burnt bricks: These brick are burnt clamp or kiln. They are classified into the following the four categories:-

1 **1^{ST} Class bricks:** R.B. work, following, as blast R.C. work arches etc.

2 **2^{nd} Class brick:** Un-important situation and for internal walls.

3 **3^{rd} Class brick:** Temporary building

4 **4^{th} Class brick:** Foundation and Floor etc.

The tests to be made on bricks, as given above, are as follows

1 **Absorption test:** To know about the amount of water absorbed of brick.

2 **Crushing strength test:** To know about the compressive strength in brick

3 **Effloresence test:** To know about the presence of soluble salt in the brick.

4 **Hardness test:** To know the hardness of brick by figure nail.

5 **Shape and size:** To know the standard size and shape of brick.

6 **Soundness:** To know about the strength of soundness.

7 **Structure:** To know about the any hole, lumps in the brick.

Special bricks (Fig 5) : These bricks differ from the commonly used building bricks with respect to their shape, specification and special purpose for they are made.

1 Specially shaped bricks

2 Heavy duty bricks

3 Perforated bricks

4 Burnt clay hollow bricks

5 Sand lime bricks

6 Sewer bricks

7 Acid resistant bricks

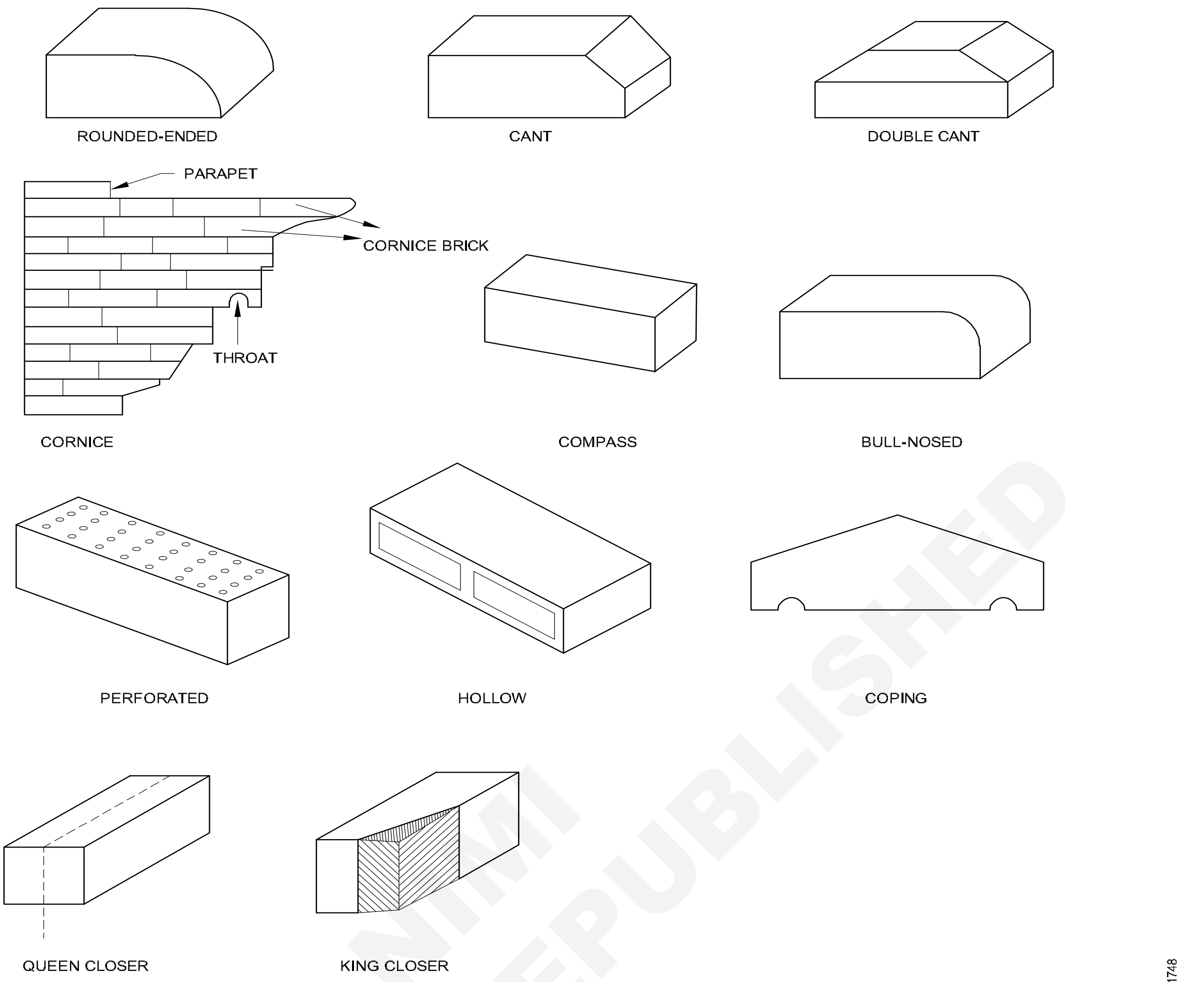
Hollow bricks

Hollow bricks are made from clay and formed with cavities which module their weight.

These bricks are used 20 mm to 25 mm thick wall. They are suitable for partition wall.

The cavity reduces the transmission of sound and hoot. The hollow bricks are machine pressed and formed cavity in the brick (Fig 5)

Fig 8



FORMS OF BRICKS

Lime

Objectives: At the end of this lesson you shall be able to
- **define lime**
- **classify lime**
- **state properties of lime**
- **describe uses of lime**
- **compare fat and hydraulic lime**
- **explain tests for lime**
- **list out the precautions in handling lime.**

Introduction : Lime is produced from calcium carbonates in the form of limestone, seashells, coral, kankar, etc.

Definition : A powder obtained by heating limestone, is called lime.

Classification : IS: 712-1973, classifies lime as follows:

Class a: eminently hydraulic lime, which can be used for structural works, such as arches, domes, etc.

Class b: semi-hydraulic lime which can be used for constructing masonry.

Class c: fat lime that can be used for finishing coat in plastering, white washing, etc. or used for masonry mortar with addition of pozzolanic material.

Class d: magnesium or dolomite lime is used for finishing coat in plastering and whitewashing.

Class e: Kankar lime produced by burning lime nodules (found in soils like black cotton soils contain silica) is hydraulic. It can be used for masonry mortar.

Class f: Siliceous dolomite lime is used generally for undercoat and finishing coat of plaster.

Notes

1 Carbide lime is a by-product of manufacturing of acetylene. It can be used for mortar for plaster work, but generally it is not recommended for whitewashing un less procured fresh in the form of a paste before it dries up or is treated properly.

2 Lime containing more than30percentage impurities like clay is called poor limes.

Properties of lime

1 Easily workable.

2 Possesses good plasticity.

3 Stiffens early.

4 Provides strength to the masonry.

5 Offers good resistance to moisture.

6 An excellent cement and adheres to the masonry units perfectly

7 Lime masonry proves durable due to low shrinkage in drying.

Uses of lime

1 It is used as a matrix for concrete.

2 It is used as a binding material in mortars for stoneware and also in bedding and joining brickwork of low strength.

3 It is used for plastering walls, ceilings, etc.

4 It is employed for white washing and as a base coat for distempers.

5 It is used for knotting of timber work before painting.

6 It is used for production of artificial stone, lime - sand bricks, foam-silicate products, etc.

7 When mixed with Portland cement, the lime-cement mortar attains such valuable properties, that it replaces the costly cement plaster and serves as a plasticizer.

8 It is used as a flux in the manufacture of steel.

9 Eminently hydraulic lime can be used for masonry work below ground level.

10 It is used in the manufacture of paints.

11 It is used for stabilizing the soils.

12 It is employed for creating good sanitary conditions in foul, damp and filthy places.

Comparison between fat lime and hydraulic limes

S.No.	Item	Fat Lime	Hydraulic lime
1	Composition	It is obtained from comparatively pure carbonate of lime containing only 5% of clayey impurities.	It is obtained from lime stones containing to the extent of about 5 to 30 % and some amount of ferrous oxide.
2	Slaking action	It slakes vigorously. Its volume is increased to about 2 to 2 1/2 times the volume of quick lime. The slaking is accompained by sound and heat.	It slakes slowly. Its volume a slightly increased. The slaking is not accompanied by sound or heat.
3	Setting action	It sets slowly in presence of air. It absorbs carbon dioxide from atmosphere and forms atmosphere and forms calcium carbonate.	It sets under water. It combines with water and forms crystals of hydrated tri-calcium silicate.
4	Hydraulicity	It does not possess hydraulic property.	It possesses hydraulic property.
5	Colour	It is perfectly white in colour.	Its colour is not so white as fat lime.
6	Strength	It is not very strong. Hence, it cannot be used where strength is required.	It is strong and can therefore be adopted where strength is required.
7	Uses	It is used for plastering, white washing, etc. and for preparing mortar with sand or surkhi.	It is used for preparing mortar for thick walls, damp places, etc. extreme care is required to prepare mortar of this lime for plaster work.

Cement

Objectives: At the end of this lesson you shall be able to

- **define cement**
- **state the properties, uses, types, manufacture and testing of cement**
- **compare cement and lime**
- **explain the flow diagram of the wet process of cement manufacturing**
- **state cement water proofer**
- **state admixtures.**

Definition : Material obtained by burning mixture of calcareous and argillaceous Materials with a small quantity of gypsum at a very high temperature and pulverized into very fine powder, known as Cement.

Properties of cement : Good cement possesses the following properties:

1 Provides strength to masonry.

2 Stiffens or hardens early.

3 Possesses good plasticity.

4 An excellent building material.

5 Easily workable.

6 Good moisture-resistant.

Uses of cement:

1 Cement mortar for masonry works, plaster, pointing, etc.

2 Concrete for laying floors, roofs and constructing lintels, beams, weather sheds, stairs, pillars, etc.

3 Construction of important engineering structures such as, bridges, culverts, dams, tunnels, storage reservoirs, light houses, docks, etc.

4 Construction of water tanks, wells, tennis courts, septic tanks, lamp posts, roads, telephone cabins, etc.

5 Making joints for drains, pipes, etc.

6 Manufacture of precast pipes, piles, garden seats, artistically design urns, flower pots, etc., dustbins, fencing posts, etc.

7 Preparation of foundations, watertight floors, footpaths, etc. The comparison between cement and lime is shown in Table - A

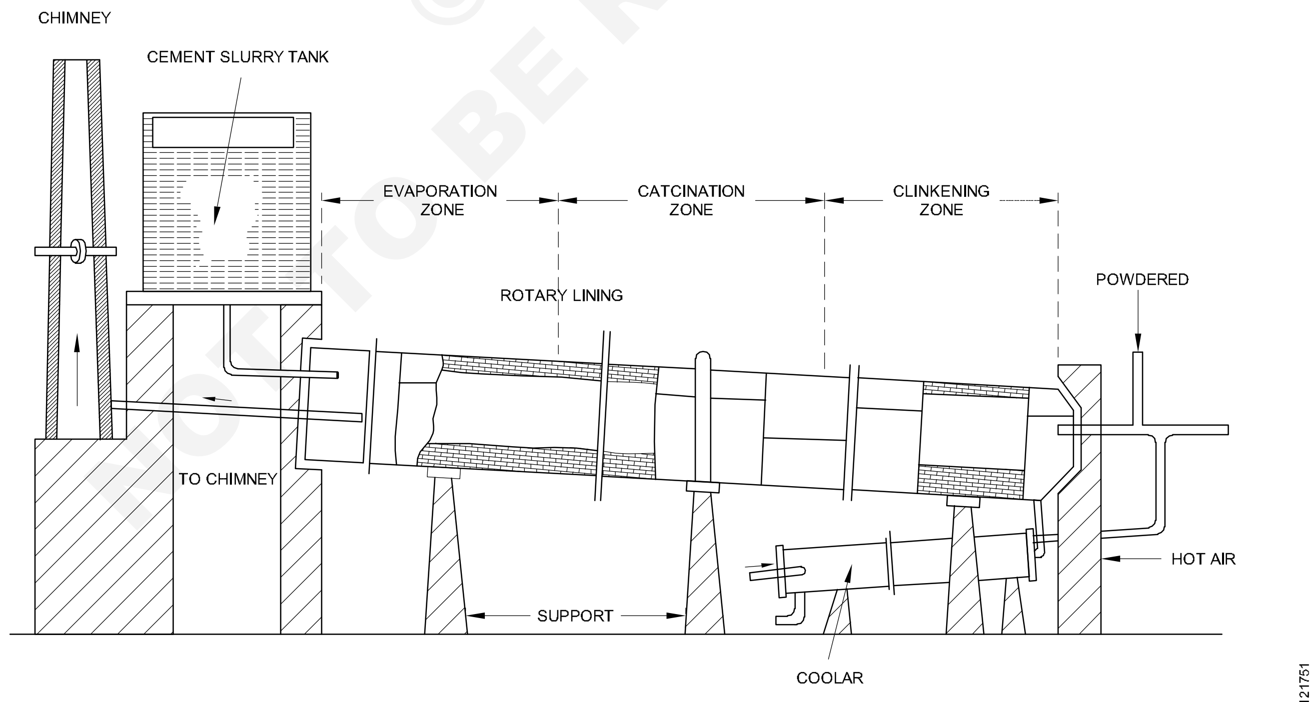
Table A

Comparison between cement and lime

S.No.	Aspects	Cement	Lime
1	Colour	Greenish grey.	White or grayish.
2	Slaking	Does not slake when wetted with water	Slakes when wetted with water
3	Setting	Sets rapidly when mixed with water	Sets slowly when mixed with water
4	Strength	Artificial cement possesses more strength	Possesses less strength.
5	Suitability	Can be used for important and heavy engineering structures	Cannot be used for important and heavy engineering structures.

Manufacture of portland cement (Fig 1 and Fig 2)

Fig 1



ROTARY KILN

There are two processes employed,

1 Wet process- this process is generally used if the raw Materials available are soft e.g. chalk and clay.

Burning: The burning is carried out in a rotary kilin as shown in fig 1. A rotary klin is formed of steel tubes. Its diameter varies form 250 cm to 300cm. Its length varies from 90m to 120m. It is laid at a gradien of about 1 in 25 to 1 in 30. The klin is supported at intervals by columns of masonry or concrete. The refractory lining is provided on the inside surface or rotary klin. It is so arranged that the klin rotates at about one to three revolutions per minute about its longitudinal axis.

The corrected slurry is injected at the upper end of klin. Fig 1 shows the rotary klin for the wet process. The hot gases or flames are forced through the lower end of kiln. The portion of the kiln near its upper end is known as dry zone and in this zone, the water of slurry is evaporated. As the slurry gradually descends, there is rise in temperature and in the next section of kiln, the carbon dioxide from slurry is evaporated. The small lumps, known as nodules, are formed at this stage .

In the modern technology of dry process, the coal brought from the coal fields is pulverised in vertical coal mill and it is stored in silos. It is pumped with required quantity of air through the burners. The preheated raw Materials roll down the kiln and get heated to such an extent that the carbon dioxide is driven off with combustion gases. The material is then heated to temperature of nearly 1400^{0}C to 1500^{0}C when it gets fused together. The fused product is known as clinkers or raw cement.

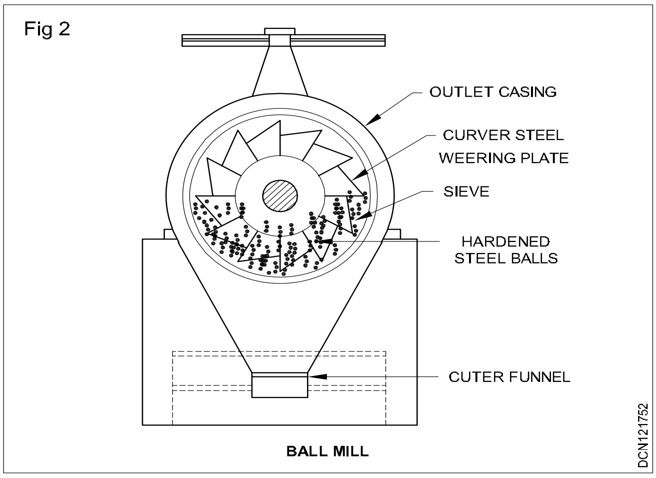
The size of clinkers varies from 3mm to 20mm and they are very hot when they come out of buring zone of kiln. The clinker temperature at the outlet of kiln is nearly 1000^{0}C to 1500^{0}C when it gets fused together. The fused product is known as clinkers or raw cement.

Grinding : The clinkers as obtained from the rotary kiln are finely ground in ball mills and tube mills. During grinding a small quantity about 3 to 4 percent of gypsum is added. The gypsum controls the initial setting time of cement. If gypsum is not added,the cement would set as soon as water is added. The gypsum acts as a retarder and it delays the setting action of cement. It thus permits cement to be mixed with the aggregate and tobe placed in position.

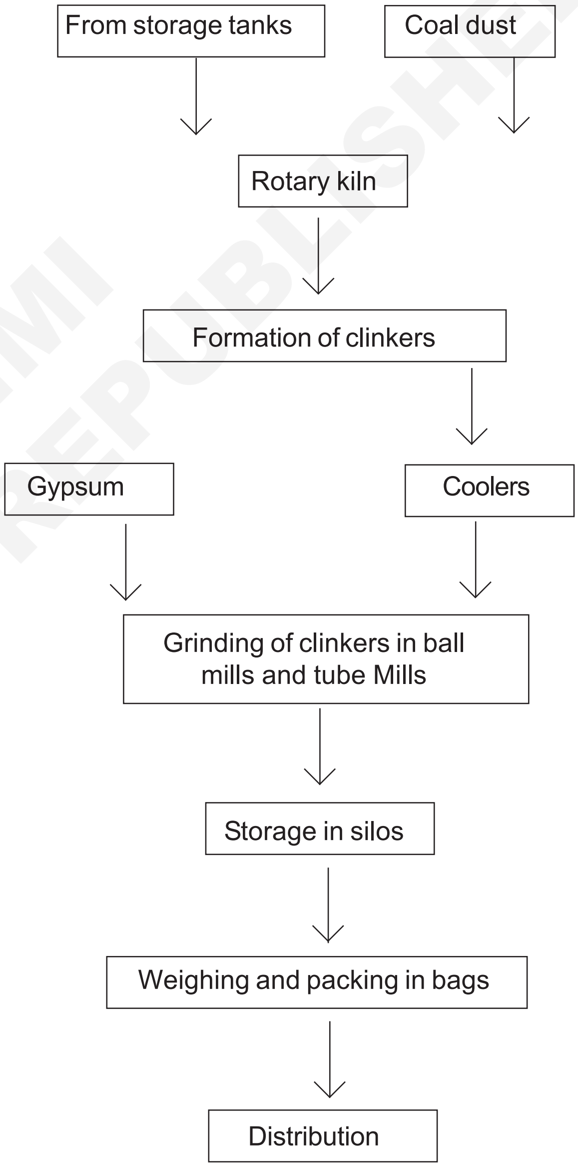
Packing of cement : The packing of cement is mostly done in our country in conventional jute or gunny bags. Most of the modern plants have electric packing plant having provision plan to account for the weights of empty bags of different types and to ensure a 50kg net weight of cement bag within $\underline{+}$200g^3 limit . Each bag of cement contains 50kg or about 0.035m^3 of cement. These bags are automatically discharged from the packer to the conveyor belts to different loading area. They are carefully stored in a dry place Fig 1 shows the flow diagram of buring and grinding operations.

Ball mill (Fig 2)

Fig 2



Flow diagram of burning and grinding operations of cement



Types of cement : The following are the IS specifications:

1 Ordinary Portland cement (OPC) in 3 grades,

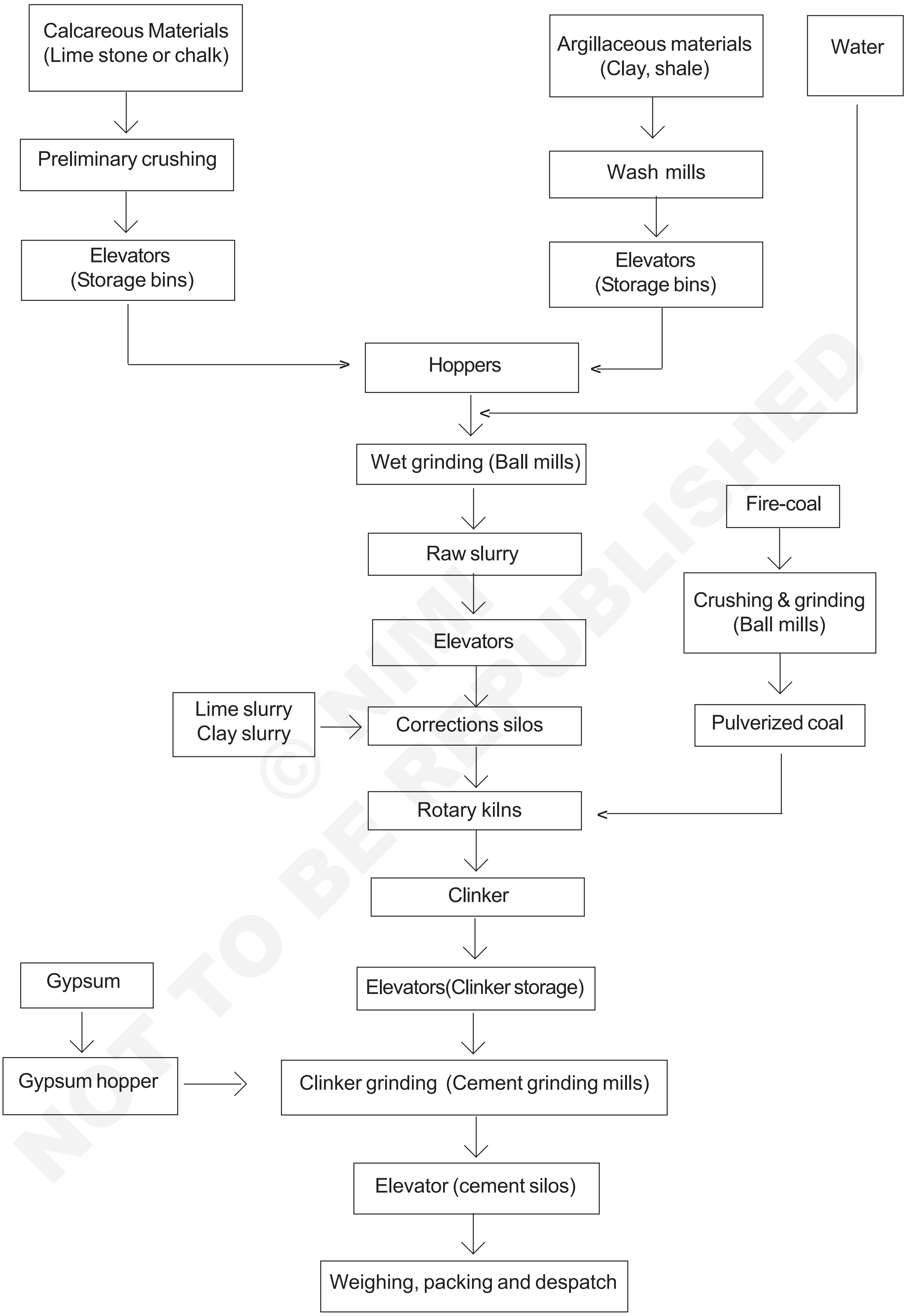
a Grade 33 - IS: 269-1989 designated as C-33,

b Grade 43 - IS: 269-1989 designated as C-43,

c Grade 53 - IS: 269-1989 designated as C-53

Cement is specified by its grade (compressive strength of 1:3 cement mortars as cubes of 50 cm² areas (7.06 cm) in 28 days for defining strength) thus, Grade-33 cement (C-33) means cement with standard mortar cube strength of 33 N/ mm² in 28 days. Only the grade of the cement is marked on the bags of 50 kg.,

FLOW DIAGRAM FOR WET PROCESS



2 Portland pozzolana cement (PPC) (a mixture of OPC and Pozzolana)

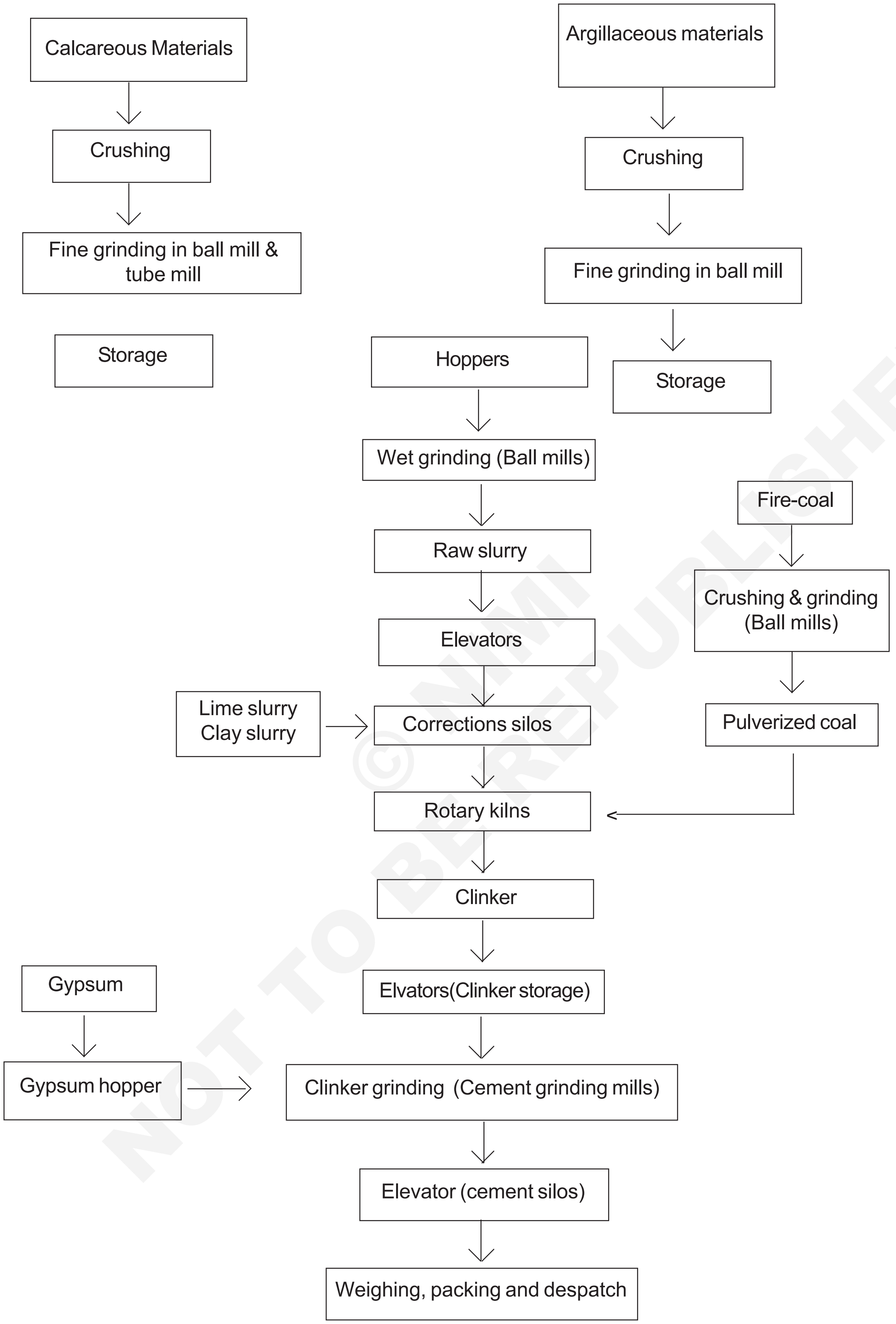
   a IS: 1489 (Part-I)-1991 (fly ash -based)

   b IS: 1489 (Part-II)-1991 (calcined clay-based)

3 Sulphate-resisting cement-IS: 12330-1988

4 Portland slag cement-IS:455-1989 (PSC)

FLOW DIAGRAM OF DRY PROCESS



5 Low- heat cement-IS: 12600-1989

6 Rapid-hardening cement-IS:8041-1990

7 Concrete sleeper-grade cement-IS: T40-1985

8 Coloured cement-white cement-IS: 8042-1989

9 Oil well cement-IS: 8229-1986

10 Hydrophobic cement-IS: 8043-1991

11 Masonry cement-IS: 3466-1988
12 High-alumina cement-IS: 6452-1989
13 Super-sulphated cement-IS: 6909-1990
14 Expansive cement
15 Quick setting cement

Properties of cement

- Provides strength to masonry
- Stiffens or hardens early
- Possesses good plasticity
- An excellent building material
- Easily workable
- Good moisture resistant

S.No.	Types	Features	Uses
1	Ordinary portland cement	General concrete structures	Medium rate of strength developed less resistance to chemcial attack
2	Acid resistant cement	Acid resistant heat resistant coating of installation of chemical industry	It cannot resist the action of water well
3	Rapid hardening portland cement	Rapid strength is developed	Curing period short, burnt at high temperature
4	Blast furnance cement	Mass concrete structure	Initial setting time not less than 30 minutes, final setting time 10 Hrs
5	Expading cement	Construction of water retaining structures repairing the damaged concrete structures	
6	Coloured cement	Finishing of floors, external surface artificial marble, stair tread	By adding 5 to 15% of suitable colouring pigment before the cement is finally ground.
7	High alumina cement	For works in chemical plant and furnaces	It is completely resistant to the action of surface
8	Hydrophobic cement	Frost resistant and water resistant	Initial stage the gain in strength is less
9	Modified portland cement	Heavy construction of heavy abutment, large piers, retaining wall etc	Less heat of hydration
10	Extra rapid hardening cement	Suitable for cold weathering concrete	Qty of calcium chloride should not exceed 3 percentage
11	Sulphate resisting portland cement	Used at places where sulphate action is severe.	

Portland - pozzolana cement (IS:1489)

- This cement is made either by intergrading port land cement clinker and pozzolana or by uniformly blending port land cement and fine prozzolana.
- The pozzolana cement contain varies from 10 to 25% by weight of cement.
- Pozzolana does not possess cementing value themselves but any how the property of combining with the lime which possess cementing property.
- It free lime is removed, the pozzolana concrete have a greatly resistance to chemical agencies and also resist the sea work better than ordinary cement.
- Pozzolana cement is popularly used in the construction of dam.
- Pozzolana cement manufactured in burnt clay or shade or fly ash.

The following table shows the compressive strengths reduces by ordinary portioned cement and port land pozzolana cement.

Table

Compressive strength of portland pozzolana cement and ordinary portland cement

Age in days	Compressive strength	
	Ordinary port land cement	**Port land Pozzolana cement**
1	77 Kg/cm^2 - 8 N/mm^2	77 Kg/Cm^2 - 8 N/mm^2
3	192 Kg/cm^2 - 19 N/mm^2	165 Kg/cm^2 - 16 N/mm^2
7	256 Kg/cm^2 - 26 N/mm^2	247 Kg/cm2 - 25 N/mm^2
14	310 Kg/cm^2 - 31 N /mm^2	301 Kg/cm^2 - 30 N /mm^2
15	375 Kg/cm^2 - 38 N /mm^2	375 Kg/cm^2 - 38 N /mm^2

Projection

Objectives: At the end of this lesson you shall be able to
- **define projection**
- **classify projections**
- **state the types of pictorial projection.**

Introduction : As object, have three dimensions like length, width and height/ thickness. The shapes and sizes of three-dimensional objects have to be represented on a sheet of drawing paper, which has only two-dimensional planes.

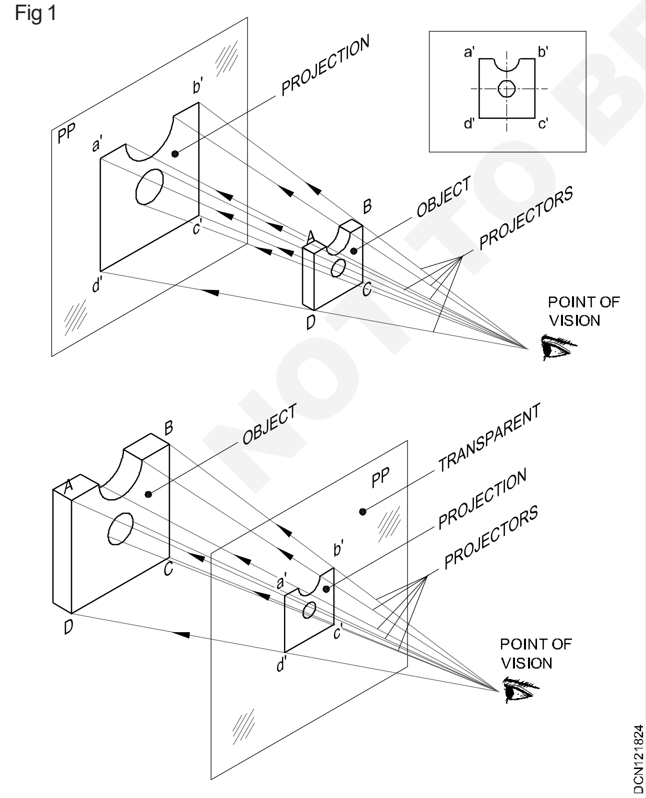
For obtaining the image of an object, various points on the contour of an object, are thrown forward on to a plane by means of straight lines or visual rays.

The figure formed by joining various points thus obtained on the plane, is the image of the object and is called Projection.

Projection: Projection is commonly used term in draughtsmans vocabulary. In the context of engineering drawing, projectors means image and it is comparable to the image formed on the retina of the eyes. (Projection can also be compared to the image of the object on the screen, where the film is projected (by the cinema projector) by the light rays.

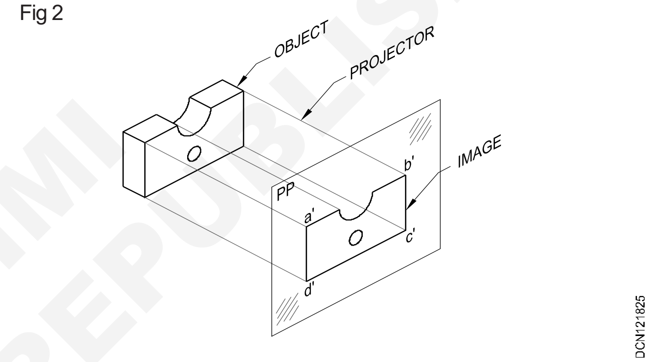
Projection or images can also be formed inbetween the eyes and the object by keeping a transparent plane. (Fig 1)

Fig 1



In this figure 1 the rays from the object converge to the eyes and this image (Projection) is smaller than the object. However if the rays are parallel as in the case of rays coming from the sun, the image (Projection) will be of the same size as that of the objects. Such a projection is called orthographic projection. The parallel lines/rays drawn from the object are called projectors and the plane on which image is formed is called plane of projection. In orthographic projection, the projectors are perpendicular to the plane of projection. (Fig 2)

Fig 2



Orthographic projection : If the projections from the object are perpendicular to the projection plane, such a projection of the object is known as Orthographic Projection. A thorough knowledge of the principles of pictorial projection is required for converting pictorial views into orthographic views.

General Procedure

1 Determine the overall dimensions of the given object for the required orthographic views.

2 Draw rectangles for the views using suitable scale. It is also required to keep sufficient space between the views and from border lines.

3 Draw centre lines for circles and arcs.

4 Draw circles and arcs of circles first, next draw straight lines for the main shapes of the object.

5 And finally draw straight lines and small curves for the minor details of the object.

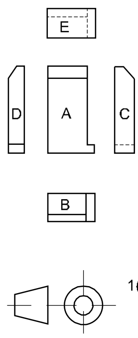
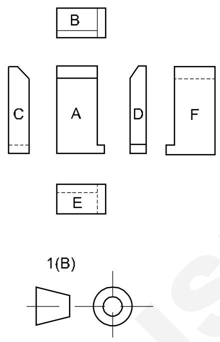
Points to be considered for converting a pictorial view in to orthographic views

- Dimensions which are parallel to the direction of viewing will not be seen. Edges which are parallel to the direction of viewing are seen as points. Surfaces which are parallel to it are seen as lines.

- The visible edges and the intersection if the surfaces are shown by object lines. But the hidden edges are shown by dotted lines.
- The centre linens of the symmetrical parts like whole cylinder etc. should be clearly shown.

System of orthographic projection

Orthographic views can be obtained by two methods:

First Angle projection	Third angle projection
Arrangement of views in first Angle projection.	Arrangement of views in Third Angle Projection.
With reference to the front view the other arranged as follows:	With reference to the front view the other arranged as follows:
 1(A)	 1(B)
The view from above is placed underneath	The view from above is placed above.
The view from below is placed above.	The view from below is placed underneath
The view from the left is placed on the right.	The view from the right is placed on the right.
The view from the right is placed on the left.	The view from the left is placed on the left.
The view from the rear may be placed on the left or on the right as may be found convenient .	The view from the rear may be placed on the left or on the right as may be found convenient .
The distinctive symbol of this projection is Fig 1a	The distinctive symbol of this projection is Fig 1b

- When a hole or a cylindrical part in seen as a circle draw two centre lines intersecting each Other at right angles at its centre line for its axis.
- When a centre line coincides with a visible edge it is drawn as a dotted line.
- When a hidden edge coincides with a visible edge, it is drawn an object line (visible out line)

First angle projection

- When the object is placed in 1st quadrant such that it is between the projection plane and the observer, the projection so obtained is called first angle projections.

Third angle projection

- In this case, the object is placed in the 3rd quadrant and the planes of projections are in between the object and the observer.

Basic principles

- Depending upon the relative position of the object, the picture plane and the station point, the following situation may arise:
- If the picture plane is in between the object and the station point, a normal perspective is obtained.
- If the object is in between the picture plane and the station point, a larger perspective is obtained.
- If the station point is in between the object and the picture plane, the perspective is reversed.

Projection of points and lines

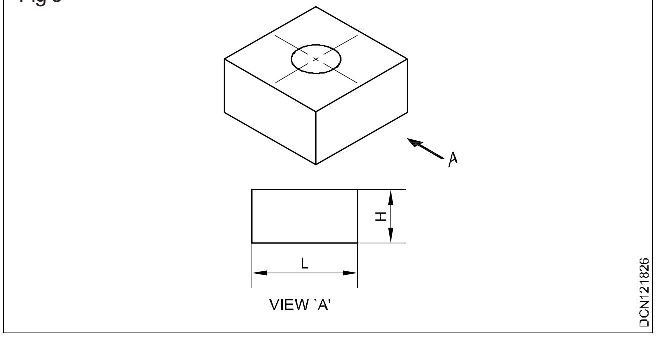
Objectives: At the end of this lesson you shall be able to
- **explain the four dihedral angles**
- **state the meaning of orthographic projection**
- **explain terms plan and elevation as applied to orthographic views**
- **state the relative position of views in first and third angle projection.**

Orthographic projection: The term orthographic is projection derived from the words. Ortho means straight or at right angles and graphic means written or drawn. The projection comes from the Old Latin words PRO means forward and Jacene means to throw. The orthographic projection literally means "Throw to forward", "drawn at right angles" to the planes of projection.

An orthographic system of projection is the method of representing the exact shape and size of a three dimensional object on a drawing sheet or any other plain surface such as drawing board.

A single orthographic view of an object will show only two of its three dimensions. The view in figure 3 shows only the length and height of the object only.

Fig 3

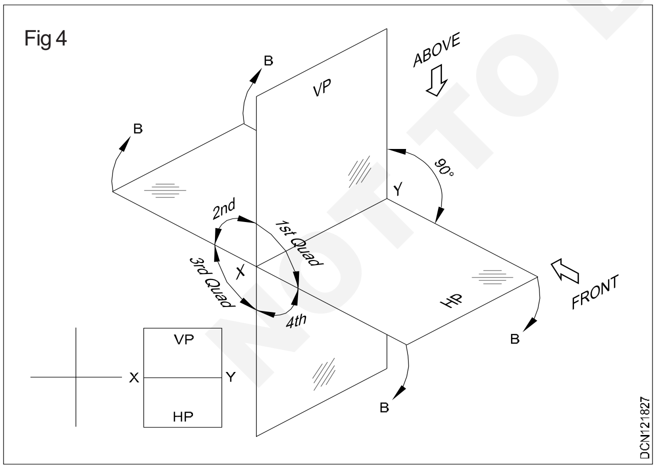


Therefore, it becomes necessary to have an additional view to show the missing dimensions (width). Therefore, we have to make two views to represent the three dimensions of an object.

The two views thus required are to be obtained on two different planes which are mutually perpendicular (one HP and one VP) with the object remaining in the same position. The projection or the view obtained on the horizontal plane is called the top view or plan and the view obtained on the vertical plane is called elevation.

First angle and third angle projection: One vertical plane (VP) and one horizontal plane (HP) intersect at right angles to each other. (Fig 4)

Fig 4



All the four quadrants have one HP and one VP formation. As per convention in mathematics, the quadrants are numbered as 1st, 2nd, 3rd and 4th. These four quadrants are called four dihedral angles, namely 1st angle, 2nd angle, 3rd angle and 4th angle.

To draw two views of an object, we assume that the object is placed in any one of the quadrant/angles, 1st angle & 3rd angle Fig 5a, 6a and its plan and elevation projected to the respective planes. Now tomake it possible to draw the two views (Plane & elevation) in one plane i.e the plane of the drawing paper, the horizontal plane is assumed to be unfolded in clockwise direction through 90° Fig 5b & 6b. We proceed this way, when the views are made. When the object is placed in the 2nd or fourth quadrant the plan and elevation will get super imposed (one up on the other) Fig 7a & b. Due to this reason the 2nd and 4th angle are not used for making engineering drawings as the three dimensions cannot be easily identified. Hence for representing the three dimension of the object, we assume the object is placed either in 1st angle or in 3rd angle. (Fig 8 & 9)

Fig 5

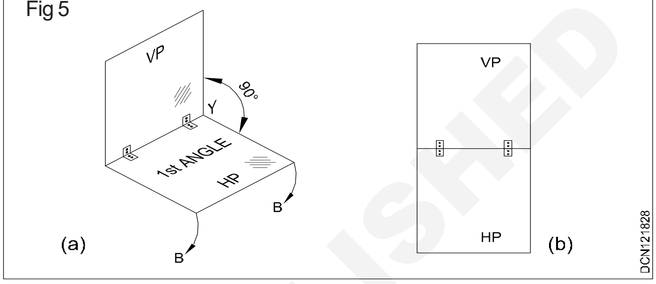


Fig 6

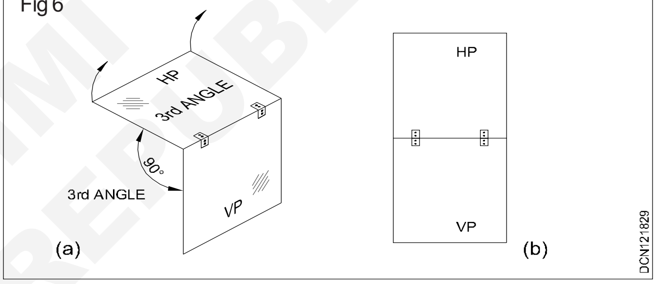


Fig 7

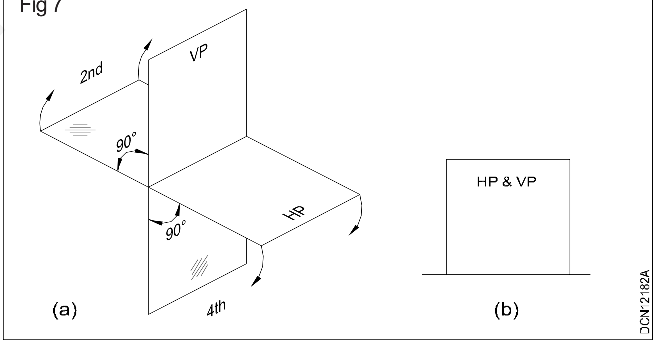


Fig 9

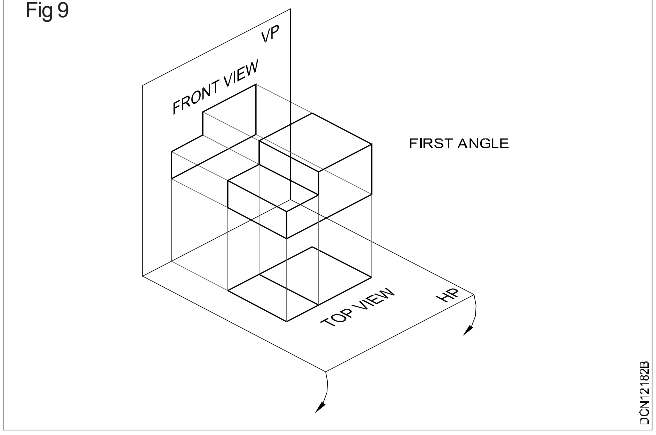
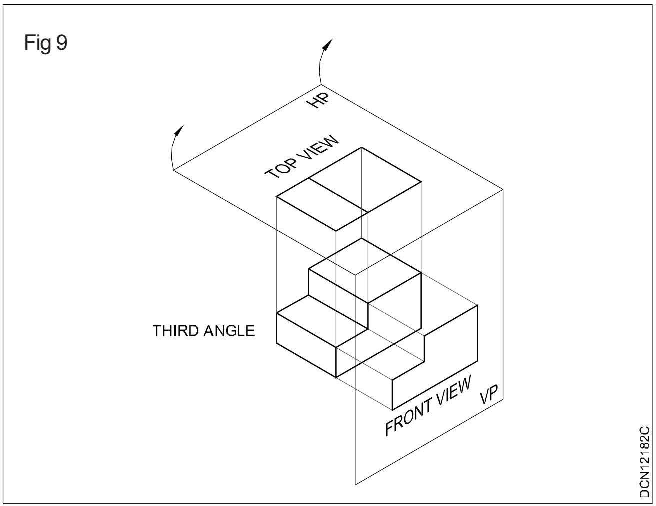
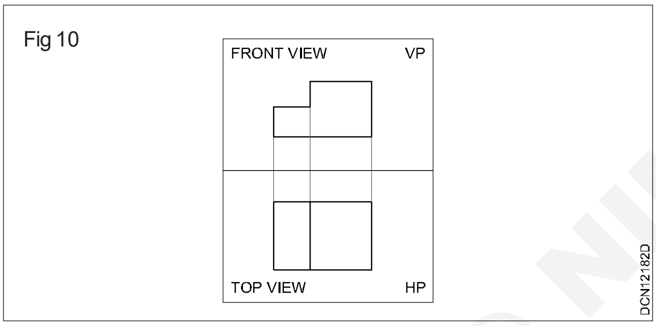


Fig 9



The placement of plan and elevation when the horizontal plane is unfolded will be different in these two systems. It may be observed in Fig 10 that in the first angle projection plan (top views) will be directly below the elevation, whereas in 3rd angle projection plan lies directly above the elevation. (Fig 11)

Fig 10

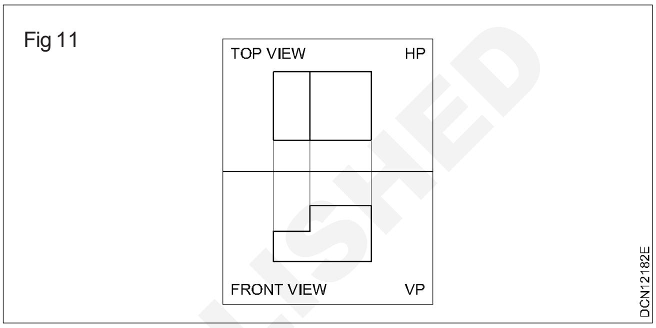


Views can be drawn in any one of these two methods. However Indian Standard (BIS) has recommended the first angle method to be used in our country.

Orthographic views are drawn, based on the principle of projection. To acquire sound knowledge to make orthographic views, one has to study solid geometry which deals extensively with principle of projections. Remember that the purpose of studying solid geometry is to have clear in sight of principle of projection which is the basis of describing the shapes of solid objects on a plain paper.

Solids are made of planes and planes are made of lines and lines and made of points. Hence the solid geometry will be dealt in the order of points, lines, planes and solids.

Fig 11

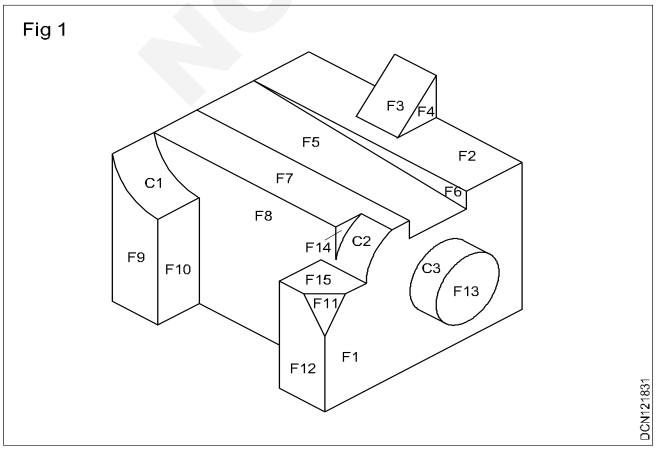


Projection of plane figures

Objectives: At the end of this lesson you shall be able to
- **distinguish between a two dimensional and a three dimensional figure**
- **identify the type of surfaces the object is composed of**
- **explain as to how the projection of a given surface will be on the different planes of projection**
- **state the meaning of the term true shape and the condition to obtain true shape and the views.**

Types of surfaces (Fig 1)**:** Surfaces may be flat or curved. Flat surfaces are also referred as planes. (Plain surfaces) Flat surfaces, depending on their orientation, may be vertical, horizontal or inclined. Fig 1 shows a solid and it has flat surfaces and curved surfaces. Flat surfaces are marked as F_1,F_2 etc.

Fig 1



Surfaces F_1,F_4,F_6,F_8,F_9,F_{10},F_{12},F_{13} and F_{14} are vertical surfaces.

F_2, F_7 and F_{15} are the horizontal surfaces.

C_1,C_2 and C_3 are the curved surfaces.

F_3, F_5 and F_{11} are inclined or oblique surfaces or their combination.

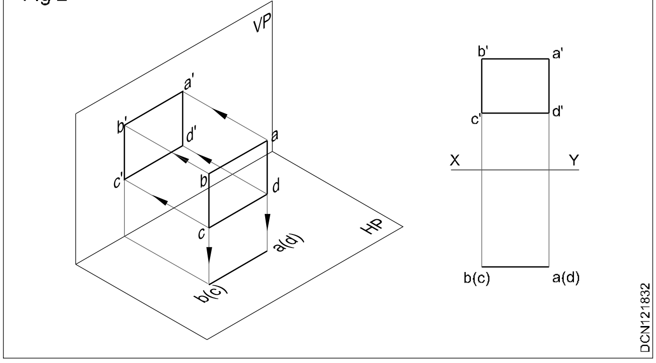
For example in F_3 is rectangular while F_{13} is circular. But surface F_1 is a combination of several plane figure.

Projection of Flat surfaces: While drawing the projection of surfaces (plane figures) the following points should be noted.

If the surface is parallel to the plane of projection, the resulting projection will be the true shape of the surface. (Fig 2)

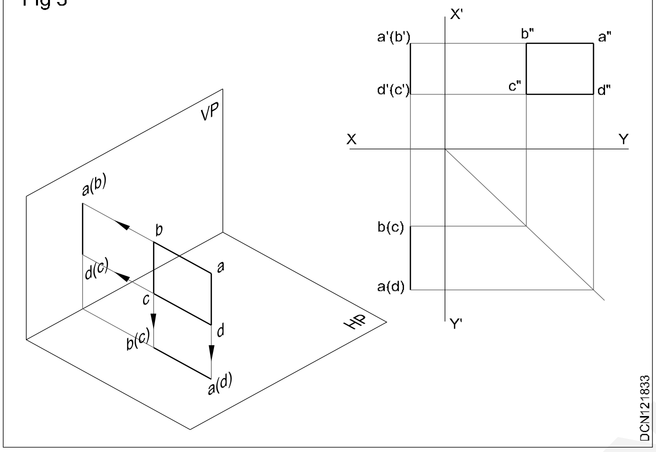
True shape: When the projection of a surface is identical to the surface projected, the projection is said to be of true shape.

Fig 2



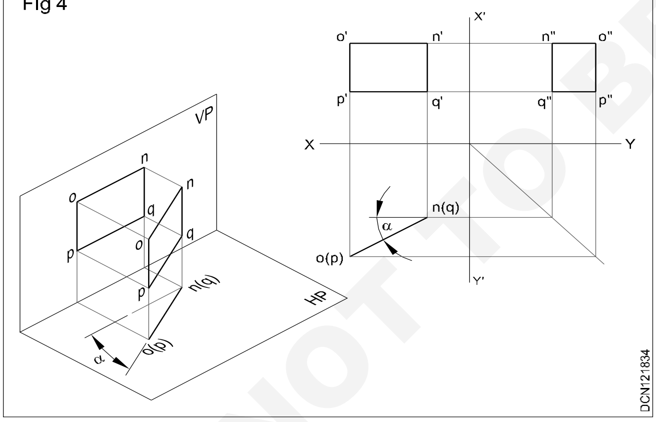
When the surface is perpendicular to the plane of projection, the resulting projection will be a straight line. (Fig 3)

Fig 3



If the surface is inclined to the plane of projection, its projection will not have the true dimensions. They are fore shortened. (Fig 4)

Fig 4



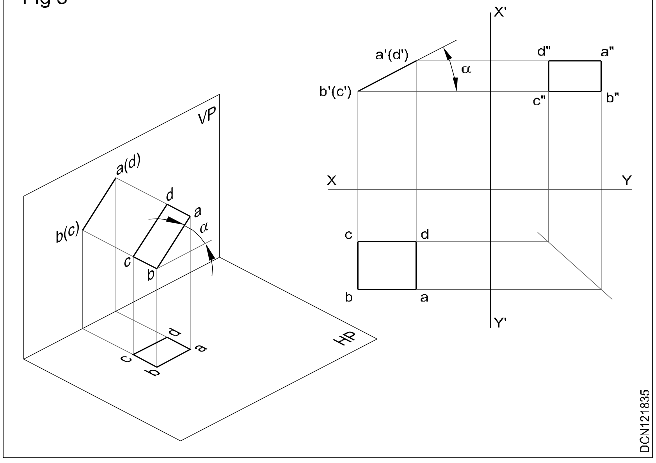
Foreshortened view: Where the projection of a surface is not identical tot he surface projected, the projection is said to be foreshortened.

In figure 4, the length pq or the length on is of true length in plan, but in front elevation and in side view same is foreshortened in a different way according to the inclination of the surface to the plane of projection.

If a surface is inclined to a vertical plane, the angle of inclination will be seen on HP and vice-versa. (Fig 4)

If a surface is inclined to horizontal plane the angle of inclination will be seen on VP and vice-versa. (Fig 5)

Fig 5

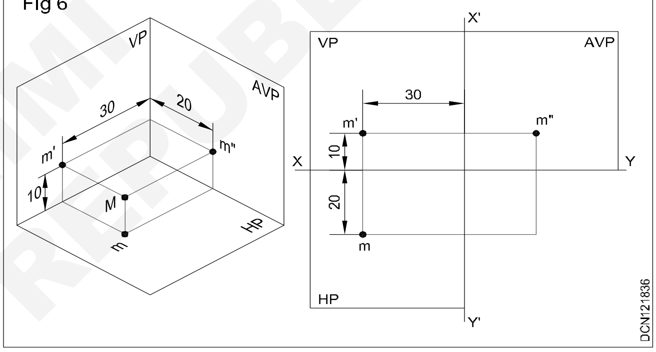


Guidelines to be followed: The intersection (folding lines) between HP and VP is marked as XY whereas the intersection between VP and AVP is marked as X'Y'.

In exercises/problems wherein the distances of the object (point, line, surface) from HP, VP and AVP are not given a convenient distances may be assumed and followed.

Terminology of views/projections (Fig 6)

Fig 6



– The view projected on HP is termed as plan or top view.

– The view projected on VP is termed as elevation or front elevation or front view.

– The view projected on AVP is termed as side view or end view or side elevation or end elevation.

The distance from XY to a point in the plan and to the corresponding point in the side view from X,Y, is equal to the distance from VP.

The distance from XY to point in the front elevation and to the corresponding point in the side view from XY is equal to the distance of the point from HP.

The distance from X,Y, to a point in the front elevation and the corresponding point in the plan from X,Y, is equal to the distance of the point from AVP.

The above three statements may be summerised as follows:

the distance of a point from one plane will not reflect in the projection on that plane, but it will be reflected in the projections of other planes.

This can be observed in the figure shown.

Point M is 10 mm from HP, 20 mm from VP and 30 mm from AVP.

In the figure B, the projections of point M in the three planes and distances from XY and X_1Y_1 are marked.

Point M is really 10 mm from HP, but the distance of 10 mm is not reflected in HP. Similarly 20 mm is not reflected in VP and 30 mm is not reflected in AVP.

Distance of 10 mm from HP is reflected in front and side views.

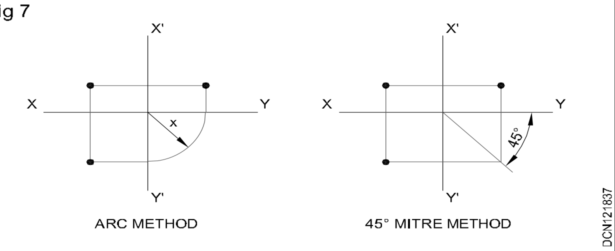
Distance 20 mm from VP is reflected in plan and side view.

Distance 30 mm from AVP is reflected in plan and front view.

If we know the projection of point in two planes, its projection to third plane can be obtained by projecting from the given/known two views and transfering distances.

For example, if you draw the front view and side view of a point (Fig 7), plan can be completed by drawing projection from the front view and side view. Transfer of distances from two views to third view may be done either by arc method or by 45° mitre line method.

Fig 7



Following standard conventional markings are to be followed for points, lines and surfaces on plan, front view and side views.

Plan	Final	just an alphabet	(a)
	1st stage		(a1)
	2nd stage		(a2)
Elevation	Final	alphabet with a dash	(a')
	1st stage		(a1')
	2nd stage		(a2')
Side elevation	Final	alphabet with two dash	(a")
	1st stage		(a1")
	2nd stage		(a2")

Isometric projection

Objectives: At the end of this lesson you shall be able to
- **state the method of isometric projection**
- **explain isometric scale**
- **explain box method of isometric view**
- **explain off set method of isometric view.**

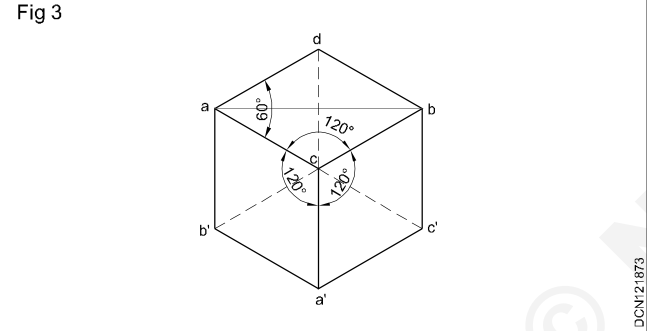
Isometric scales are used to get the fore shortened lengths required for isometric projection.

Before constructing an isometric scale, you must understand is the relationship between the true length of an edge and the length of the same in isometric projection.

To determine the relationship between the true length and corresponding length in isometric projection, proceed as follows:

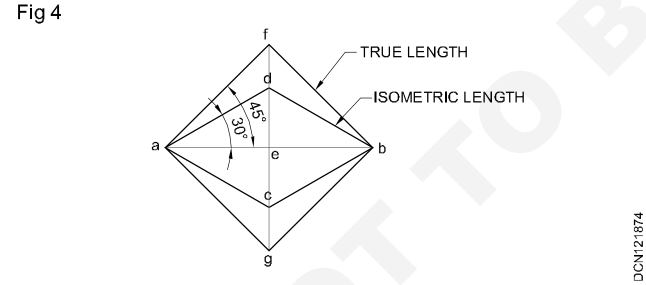
Consider the isometric projection of a cube. (Fig 1)

Fig 3



Separately draw the top face of the cube adbc and join the longer diagonal ab. (Fig 2)

Fig 4



Note that the diagonal ab is of same length both in the isometric view of the face and the true face. Assume the top true face of teh cube as afbc.

Now superimpose the true top face afbg keeping the diagonal ab common. (Fig 2)

$\angle FAE = 45° \text{and} \angle DAE = 30°$

x $AE = AF \times Cos45° \text{and} AD = AE \div Cos30° = AF \times$

$$\frac{\text{Isometric length}}{\text{True length}} = \frac{AD}{AF}$$

$$\frac{AD}{AF} = \frac{AF \times Cos45°}{AF \times Cos30°} = \frac{Cos45°}{Cos30°}$$

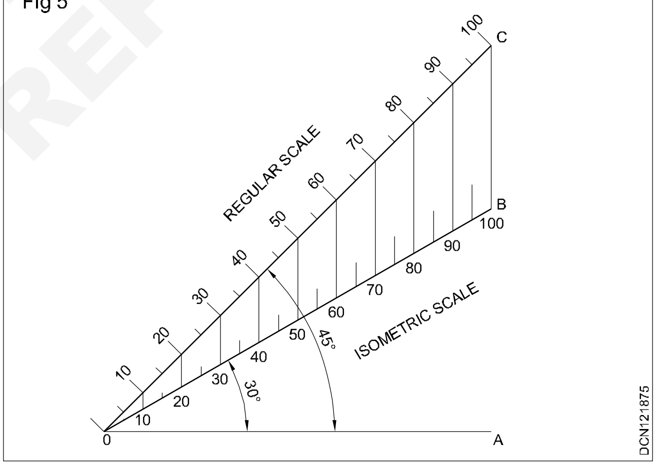
$$\frac{AD}{AF} = \frac{AF \times Cos45°}{AF \times Cos30°} = \frac{Cos45°}{Cos30°} = 0.8165$$

AD = 0.82 AF. This means that the length of a line in isometric projection is 0.82 times of it true length. While drawing an object in isometric projection, the dimensions on or parallel to isometric axes are reduced to this proportion. To make things easier we can construct a scale to the above ratio. Such a scale is called as isometric scale.

Procedure to construct

Isometric scale (Fig 3)

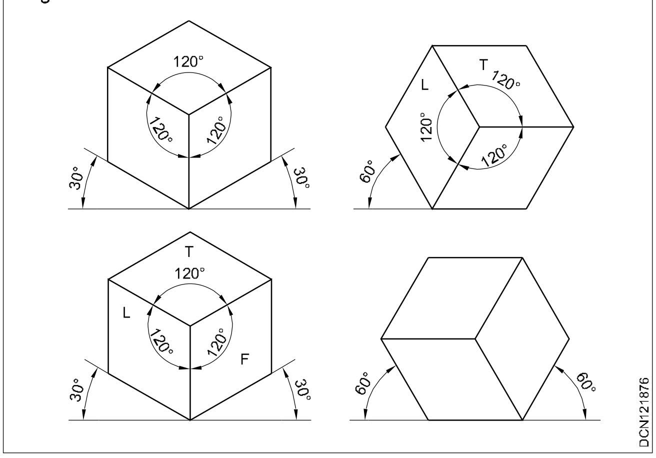
Fig 5



- Draw a horizontal line OA.
- Draw lines OB and OC making 30° and 45° with OA respectively.
- Mark 5 mm, 10 mm, 15 mm upto 100 mm on line OC.
- From the marked points on the regular scale OC, draw perpendiculars to OA meeting at OB.
- Print the corresponding values on the line OB resulting in the isometric scale.

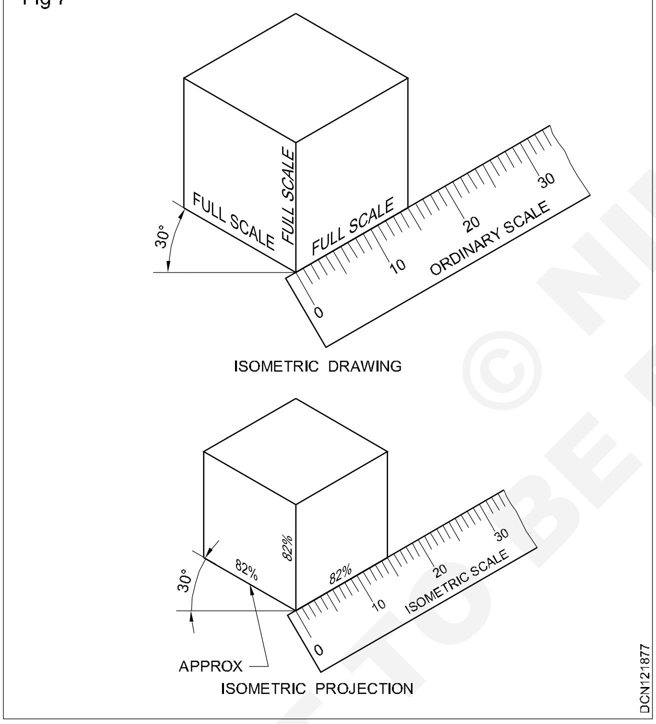
Orientation of isometric axes: While the isometric axes make 120° to each other they may have different orientation as shown in Fig 4. Each of the orientation show3 of the 6 faces (left, right, top, bottom, front and rear) are shown in different combinations.

Fig 6



Isometric view and Isometric projection: A drawing is made with true lengths (dimensions) is called isometric view or isometric drawing. Whereas the same drawing made with isometric lengths is termed as isometric projection. (Fig 5)

Fig 7

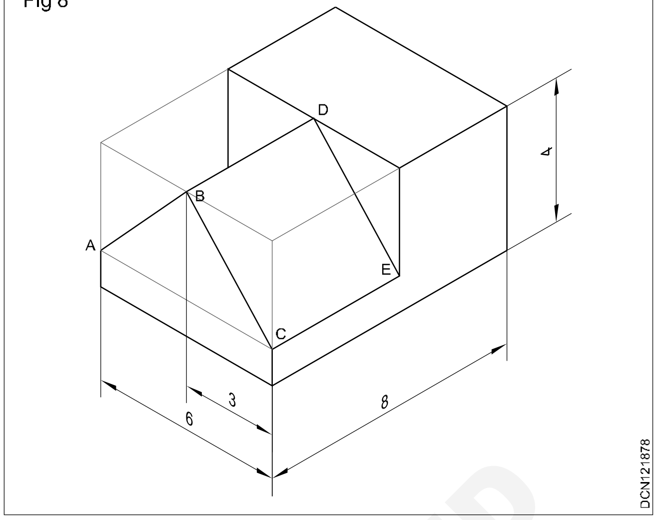


Isometric and non-isometric lines: Fig 6 shows the isometric view of a shaped block. Here all lines except AB, BC and DE are parallel to isometric axis. Lines such as then which are parallel to isometric axes are called isometric lines whereas such as lines AB, BC and DE which are not parallel to isometric axes are called non-isometric lines.

The length of non-isometric lines will not follow the scale used for isometric lines. To proove this point consider the non-isometric lines AB or BC. The true length of both AB and BC is 5 cm while BC will be longer. Because of this reason non-isometric lines are drawn first by locating their starting and end points on isometric lines.

To locate the end points and to draw the non-isometric lines two methods are employed. They are

Fig 8



– Box method

– Off-set method

Box method: The object is assumed to be inside a rectangular box. Starting and end points are located and marked. By joining the points isometric view is drawn.

Off-set method: This method is most suited for the objects consisting of number of planes at a number of different angles.

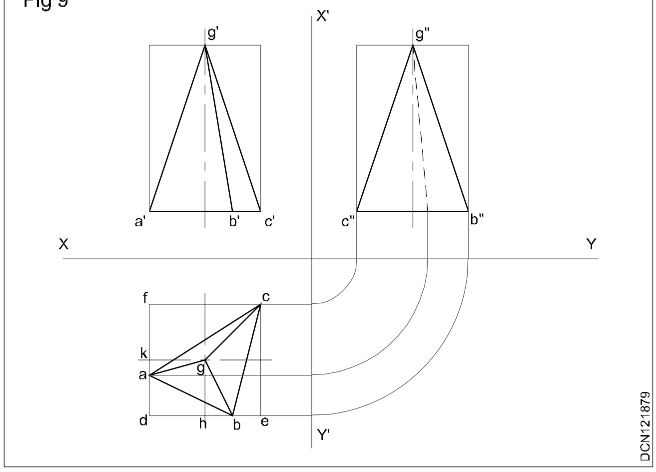
These methods are not only useful for isometric views involving non-isometric lines but also for the isometric views involving isometric lines.

Box method of drawing a pyramid

Example

Draw an isometric view for the triangular pyramid shown in Fig 7 using a box method.

Fig 9

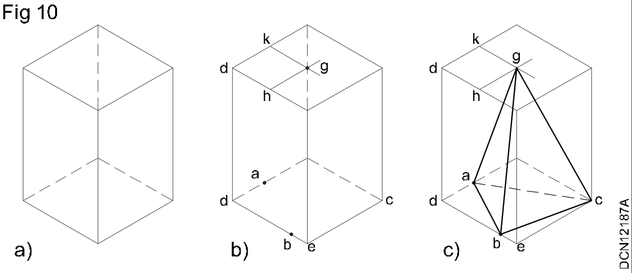


– Construct a rectangular box to the overall size of the pyramid (Fig 8a)

– Mark the distances ad and be from the plan of Fig 7 in the base of the box.

– Mark the distances kg and dh on the top face of box. (Fig 8a)

Fig 10



– Join the points AB, BC, CA, AG, BG and CG and complete the isometric view of the pyramid in box method. (Fig 8b)

Off-set method of drawing a pyramid

Example

Same triangular pyramid (Fig 7) is considered for drawing isometric view using offset method.

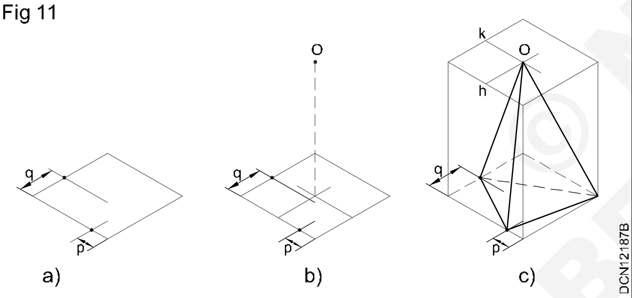
– Draw an isometric square/rectangle considering the corners of the base of the pyramid. (Fig 9a)

– Locate the corners 1,2 & 3 with help of offsets P and Q.

– Locate the projection of the vertex O_1 on the base by offsets x and y and draw the vertical centre line O_1O to the height of the pyramid. (Fig 9b)

– Join 1-2, 2-3, 1-3, 0-1, 0-2, 0-3 and complete the isometric view of the pyramid. (Fig 9c)

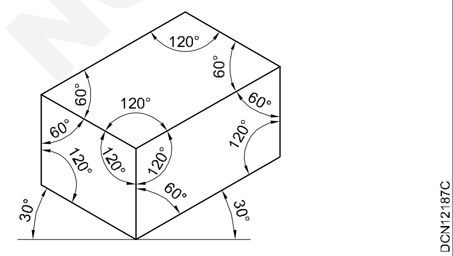
Fig 11



Angles in isometric projection: The angles of inclined surfaces will not have true value in the isometric projection, but will be more in some cases and less in other cases.

For example, in the isometric view of prism shown in Fig 10 the true value of all the angles is 90°. But in isometric projection the angles are 60° in some cases and 120° in others.

Fig 12



Isometric circles: The term isometric circle refers to the shape of circle in isometric view. An isometric circle will be elliptical in shape as shown in Fig 11 while drawing isometric view of cylindrical features isometric circles will have to be used. (Fig12)

Fig 13

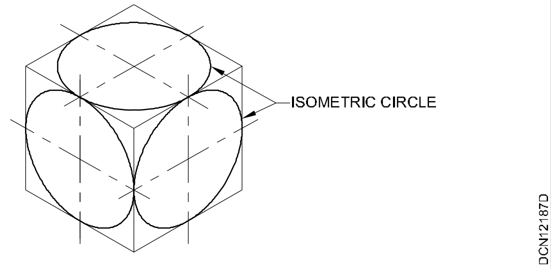
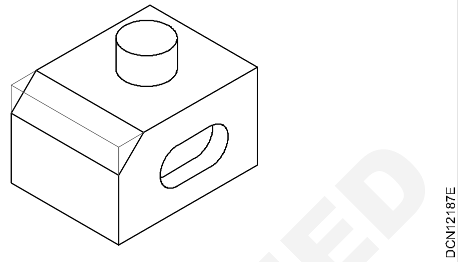


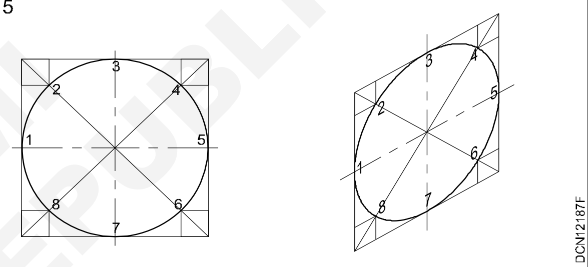
Fig 14



An isometric circle can be drawn either be plotting/offset method or by arc method.

Plotting method (Fig 13)

Fig 15



– Draw a square of side equal to the dia of circle and inscribe the circle.

– Divide the circle into any number of equal parts and mark points such as 1,2,3,4,5,6,7,8 on the circle.

– Through the points 1,2,3 etc draw lines parallel to the both the axis of cylinder.

– Draw isometric view of the square.

– Mark points corresponding to 1,2,3....8 with isometric view of the square as points 1',2',3'....8'.

– Join these points with a smooth curve to for an ellipse.

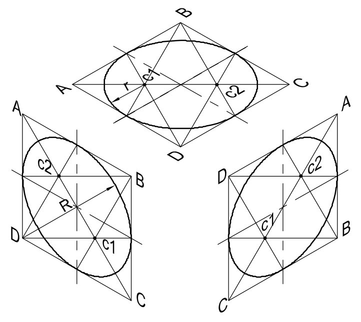
Note: The orientation of the isometric circle will depend upon the plane on which the circular feature exists.

Arc method: Isometric circles drawn by offset method is the ideal method of making isometric circles as the ellipse obtained this way is geometrically true. But by free hand we cannot get a clear line.

Fig 14 shows the construction of isometric circle in 3 different orientation by arc method. Four arcs are to be drawn and the centres an C_1, C_2, B & D. While centre B and D are the corner of the rhombus C_1 and C_2 are intersection points of the longer diagonal with lines from points B or D to the mid point of the side of the rhombus.

Note: The arc method gives a clean ellipse, but this ellipse drawn this way will slightly deviate from true ellipse. It does not matter for our purpose.

Fig 16



The isometric circles can also be drawn using templates which can be bought from stationary shops.

Isometric views profiles: The profile MN of the block shown in Fig 15 is irregular in nature. The isometric views of such lines may be drawn by offset method described earlier. The points 1,2,3 and 4 lie on the profile. Lines A-1, B-2, C-3, D-4 are isometric lines and their length are same both in Fig 15 & Fig 16. After getting the points 1,2,3 & 4, they joined by smooth curve.

Fig 17

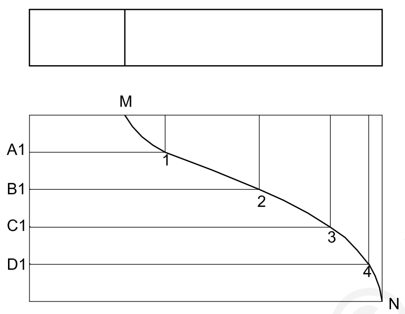
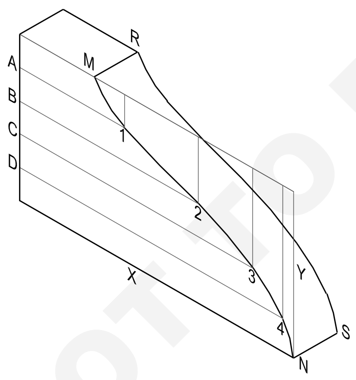


Fig 18



Note: In offset method more the number of points, better will be the accuracy of the curve.

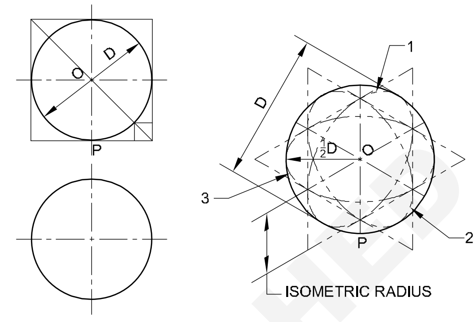
Isometric projection of sphere: The Orthographic view of a sphere seen from any direction is a circle of diameter equal to the diameter of the sphere. Hence, the isometric projection of a sphere is also a circle of the same diameter.

The front view and the top view of a sphere resting on flat surface are shown in Fig 17a.

O as its centre, D is the diameter and P is the point of contact with the surface.

Assume a vertical section the centre of the sphere. Its shape will be a circle of diameter D. The isometric projection of this circle are ellipses 1 & 2 Fig 17(b) drawn in two different vertical positions around the same centre O. The major axis in each case is equal to D. The distance of the point P from the centre O is equal to the isometric radius of the sphere.

Fig 19



Again, assume a horizontal section through the centre of the sphere.

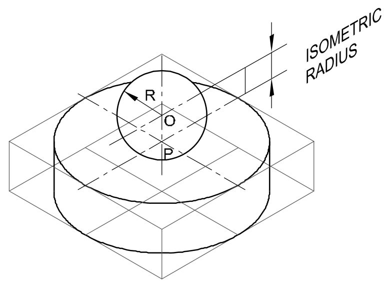
The isometric projection of this circle is shown by the ellipse 3, drawn in a horizontal position around the same centre O. In all the three cases 1,2 & 3 the outermost points on the ellipse from the centre O is equal to 1/2 D.

Thus, it can be seen that in an isometric projection, the distances of all the points on the surface of a sphere from its centre are equal to the radius of the sphere. Hence, the isometric projection of a sphere is a circle whose diameter is equal to the true diameter of the sphere.

Also the distance of the centre of the sphere from its point of contact with the flat surface is equal to the isometric radius OP of the sphere.

It is therefore of the utmost importance to note that isometric scale must invariably be used while drawing isometric projection of solids in conjunction with spheres or having spherical parts.

Fig 20



Geometrical solids

Objectives: At the end of this lesson you shall be able to
- **define various geometrical solids**
- **define solids of revolutions**
- **state the method of drawing the three views of solids in different position**
- **auxiliary view**
- **sectional views.**

Solids: Solids are the objects which have definite shape, size and occupies certain space. They have three dimensions viz., length, breadth or width and height. According to their shapes. They are classified into two groups.

– Polyhedra

– Solid of revolution

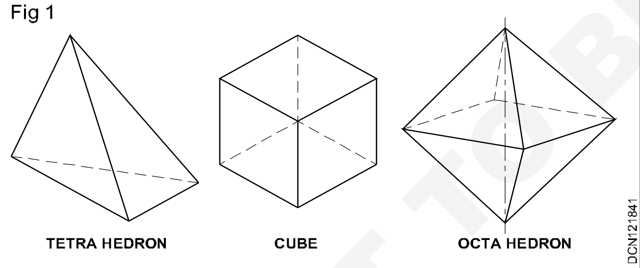
Polyhedra: are solids having (poly-many) more than thre flat surfaces called faces. The ends of surfaces meeting with each other are called edges. When the faces are identical to each other, they are called `Regular Polyhedra'. Depending on the number and shape of faces regular polyhedrons are named. Of the many regular polyhedrons three are defined below:

Tetrahedron: A solid having four equilateral triangular faces solid having least number of flat surfaces.

Cube or Hexahedron: A solid having six regular square faces.

Octahedron: A solid having eight equilateral triangular faces. (see Fig 1)

Fig 1

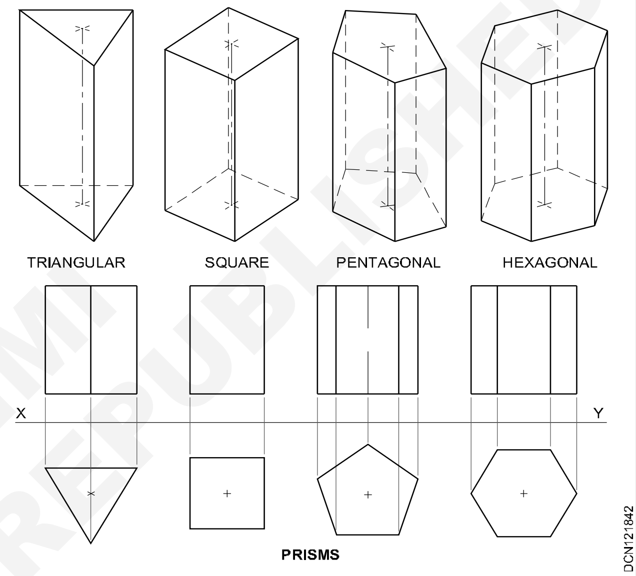


When solids are not composed of identical surfaces, such polyhedrons are either Prisms or Pyramids.

Prism: Prism is `Polyhedron' having two identical end faces. The top and bottom base surfaces are joined by parallelograms or rectangular surfaces. Imaginary line joining the centre of the end faces is called the axis. The axis is right angles to the end faces. Prisms are in general designated according to the shape of the end faces. Eg. Square, rectangular, triangular, hexagonal, pentagonal, octoganal (Prisms) etc. Prisms are right or oblique, the axis of regular prisms is at right angles to the face. Whereas in oblique prisms the axis is inclined to the end face. (Fig 2)

Pyramids: Pyramids are polyhedra solids having a base surface whose shape may be triangular, square or polygon and as many slant triangular faces as there are sides in the base. All the slant triangular faces join at a common point called APEX.

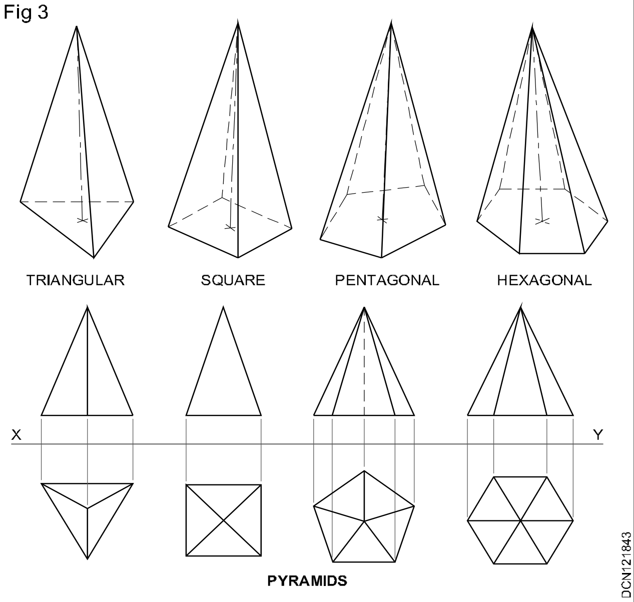
Fig 2



Similar to prisms, pyramids also are known by the shape of their base viz triangular, square, rectangular, pentagonal, hexagonal etc. The imaginary line joining the centre of the base to the apex is called the AXIS.

Fig 3 shows some pyramids and their views.

Fig 3

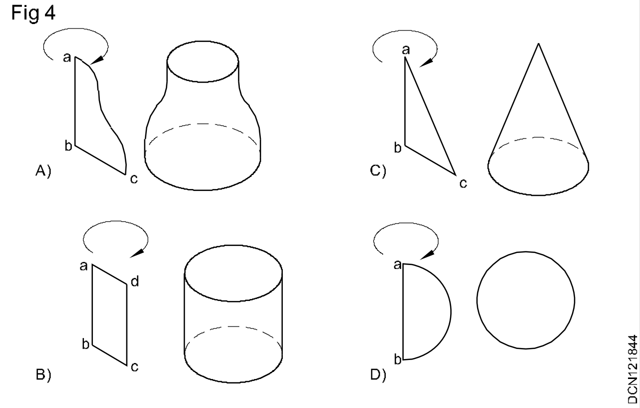


Solids of revolution: When a plane figure revolves about an axis a solid is generated.

Example

The solid shown in the Fig 4 is formed by the revolution is formed by the revolution of the plane (Fig 4a) ABC about the axis AB.

Fig 4



Geometrical solids like cylinder, cone and sphere are solids of revolutions.

Cylinder: When a rectangle rotates about one of its sides a cylinder is generated.

Cylinder has two flat circular faces and a curved surface. (Fig 4b)

Cone: When a right angled triangle revolves about one of its side formign the right angle, a cone is generated. Cone forming has a circular face and a slant curve surface. (Fig 4c)

Sphere: When a semi-circle revolves about its diameter a sphere is generated. A sphere has no flat surface. (Fig 4d)

The term solids of revolution is a mathematical concept and a physical requirement in geometry.

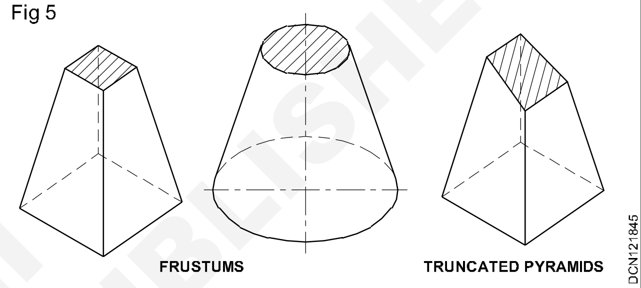
Frustums: When the pyramids or cone are cut parallel to the base and top of remaining the pyramid or cone is removed, the parts are called frustums.

If the cutting plane is at an angle to the axis/base, of the pyramids or cone they are called "Truncated pyramids or cones".

Fig 5 shows frustums and truncated pyramids.

All items we use are solids. Their shapes may confirm to individual geometrical solids like prisms, cones or other combination.

Fig 5



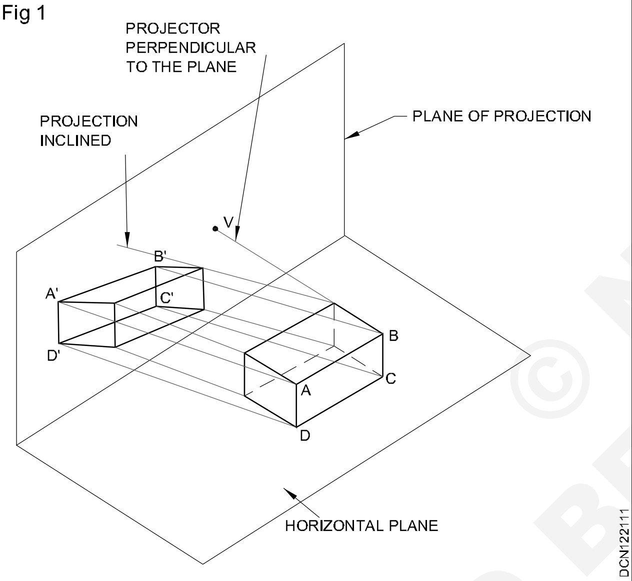
Oblique projection

Objectives: At the end of this lesson you shall be able to
- **state what is an oblique view**
- **compare oblique view with isometric view**
- **identify the different types of oblique views**
- **explain various angle used for drawing oblique views**
- **list the hints on positioning and drawing oblique views.**

Oblique projections are yet another type of pictorial projections, they differ from isometric projections in two ways.

– In oblique projections, projections are oblique (inclined) to the plane of projection. whereas in isometric projections projectors are perpendicular to the plane of projection. (Fig 1)

Fig 1

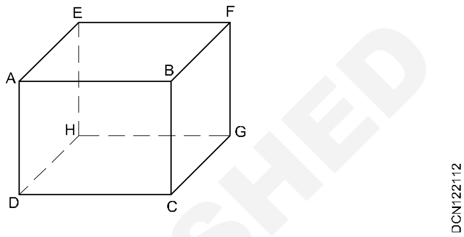


– In an oblique projection one of the principal faces of the object is kept parallel to the plane of projection, but in isometric, none of the faces of the object is parallel to the plane of projection.

Even though one of face of the object is positioned parallel to the picture plane, we still get a pictorial view and the projections are inclined to both HP and VP.

Because one of the principle faces of the object is parallel to the plane of projection. In the oblique projection, the projection of this face and faces parallel to it will appear in true size and shape. In the oblique projection of a prism is shown in Fig 2, the faces ABCD and EFGH are parallel to the plane of projection and they appear to be true in size and shape. The other four faces which are perpendicular to the plane of projection do not appear in true shape. (all these four faces are seen as parallelogram) However the vertical edges of these faces are parallel to the plane of projection and hence the projection of these edges will measure to their true lengths.

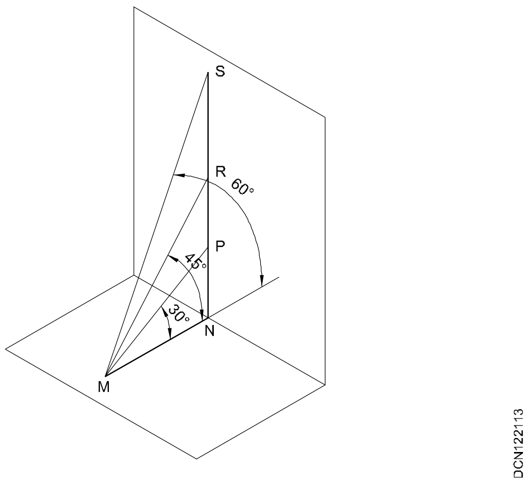
Fig 2



Projection of edges such as AE, DH, BF and CG which are perpendicular to the plane of projection will measure differently depending on the angle of inclination of the projectors. If the inclination of the projectors is 45° the projections of these edges measure to their true lengths. If the angle is less than 45° the projection of such perpendicular edges will measure less than the true length, if the angle of inclination of the projectors is greater than 45°. Projection of such perpendicular edges will measure more than the true length.

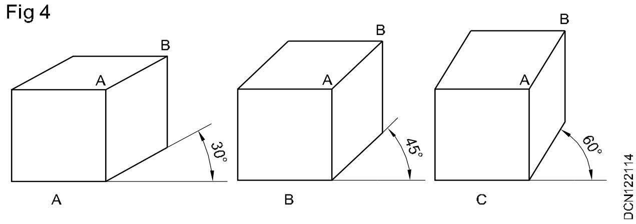
In the Fig 3, a line MN is drawn perpendicular to the plane of projection. NP, NR and NS are its projection when the projectors are 30°, 45° & 60° respectively. NR is equal to MN, NP is less than MN and NS is greater than MN.

Fig 3



Figures 4a,b and c shows the oblique views of a square prism when the angle of the projectors are 30°, 45° & 60°. Because of the variation of the length of edges (AB) which are perpendicular to the plan of projection the views give a rather distorted picture of the prism. This is a disadvantage of oblique projections over isometric projections.

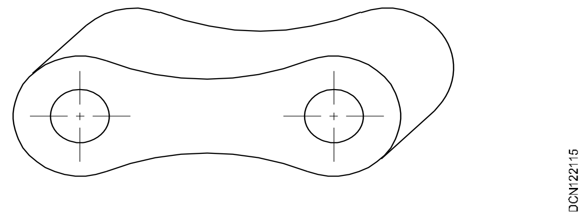
Fig 4



Oblique projections nevertheless have an unique advantage what we want to make pictorial drawings of object having curved features. For making isometric views of a curved feature we have first to draw their orthographic views in order to find out the offsets of points lying on the curve. But this difficult procedure is not necessary in the case of oblique views.

For example the component shown in Fig 5 has several curved features. While drawing oblique view of this component the curved features are drawn to true shape using compass. This is relatively easier method in comparison to the drawing of the same component in isometric view.

Fig 5



Perspective views

Objectives: At the end of this lesson you shall be able to
- **explain perspective projection**
- **explain various terms used in perspective projection**
- **differentiate between the three types of perspective views.**

Perspective projection: Perspective projections are pictorial views that look more like a photograph or rather it is a pictorial view similar to how an object looks like when it is viewed by the human eye. The basic characteristic of a perspective view is that parallel feature look tapered or converging as the distance from the feature increases from the observer's eye. (Fig 1) whereas in axonometric and oblique projections the projectors are parallel to each other. (Fig 2)

For producing a perspective view/projection, you should be familiar with the following terminologies. (Fig 3)

Fig 1

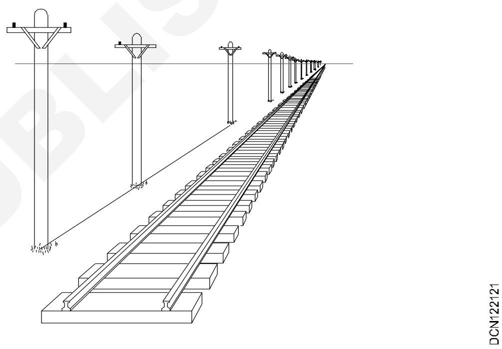


Fig 2

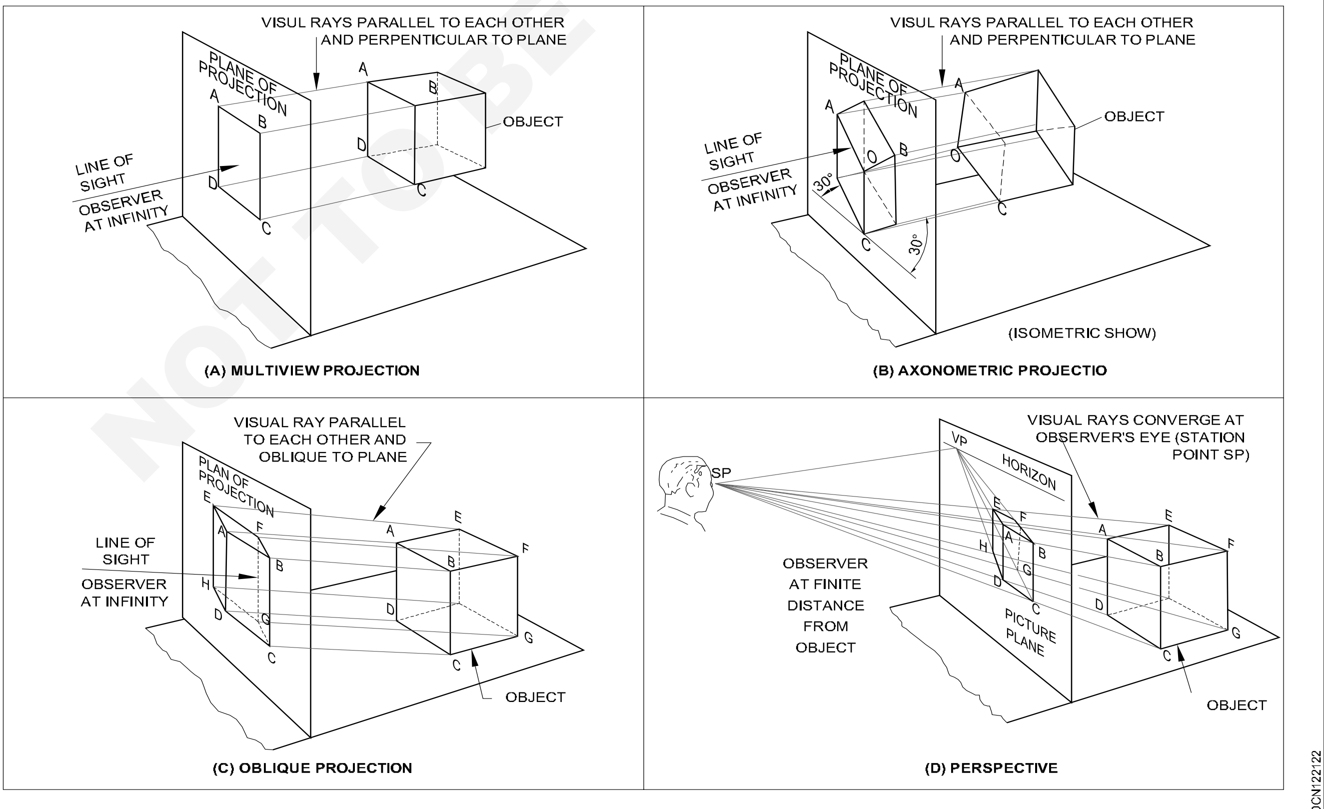
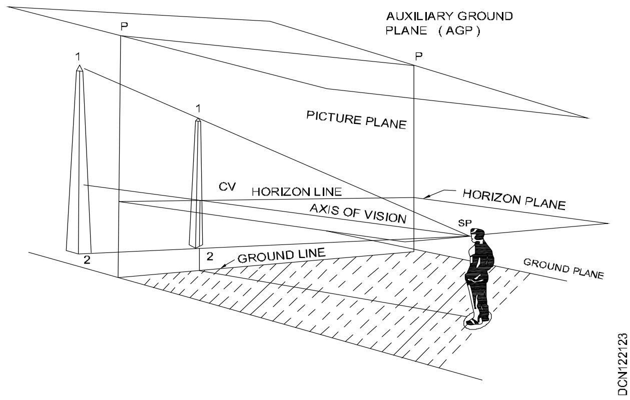


Fig 3



Ground plane (GP)**:** It is the horizontal plane on which the object is assumed as resting on which the observer stands.

Station point (SP)**:** It is the point where the observer's eye is located while viewing the object.

Picture plane (PP)**:** It is the (imaginary) vertical plane, resting between the station point and the objects being viewed. This is the plane (surface) on which the perspective view is formed.

Ground line (GL)**:** It is the line of intersection of the picture plane with ground plane.

Horizon plane (HP)**:** It is an imaginary plane, at the level of the eye i.e. station point. It is a horizontal plane above the ground plane and at right angle to the picture plane.

Auxiliary ground plane (AGP)**:** This plane is placed above the normal HP and the object. The view from top view (TV) of the object and of the perspective elements are projected on this plane.

Horizontal line (HL)**:** It is the line of intersection of horizontal, plane and the picture plane.

Axis of vision or perpendicular axis (PA)**:** It is the line drawn through the station point perpendicular to the picture plane.

Centre of vision (CV)**:** It is the point on the picture plane where at which the perpendicular axis passes through the picture plane.

Central plane (CP)**:** It is the imaginary vertical plane, which passes through the station point and the centre of vision. It is perpendicular to the picture plane as well ground plane.

Position of station point: Station point is the viewing point and its location should be where the object can be viewed to the best advantage.

The appearance of the finished perspective drawing depends very much on the position of the station point and hence considerable care must be exercised in selecting its location. The following points may serve as guidelines for selecting the location of the station point.

– the distance from the picture plane to the station point shall be atleast twice the maximum dimension (width, height or depth) of the object.
– visual rays from the station point to the outermost boundaries of the object shall be within a cone having an angle of not more than 30°.
– the station point should be offset slightly to one side and should be located above or below the exact centre of object if the object is small.
– when making perspective of tall objects such as buildings the station point shall in at the eye level of the viewer who is standing on the ground.
– The location of the station point shall be fixed so that the angle between the visual rays from the station point and the outermost boundaries of the object is approximately 30°. (Fig 5) If this angle is very wide, the picturisation may not be good.

Position of object

– The object is assumed to be placed on the ground plane. (GP)
– The object is placed either with one principal face parallel or at an angle to the picture plane.
– If kept at an angle the value of the angle shall be 30° for objects like rectangular prism. (Fig 4)

Fig 4

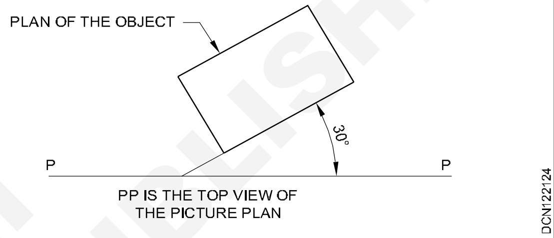
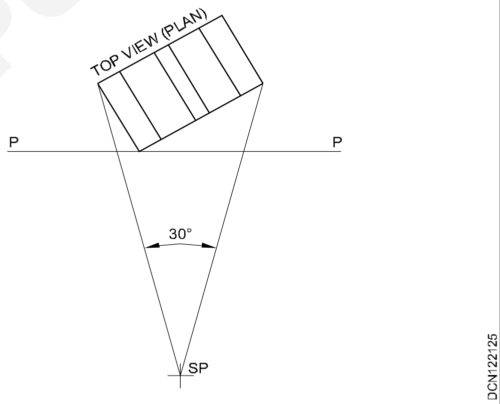


Fig 5



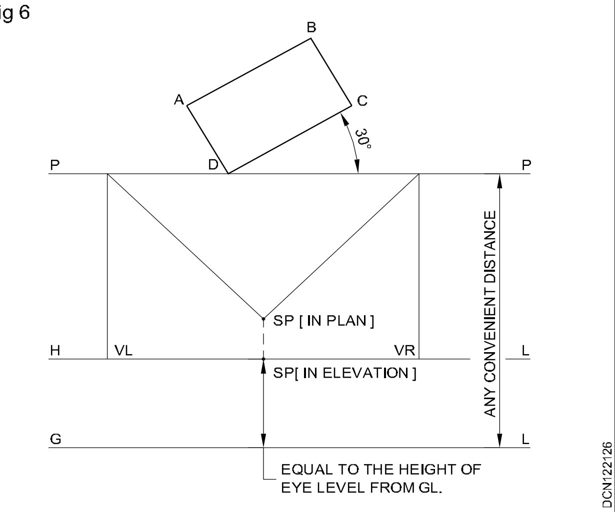
The position of the picture plane with reference to the object determines the size of the perspective view. When the object is placed behind the picture plane, the view is reduced as it is moving towards the picture plane, the view increases. When the object is placed in front of the picture plane, the view is bigger than the object. If the object is on the picture plane, the height of the view is same as the object.

Vanishing point (VP)**:** It is a common knowledge that parallel features like the one shown in Fig 6 appears to meet at a point in infinity and this point is termed as "Vanishing point".

In practice, the point at which the visual ray from the eye (station point - SP) to that infinitely distant vanishing point pierces the picture plane is referred to as the vanishing point.

Note that the vanishing point will be at the same height as that of station point and will lie on the horizon line (HL).

Fig 6



Procedure for determination of vanishing point

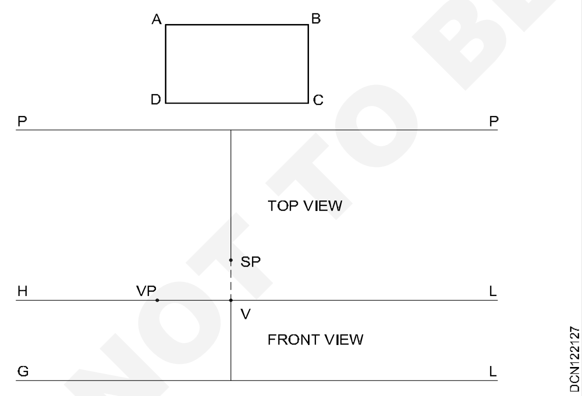
– Draw three parallel lines PP, HL and GL to represent picture plane (PP), Horizon plane (HP) and Ground plane (GP).

Note: In figure 6 the plane of the paper is the picture plane. The auxiliary GP (AGP) is rotated to bring it in plane with the picture plane. so the AGP extends above and below the line PP which also is the top view of the picture plane. The lines HL and GL are the elevations (front view) of horizon plane and ground plane respectively.

The distance between PP and GL may be decided as per our convenience. The distance between GL and HL will be equal to the height of station point. (eye level)

– Draw the plan of the object in the desired/defined positions. The plan will be above the line PP as the object is behind the picture plane or touching the picture plane. (In Fig 7 the plan of a rectangular prism is drawn)

Fig 7



– Mark the top view of the SP. This will be below the line PP. The picture plane is inbetween the SP and the object (rectangular prism).

– Draw the line from SP parallel to DC meeting PP at R.

– Draw the line from SP parallel to AD meeting PP at L.

– Project R and L vertically down to meet HP at VR and VL.

Now VR and VL an vanishing points at right and left of the object and they are at the same height as the height of SP.

Instead of placing the rectangular prism at an angle as in previous Fig. If it is placed such that one of its principle face is parallel to the picture plane there will be only one vanishing point as against two in the previous case. Because the lines AB and CD and parallel to the picture plane this set of lines will not have any vanishing point. The only vanishing point will be for the lines AD and BC which are perpendicular to the PP.

To obtain this vanishing point draw a line from station point (SP) parallel to AD (Perpendicular to PP), mark the point V and extend the line down to HL. The intersecting point on HL is the vanishing point V. This point incidentally coincides with the front view of station point and centre of vision.

Methods of drawing perspective views: Basically there are two methods for constructing perspective drawings. They are:

– Vanishing point method

– Visual ray method

Depending on the position of the object relative to the picture plane vanishing point method is further classified as

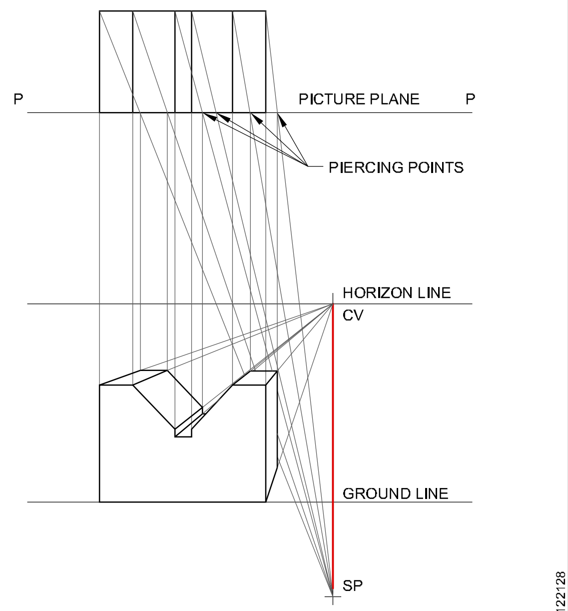
– One point perspective

– Two point perspective

– Three point perspective

One point perspective (Fig 8 & 9)**:** In this method the bottom face of the object is parallel to the ground and one of its vertical faces is parallel to the picture plane. One point perspectives are also called as parallel perspective. Fig 8 & 9 are examples of parallel perspective. Notice that there is only one vanishing point in both the examples and it coincides with centre of vision (V).

Fig 8

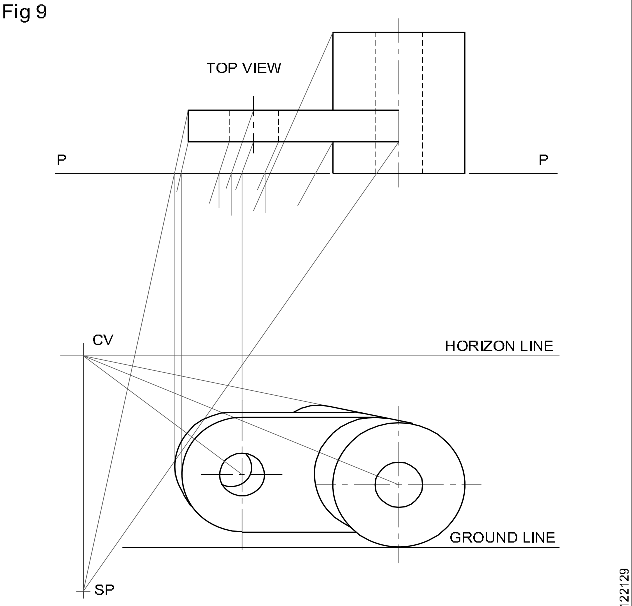


PARALLEL PERSPECTIVE

One point perspective has the similar advantage as oblique drawings in the sence that we can draw curved features parallel to the picture plane and draw the circular features using compass.

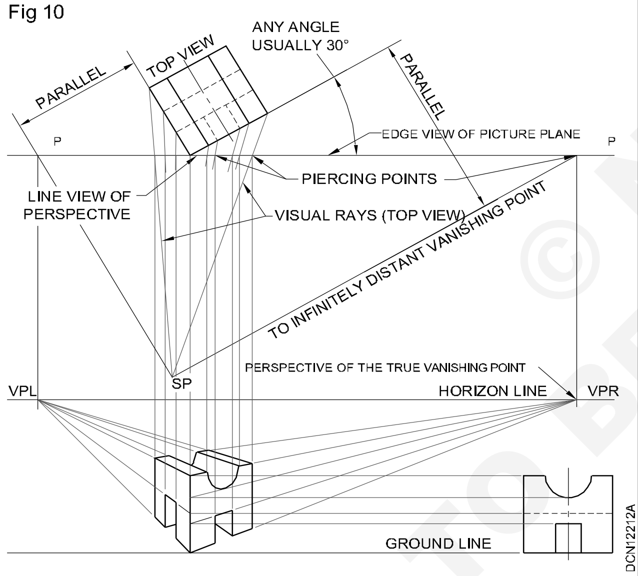
Two point perspective (Fig 10)**:** Also called as angular perspective. In this method of construction the vertical faces of the object are at an angle to the picture plane while the bottom face to parallel to the ground plane. As these are two sets of parallel edges, two vanishing points are required for this construction. Examples of two point/ angular perspective are shown in figures.

Fig 9



CIRCLE IN PARALLEL PERSPECTIVE

Fig 10



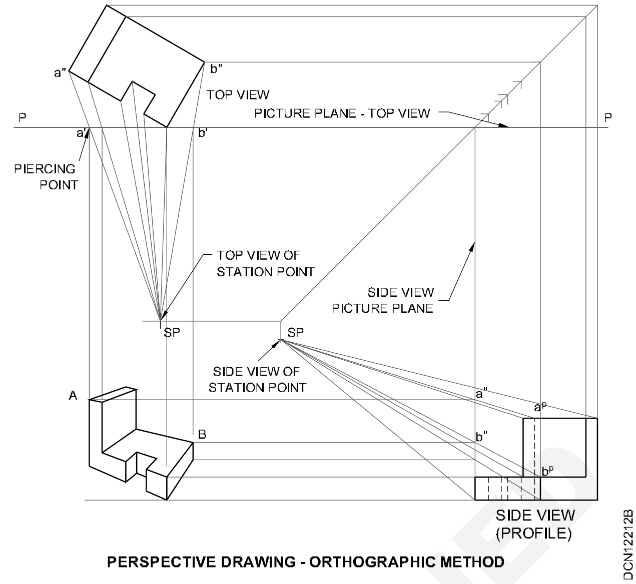
Three point perspective: In this type of perspective all the three prime faces are inclined to the picture plane. The object is placed in a similar fashion as in axonometric projection.

For such position of the object three vanishing points are required for making the perspective. This method is used only very rarely and hence it is not dealt in detail.

Visual ray method: Using this we can make a perspective drawing by projecting from the plan and elevation of the object. (Fig 11)

In figure the object is placed such that vertical faces are inclined to picture plane (This corresponds to the position for angular perspective). The side view for this position is drawn on the ground line. Now projectors are drawn from top view and side view for obtaining the perspective of the block.

Fig 11



PERSPECTIVE DRAWING - ORTHOGRAPHIC METHOD

The most generally used method for creating a perspective is two point method. (Angular perspective)

General procedure for making perspective drawing: The general steps for making perspective drawings are given below in the order of sequence. While reading these steps reference may be made to figures.

To make a perspective drawing

– Draw the top view (edge to the picture plane)

– Orient the object relative to the picture plane so that the object will appear to advantage, and draw the top view of the object.

– Select a station point that will best show the shape of the object.

– Draw the horizon and ground line.

– Find the top view of the vanishing points for the principal horizontal edges by drawing lines parallel to the edges, through the station point, and to the picture plane.

– Project from the top views of the vanishing points to the horizon line, thus locating the vanishing points for the perspective.

– Draw the visual rays from the station point to the corners of the object in the top view, locating the piercing point of each ray with the picture plane.

– Start the picture, building from the ground up and from the nearest corner to the more distant ones.

Reference : Detailed procedure for each of the methods of making perspective drawing is given in the relevant section of the exercise book.

Note: Pictorial drawing of the perspective type are more difficult to make in comparison to Axanometric and oblique drawings. Therefore it is not a method of preference to make pictorial views of machines and component. However it is very popular among architech as they can create photographic like picture of the finished building etc even before the construction begins.

Admixtures of concrete and application

Objectives: At the end of this lesson you shall be able to
- **state the classification of admixture by function**
- **uses of concrete admixture.**

Admixtures are those ingredients in concrete other than portland cement, water, and aggregates that are added to the mixture immediately before or during mixing (Fig 1) Admixtures can be classified by function as follows:

Fig 1

Liquid admixtures, from left to right : antiwashout admixture, shrinkage reducer, water reducer, foaming agent, corrosion inhibitor, and air-entraining admixture. (69795)

1 Air-entraining admixtures
2 Water - reducing admixtures
3 Plasticizers
4 Retarding admixtures
5 Hydration- control admixtures
6 Accelerating admixtures
7 Corrosion inhibitors
8 Shrinkage reducers
9 Alkali-silica reactivity inhibitors
10 Coloring admixtures
11 Miscellaneous admixtures such as workability, bonding, dampproofing, permeability reducing, grouting, gas-forming, antiwashout, foaming, and pumping admixtures.

1 **Air - entraining admixtures :** Air-entrained concrete contains minute air bubbles that are distributed uniformly throughtout the cement paste. Intrained air can be produced in concrete by use of an air-entraining cement, by introduction of an air-entraining admixture, or by a combination of both methods. An air-entraining cement is a portland cement with an air-entraining addition interground with the clinker during manufacture. An air-entraining admixture, on the other hand, is added directly to the concrete materials either before or during mixing.

2 **Water - reducing admixtures :** Water- reducing admixtures are used to reduce the quantity of mixing water required to produce concrete of a certain slump, reduce water - cement ratio, reduce cement content, or increase slump. Typical water reducers reduce the water content by approximately 5% to 10%.

3 **Plasticizers for flowing concrete :** Plasticizers, often called superplasticizers, are essentially high - range water reducers. Flowing concrete is a highly fluid but workable concrete that can be placed with little or no vibration or compaction while still remaining essentially free of excessive bleeding or segregation. Following are a few of the applications where flowing concrete is used; (1) thin-section placements (Fig 7), (2) areas of closely spaced and congested reinforcing steel, (3) tremie pipe (underwater) placements, (4) pumped concrete to reduce pump pressure, thereby increasing lift and distance capacity, (5) areas where conventional consolidation methods are impractical or can not be used, and (6) for reducing handling costs.

* Represents air content measured after addition of admixture

* Represents air content taken at point where slump falls below 25 mm (1 in.)

4 **Retarding admixtures** : Retarding admixturs are used to delay the rate of setting on concrete. High temperatures of fresh concrete (30°C (86°F) are often the cause of an increased rate of hardening that makes placing and finishing difficult.

5 **Hydration - control admixtures** : Hydration controlling admixtures became available in the late 1980s. They consist of a two part chemical system; (1) a stabilizer or retarder that essentially stops the hydration of cementing materials, and (2) an activator that reestablishes normal hydration and setting when added to the stabilized concrete. The stabilizer can suspend hydration for 72 hours.

6 **Accelerating admixtures** : An accelerating admixture is used to accelerate the rate of hydration (setting) and strength development of concrete at an early age. finishes.

7 **Corrosion inhibitors** : Corrosion inhibitors are used in concrete for parking structures, marine structures, and bridges where chloride salts are present. The chlorides can cause corrosion of steel reinforcement in concrete. Ferrous oxide and ferric oxide form on the surface of reinforcing steel in concrete. Ferrous oxide, though stable in concrete's alkaline environment, reacts with chlorides to form complexes that move away from the steel to form rust. The chloride ions continue to attack the steel until the passivating oxide layer is destroyed. Corrosion-inhibiting admixtures chemically arrest the corrosion reaction.

8 **Shrinkage - reducing admixtures :** Shrinkage-reducing admixtures, introduced in the 1980s, have potential uses in bridge decks, critical floor slabs, and buildings where cracks and curling must be minimized for durability or aesthetic reasons. Propylene glycol

and polyoxyalkylene alkyl ether have been used as shrinkage reducers. Drying shrinkage reductions of between 25% and 50% have been demonstrated in laboratory tests. These admixtures have negligible effects on slump and air loss, but can delay setting. They are generally compatible with other admixtures.

9 **Chemical admixtures to reduce alkali-aggregate reactivity (asr inhibitors) :** Chemical admixtures to control or reduction of alkali-silica reactivity (alkali-aggregate expansion).

10 **Coloring admixtures (Pigments) :** Natural and synthetic materials are used to make color concrete for aesthetic and safety reasons. Generally, the amount of pigments used in concrete should not exceed 10% by weight of the cement. Pigments used in amounts less than 6% generally do not affect concrete properties.

11 **Dampproofing admixtures** : The passage of water through concrete can usually be tracted tobe existence of cracks or areas of incomplete consolidation. Sound, dense concrete made with a water-cement ratio of less than 0.50 by mass will be watertight if it is properly placed and cured.

Permeability - reducing admixtures : Permeability-reducing admixtures reduce the rate at which water under pressure is transmitted through concrete. One of the best methods of decreasing permeability in concrete is to increase the moistcuring period and reduce the water-cement ratio to less than 0.5. Most admixtures that reduce water -cement ratio consequently reduce permeability.

Pumping aids : Pumping aids are added to concrete mixtures to improve pumpability. Pumping aids cannot cure all unpumpable concrete problems; they are best used to make marginally pumpable concrete more pumpable. These admixtuers increase viscosity or cohesion in concrete to reduce dewatering of the paste while under pressure from the pump.

A partial list of materials used in pumping aids is given in Table 1. Some admixtures that serve other primary purposes but also improve pumpability are air-entraining agents, and some water- reducing and retarding admixtures.

Bonding admixtures and bonding agents : Bonding admixtures are usually water emulsions of organic materials including rubber, polyvinyl chloride, polyvinyl acetate, acrylics, styrene butadiene copolymers, and other polymers. They are added to portland cement mixtures to increase the bond strength between old and new concrete. Flexural strength and resistance to chloride-on ingress are also improved. They are added in proportions equivalent to 5% to 20% by mass of the cementing materials.

Grouting admixtures : Portland cement grouts are used for a varity of purposes: to stabilize foundations, set machine bases, fill cracks and joints in concrete work, cement oil well, fill cores of masonry walls, grout prestressing tendons and anchor bolts, and fill the voids in preplaced aggregate concrete. To alter the properties of grout for specific applications, various air-entraining admixtures, accelerators, retarders, and nonshrink admixtues are often used.

Gas - forming admixtures : Aluminum powder and other gas- forming materials are sometimes added to concrete and grout in very small quantities to cause a slight expansion of the mixture prior to hardening.

Major reasons

The major reasons for using admixtures are:

1 To reduce the cost of concrete construction.

2 To achieve certain properties in concrete more effectively than by other means.

3 To maintain the quality of concrete during the stages of mixing, transporting, placing and curing in adverse weather conditions.

4 To overcome certain emergencies during concreting operations.

Sand

Objectives: At the end of this lesson you shall be able to
- **define sand**
- **state the characteristics of sand**
- **state the type of sand**
- **state uses of sand.**

Sand

- Sand particles consists of small grains of silica.
- Sand is formed by decomposition of sand stone due to various effects of weather. Decording to the material sources sand is obtained. Artificial sand is prepared by crushing stones and gravel to powder.

Characteristics of good sand

1 Sand should be clean and free from coatings of clay and silt.

2 Sand should be free from salt

3 Sand should be coarse, angular, hard and sharp grows

4 Sand should not contain organic matter.

5 It should be strong and durable

6 It should be chemically inert.

7 Sand should pass through 40.75 mm sieve and entirely retained on is sieve of 75 micron

Types of sand : There are three types of sand

1 Pit sand

2 River sand

3 Sea sand

1 Pit sand

- Pit sand is found as deposits in soil
- It is obtained by forming pits into soils.
- Sand is excavated from a depth of about 1 m to 2 m from the ground level.
- Pit sand consists of sharp, angular grains and also free from salts.
- For preparing mortar, clean the pit sand free from organic matter.

2 River sand

- River sand is obtained from bed of rivers
- River sand consists of fine round grains
- Colour of sand is almost white.
- River sand is available in clean condition
- This sand is used for purposes

3 Sea sand

- This sand is obtained from sea shore.
- Sea sand consists fine rounded grains like river sand
- The colour of sea sand is light brown.
- Sea sand contains salts.
- The salts absorb moisture from the atmosphere and causes dampross, efflorescence and disintegration of work.
- Sea sand retorts the setting action of cement
- Due to above reason, to avoid the use of sea sand for engineering works.

Classification of sand according to the size of grains

1 Fine sand

2 Coarse sand

3 Gravelly sand

1 Fine sand

- Sand passing through a sieve with clear opening of 1.5875 mm is known as fine sand. This sand is used for plastering.

2 Coarse sand

- Sand passing through a sieve with clear opening of 3.175 mm is known as coarse sand. This sand is used for masonry work.

3 Gravelly sand

- Sand passing through a sieve with clear opening of 7.62 mm is known as gravelly sand. This sand is used for concrete work.

Bulking of sand

- The presence of moisture is sand increases the volume of sand is called bulking of said.

Uses of sand

- Sand is used as binding materials to make the mortar economical.
- It is used for making mortar and concrete
- Sand helps in early setting of mortar
- Sand increases the density of mortar
- Sand is used to fill the basement.

Clay products (Tiles)

Objectives: At the end of this lesson you shall be able to
- **define ceramic**
- **state clay for ceramic**
- **explain technical terms of ceramic products**
- **classify and describe the tiles.**

Introduction : Ceramic means the technology and the art of making objects with clay and similar Materials by treating with fire. Clay products, refractories and glass come under this. As tiles in various forms are the principal ceramic products used in building.

Clay for ceramic : The special ceramic product requires its own type of special clay, even though ordinary earthenware's can be made from many types of ordinary clay. Fine white clay is required to manufacture porcelain articles. Refractory clay, which is special heat-resisting clay, is necessary for making refractories for chimney and ovens.

Classification of tiles

1 Common clay tiles for floors

2 Clay tiles for terraces

3 Clay tiles for ceiling

4 Glazed tiles for floors and walls

5 Vitrified tiles

6 Common clay roof tiles

7 Country roof tiles

(Encaustic tiles are the tiles initially painted with colours and the colours get fixed to the tiles with heat)

Clay floor tiles : There are generally salt glazed to give a good appearance. Floors made of these tiles, unlike cement floors, are more suitable for walking barefooted.

Clay terracing tiles: These tiles are to be made according to IS: 2690-1964.

Clay ceiling tiles : (IS: 1464-1959) these tiles are usually placed on reepers, over these ceiling tiles, Mangalore tiles are laid. They are generally given a floor pattern decoration on the exposed faces.

Glazed ceramic tiles : These tiles were exclusively used as wall tiles for bathrooms in hospitals etc. large size with thick glazing are being used for flooring in offices, airports, etc.

Fully-vitrified tiles : These tiles bridge the gap between ordinary ceramic tiles and marble floors. These tiles are especially used in kitchen floors as ordinary ceramic tiles are brittle and the full of any heavy object is liable to chip the ceramic tiles.

Porcelain tiles : These are available in many forms as plain, coloured and also with decorative patterns and sizes. They are rather expensive compared to the traditional floors.

Common clay roof tiles : There are many types of clay roof tiles. They are mostly used for covering sloped roofs, e.g.,

1 Mangalore pattern roofing tiles(Fig 1)

2 Half round country tiles (Spanish tiles) (Fig 2)

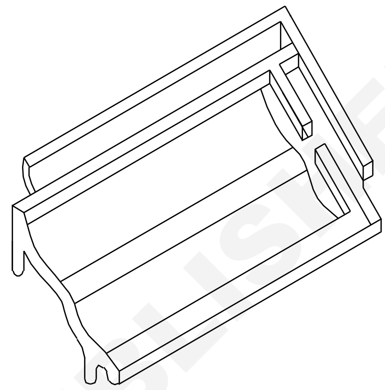
3 Allahabad tiles (Italian tiles) (Fig 2)

Mangalore pattern roofing tiles (Fig 1) : (IS: 654-1972) These are available in various shape and dimensions. They overlap on the tile below and also lock with the adjacent tile.

Clay half round country tiles (spanish tiles) : These are laid in pairs as under tiles and over tiles. These tiles are also sometimes placed over A.C. or G.I. sheets.

Allahabad tiles (italian tiles) : These are two types- the bottom and top tiles. The bottom tiles are flat, tapered with upturned flanges at the sides. The over tiles are half round and tapered.

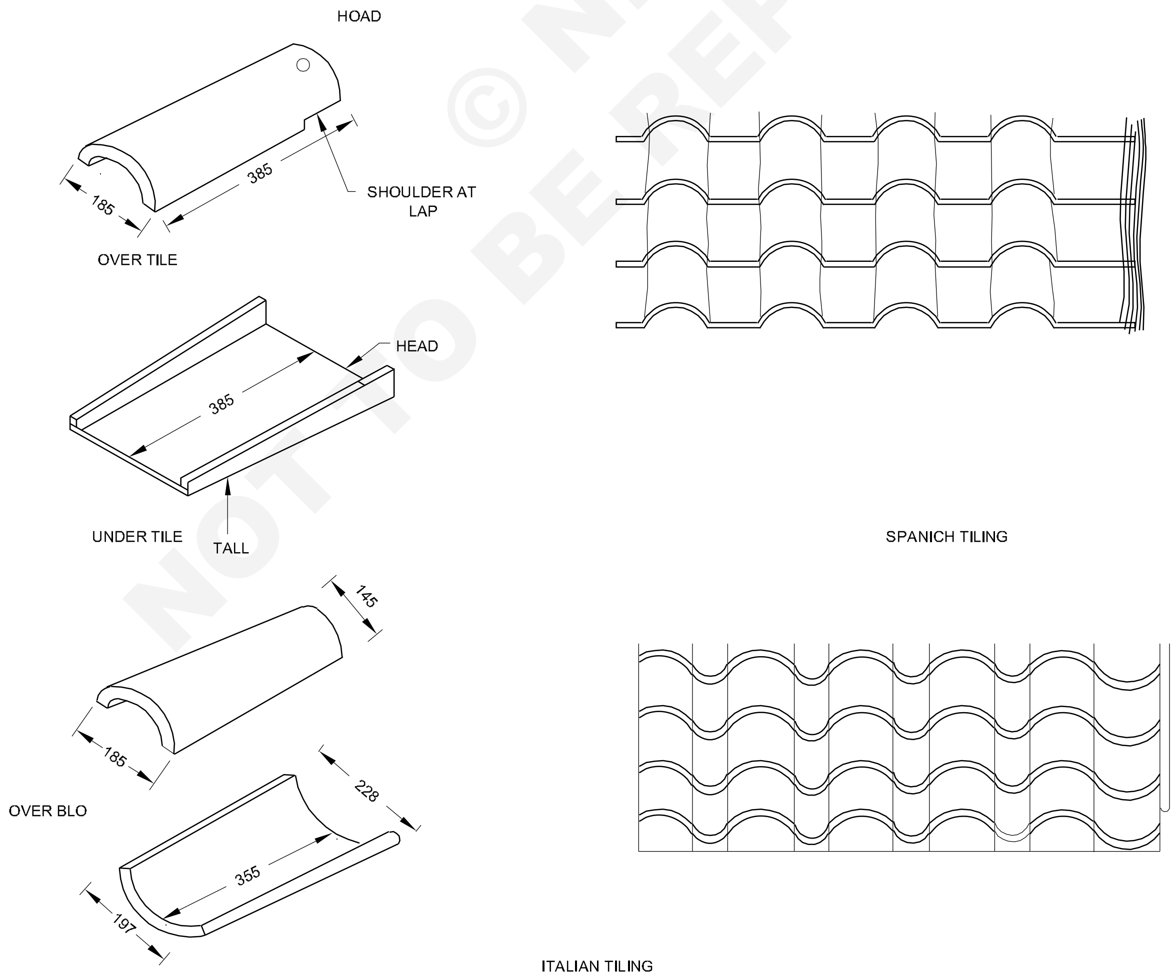
Fig 1



MANGALORE TILE

DCN122011

Fig 2



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Terra - cotta : The terra means earth and cotta means baked. Hence terrra-cotta means baked earth. It is thus a type of earthenware or porous pottery made from local clays and glazed with glazes contianing galena.It is soft enough to be scratched by a knife.

Varities of terra-cotta

The terra-cotta articles are of the following two types:

1 Porous terra-cotta 2 Polished terra cotta

Porous terra cotta : To prepare porous terra-cotta, the saw dust or ground cork is added in clay before the stage of moulding. When articles from such clay are burnt in a kiln, the organic particles are brunt and they have leave pores in the articles. The porous terra-cotta is a fire-proof and a sound-proof material. It can be chiselled, sawn and nailed easily with nails, screws, etc. It is light in weight, but it is structurally weak.

Polished terra-cotta : This is also known as fine terra-cotta or faience. To obtain this variety of terra-cotta, the article are burnt at a lower temperatrue of about 650^{0}C. This first buring is known as biscuiting. The articles brought to biscuit stage are removed from kiln and are allowed to cool down.

They are then coated with glazing compound and burnt again in the kiln at a temperature of about 1200^{0}C .The faience is svailable in a variety of colours and it indicates superior quality of terra-cotta.It is used for ornamental purposes and in industrial areas since it is ordinarily unaffected by the adverse atmospheric conditions.

Advantages of terra-cotta : Following are the advantages of terra-cotta

It is strong and durable material

It is available in different colours

It is cheaper than ordinary finely dressed stones

It is easily cleaned

It is easily moulded in desired shapes

It is fire-proof and can, therefore, be conveniently used with R.C.C work.

It is light in weight

It is not affected by atmospheric agencies and acids and is capable of withstanding weathering actions better than most kinds of stone.

Disadvantages of terra-cotta

It can not be fixed during the progress of work. But it is to be fixed when the work is in final stage of completion.

It is twisted due to unequal shrikage in drying and burning.

Uses of terra-cotta : Following are the uses of terra-cotta

The hollow terra-cotta blocks are used for various ornamental purposes such as facing work, arches, cornices, casing for columns,etc.

It is adopted for all sorts of ornamental work

It is used as a decorative material in place of stones for ornamental parts of buildings such as cornices, string courses, sills, copings, bases of pillars, fire places etc.

Earthenware: The term earthenware is used to indicate wares or articles prepared from clay which is burnt at low temperature and cooled down slowly. The clay is mixed with required quantity of sand, crushed pottery, etc.

The addition of such Materials prevents the shrinkage during drying and burning. The earthenwares are generally soft and porous. When glazed, the earthenwares become impervious to water and they are not affected by acids or atmospheric agencies. The terra-cotta is a kind of earthenware.

The earthenware is used for making ordinary drain pipes, electrical cable, conduits, partition blocks etc.

Stoneware : The term stoneware is used to indicate wares or articles prepared for refractory clays which are mixed with stone and crushed pottery. Such a mixture is then burnt at a high temperature and cooled down slowly.

The stoneware is more compact and dense than earthenware.When glazed, the stoneware become impervious to water and they are not affected by acids or atmospheric agencies. The sound stonewares give clear ringing sound when struck with each other.

The stoneware are strong impervious durable and assistant to corrosive fuluids and they resemble fire bricks. The stoneware can be kept clean easily and hence, they have become very popular as sanitary articles such as wash basins sewer pipes, glazed tiles, water closets, gully traps etc. They are also used as jars to store chemicals

Porcelain : The term poreclain is used to indicate fine earthenware which is white thin an semi-transparent. Since the colour of porcelain is white, it is also referred to as whiteware.

The clay of sufficient purity and possessing high degree of tenacity and plasticity is used in preparing porcelain. It is hard, brittle and non-porous. It is prepared from clay, felspar.

Refractories: The term refractories is used to indicate substances that are able to resist high temperature. The desired properties of refactories are as follows:

It must possess excellent resistance to rapid changed in temperature i.e. thermal shocks

Its dimensional stability i.e. resistance to change in volume at high temperature should be excellent.

It should be able to withstand abrasion and rough usage and should give reasonably long life without cracking or spalling.

It should be strong i.e. it must be capable of resisting compressive crushing and tensile forces in hot or cold conditions.

It should not fall into pieces at high temperatures

Its melting point should be high.

Its thermal conductivity should be suitable for the purpose for which it is to be used.

Classification of refractory materials

The refractory Materials are classified in the following two ways

i according to chemical properties and

ii according to resistance to temperature

According to chemical properties

The refractory Materials are divided into the following three categories as per their chemical properties , acidic, basic and neutral.

According to resistance to temperature

The refractory Materials are divided into the following two categories as per their capacity to resist temperature.

low quality and high quality

The low quality refractory Materials are used in the manufacture of fire-bricks, as lining material for furnaces, etc. The melting point of such Materials is more than 1580^{0}C.

The high quality refractory Materials containing pure clay are pure oxides of alumina, magnesia, etc. or nitrides or carbides. Those metals which melt at a temperature of about 1600^{0}C can be used as metal refractories. Such metals are molyblendum, tungsten, zirconium etc. These metals and their alloys are used as refractory materials.

The term cermet (cer from ceramics and met from metals) is used to indicate the refractory Materials containing a combination of clay and metal. The usual percentages are 80% clay and 20% metal. The usual metals employed for cermets are aluminium, chromium, cobalt, iron, etc. The cermets are widely used where shocks due to sudden changes of temperature are to be resisted.

The high quality refractory Materials are stable even at high temperature and they are used in the construction of modern aeroplanes such as rockets, jets, etc. These Materialsare composed of either pure clay or metals or combination of clay and metals.

High Voltage Porcelain

Sl.No.	Name	Properties	Uses
1	Carbon and graphite	Its is a refractory material of high quality. But it is oxidized at high temperature	It is used for making electrodes and in the construction of atomic reactor rockets.
2	Carbon brick	It is prepared from powder coke and tar. It can resist high temperature	It is used as lining material for electric furnaces
3	Cordierite porcelain	It contains 22% alumina, 35% clay and 43% silicate of magnesia. It is available in porous, partly porous and glassy form	It is used for electric furnaces, refractory bricks, etc.
4	Steatic porcelain	It contains 70 to 90% silicate of magnesia. etc.	It is used as electrical insulator for high intensity electric current, vacuum tubes,
5	Zircon porcelain	It contains 45 to 60% zircon, 15 to 30% clay and 15 to 30% silicate of zircon. Its dielectric constant at high temperature is good	It is used in the manufacture of spark plugs.

Acidic refractory materials

Sl.No.	Name	Properties	Uses
1	Fire - clay	Its important constituents are alumina and silica.	It is used for manufacture of firebricks, crucibles, lining material for furnaces, hollow tiles, etc.
2	Quartzite	It is a metamorphic stone. It is hard, brittle, crystalline and compact. Its melting point varies from 1650^{0}C to 1720^{0}C	It is used as lining material for electric furnance
3	Silica	It is available in the form of sand with some impurities from river bed. It melts at 1730^{0}C	It is used for preparing sillica bricks, coke oven and lining for glass furnance.

Basic refractory materials

Sl.No.	Name	Properties	Uses
1	Dolomite	It is carbonate of lime and magnesium. Its melting point varies from 2300^{0}C to 2600^{0}C	It is used for making refractory bricks
2	Magnesia	It is available in crystalline form. It melts at 2800^{0}C	It is used for preparing magnesia bricks

Neutral refractory materials

Sl.No.	Name	Properties	Uses
1	Bauxite	It is mixed with clay and finely ground. Its melting point is 1200^{0}C. It is an atmosphous substance with dirty-white, brown or reddish-brown colour.	It is used for preparing fire-bricks containing more percentage of silica.
2	Carbon	It is available in three forms-amorphous carbon, graphite and diamond. Its melting point is 3500^{0}C	It is used as activated carbon, absorbent, catalyst, etc. It is also used as lining material for furnaces.
3	Chromite	It is the oxide of iron and chromium. Its melting point is 2180^{0}C	It is the most powerful neutral refractory material.
4	Forsterite	It does not spall easily and it maintains well its volume at high temperature. Its melting point is 1890^{0}C	It is widely used in the furnace for melting copper.

Mortar & concrete

Objectives: At the end of this lesson you shall be able to
- **define mortar**
- **describe ingredients of mortar**
- **state the functions of mortar**
- **explain properties of good mortar**
- **list out the uses of mortar.**
- **state the types of mortar**
- **state preparation of mortar**
- **list out the tests for mortar**
- **select the mortars for different engineering works.**

Inroduction : For construction of buildings, nowadays, we mostly use cement mortar and cement plasters. A large amount of cement is consumed for these works. The total consumption is about 3 bags per square metre of plinth area in residential buildings and about 4 bags per square metre of plinth area in office buildings of this a major part is used for making mortar and plasters.

Definition : A paste formed by the addition of water to a mixture composed of an aggregate such as sand and a matrix or binding material like lime or cement is called mortar.

Ingredients of mortar

1 Binding or cementing materials…..such as cement or lime

2 Fine aggregates……………such as sand, surkhi, ashes, cinder, etc.

3 Water…………………should be free from oils, acids, alklies and other inorganic impurities.

Functions of mortar

- It's binds together stones or bricks properly.
- In any concrete, it holds coarse aggregates together.
- In stone masonry and brick masonry, it fills up empty joints; a thin liquid mortar used for such purposes is termed as grout.
- It provides a durable / weather resisting layer between different course of masonry in the structure.
- It forms a homogeneous mass of the structure so that it may resist all the loads coming over it and transfer the same uniformly to its foundation.
- It does pointing or plastering to the structure.

Properties of a good mortar

- It should be capable of developing good adhesion with the building units.
- It should be easily workable
- It should be cheap.

- It should be durable
- It should be capable of resisting penetration of rain water
- It should be capable of developing the design stresses.
- It should be durable and should not affect the durability of other materials.
- The joints formed by mortar should not develop cracks and they should be able to maintain their appearance for quite a long period.

Uses of mortar

1 To bind the building units such as bricks, stones, etc. into a solid mass.

2 To carry out pointing and plaster work on exposed surfaces of masonry.

3 It is employed for moulding purposes.

4 It is used to form joints of pipes.

5 It is used to improve general appearance of structure.

6 It is used to hide open joints of a masonry work.

7 It is used as a matrix in concrete.

Preparation of mortar (Fig 1) : It may prepare by Hand mixing or Machine mixing. When a small quantity of mortar required, hand mixing method is adopted. When large quantity of mortar is required continuously at a fast rate, it is prepared by mixing of the ingredients in mechanical mixtures.

In order to test the quantity of mortar, the following tests are usually conducted:

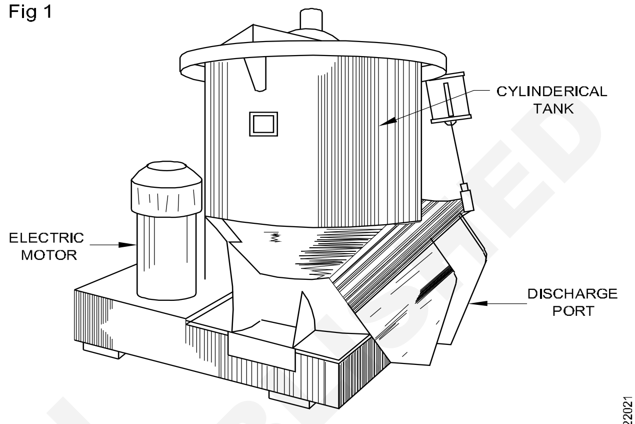
1 Adhesiveness to building units test.

2 Crushing strength test.

3 Tensile strength test.

4 Setting time test

Fig 1



TURBULENT MORTAR MIXER

SELECTION OF MORTARS FOR DIFFERENT ENGINEERING WORKS

S. No.	Nature of Work	Mortar - Type and Composition
1	Thick joints in stone masonry	Hydraulic time sand mortar (1:2:3)
2	Stone masonry in foundations and superstructure of ordinary buildings.	1:2 fat lime surkhi mortar or 1 part lime, 1 part surkhi and 1 part sand.
3	Brickwork in arches, plastering inside of walls. mortar (1:2) or lime, surkhi and sand. (1:1:1)mortar.	1:5 to 1:6 cement mortar, or lime surkhi
4	Reinforced brickwork.	1:3 cement mortar.
5	Mass concrete in foundations, paving tiles, cavity walls, plastering of ceiling and external plastering work etc., where good finish is required.	1:4 cement sand mortar or 1:2 to 3hydraulic lime mortar.
6	Massive work below ground level especially in water logged areas.	1:3 cement sand mortar or 1:3 lime (eminently hydraulic) sand mortar.
7	Massive works, dams, retaining walls, damp proofing, flooring, etc. where very high finish is required.	1:3 cement sand mortar.
8	Pointing work	1:1 to 1:2 cement sand mortar.
9	General R.C.C. works such as slabs, beams and columns cement concrete flooring etc	1:2 cement sand mortar.
10	Damp proof course and cement concrete roads.	1:2 cement sand mortar.
11	R.C.C tanks and other retaining structures etc.	1:1½ cement sand mortar.
12	Highly stressed numbers of structure	1:1 cement sand mortar.
13	Laying fire-bricks.	Fire- resisting, mortar consisting of 1 part of luminous cement to 2 parts of finely crushed of fire-bricks.

Substitute for sand : In place of sand attain materila such as stones screenings burned clay or sunkhi ashes from coal, coke dust it may be used to prepaie mortor, The steps screenings are obtained by screening crushed stones. They are sharp and impart more strength to the mortor. They are generally used in big construction projects like concrete dams, bridges etc. Where sand in high quantities is not available where the place of work they should used the stone dust. The surkhi is the popular substitute for sand. It is obtained by finally grinding burned clay it is clean and face from any impurities. It gives strength and improves hydraulic property of mortor. Mortar with surkhi should not be used for external plaster or pointing work etc it disintegrates under the action of air and humididty.

Classification of mortars : The mortars are classified on the basis of the following

Bulk density

Kind of binding material

Nature of application

Special mortar : Bulk density : According to the bulk density of mortor in dry state there are two ways of mortor.

1 Heavy mortor 2 light weight mortor

The mortor having bulk density of 15KN/MM^3 or more are known as heavy mortor. If it is less than 15kn/mm^3 known as light weight mortor.

Kinds of binding materials : According to the kind of binding material mortars are classified into following five categories.

Lime mortar	Surkhi mortar
Cement mortar	Gauged mortar

Gypsum mortar

Lime mortar : In these type lime fat lime or hydraulic lime is used in binding material. The lime should be slaked before use. This mortar is not suitable for water logged areas or in damp situation. The proportion of lime to sand by volume is about 1:2 as so. It is durable and hardens slowly. It is generally used for lightly loaded above ground parts of building.

Surkhi mortar : In this type of mortar using fully surkhi instead of sand or half surkhi instead of lime. The powder of surkhi should be fine enough to pass BIS No.9.

The residure should not exceed more than 10% by weight. Surkhi mortor is used for ordinary masonry work of all kinds of foundations and super structure. But is cannot be used for plastering or pointing. Since surkahi is likely to desintegrate after some time.

Cement mortar : In this type of mortor the cement is used as binding material. Depending upon the strength required and important of work the proportion of cement to sand by volume varies from 1:2 to 1:6 the sand only can be used to form cement mortar. The proportion should be determine with due regard to the specified durability and working condition. The cement mortar is used where a mortar required such as underground constructions water saturated soils etc.

Gauged mortar : To improve the quality of lime mortar and to achieve only strength the cement is sometimes added to it.This process is known as gauging. It makes mortar economical, strong and dense. The usual proportion of cement to lime by volume is about 1:6 - 1:8 . This mortar is also known as composite mortar or lime cement mortar.

Gypsum mortar : These mortar are prepared from gypsum as binding material.

Preparation of different mortars

Lime mortar : The time mortar is prepared within by pounding or grinding. For preparing small quantities the pounding is adopted. And for large quantities or a continuous supply grinding is adopted. The following are the objects of pounding or grinding.

To crush the particles of unslaked lime if any so as to and ensure slaking

To make and intimate mixtue of whole mass so that no gains of sand are without a film of binding material

Pounding : In this method the pits are formed in hand ground with lining of bricks or stones at there side and bottom. The pits are 180cm long 40 cm wide at bottom and 500m wide at topand 50cm deep. The dry mixture is then placed in pits. Small quantity of water is added and 4-5 persons with heavy mortar wooden poundans or beaten as work on mortar. They turn mortar up and down and required quantity of water is added at intervels. When desired consistency is achieved the mortar from pits is taken out.

Grinding : In the method grinding mills are used to prepare mortar. This grinding mills are either bullock driven or power driven.

Surkhi mortar : The mix of fat time and surkhi or fat lime surkhi and sand is decided and it is converted into a good paste by grinding in a mortar mill or pounding

Cement mortar : It does not require pounding or grinding. The cement and sand are mixed in required proportion in dry state twice or thrice on water tight platform and the water is then added and the ingredients are again thoroughly mixed.

Gauged mortar : The lime mortar is prepared as per about and the required quantity of cement is then added and the ingredient are thoroughly turn up and down to cause intimate mixing.

Precautions in using mortar : Following precautions to be taken while making use of mortar

Consumption of mortar : After preparation the mortar should be consumed as only as possible the cement mortar should be consumed within 30 minutes after adding water. Therefore it is advisable to prepare cement mortar of 1 bag of cement at a time. The gauged mortar should be used with 2 hrs of the addition of cement.

Staking of building units : The presence of water in mortar is essential to cause its salting action of mortar. Hence the building units should be soaked in water before mortar is applied this precaution is not taken, the water of mortar will be absorbed by the building units and the mortar will become weak.

Sprinkling of water : The water may be sprinkling for about 7-10 days.

To avoid rapid drying of mortar the exposed surfaces are some times correct to give protection against sun.

Workability : The excess mortar from joints should be neatly taken of by a travel. The mortar should not contain excess water and it should be as stiff as can be conveniently used.

Selection of mortar : Depending upon the nature of civil engineering work suitable type of mortar should be selected.

Plain cement concrete

Objectives: At the end of this lesson you shall be able to
- **define concrete**
- **state the proportioning of concrete**
- **describe the advantages of concrete**
- **state the disadvantages of concrete**
- **list out the uses of concrete.**

Definition: Concrete is a mixture obtained by mixing a binder (cement or lime), aggregate (fine and coarse) and water in certain proportions.

Proportioning concrete: The process of selection of relative proportions of cement, sand, coarse aggregate and water, so as to obtain a concrete of desired quality is known as the proportioning concrete.

There are different methods of proportioning concrete:

a Arbitrary method

b Fineness modulus method

c Minimum voids method

d Maximum density method

e Water-cement ratio method

The concrete as per BIS: 456:1978 is designed in several grades, M10, M15, M20, M25, M30, M35 and M40. The letter M refers to the mix and the number indicates the specified compressive strength of that mix at 28 days expressed in N /mm².

Grade	Proportion	Grade	Proportion	Grade	Proportion
M5	1:5:10	M10	1:3:6	M20	1:1½:3
M7.5	1:4:8	M15	1:2:4	M25	1:1:2

Advantage of concrete

High compressive strength

Corrosive and weathering effect minimized

Economical

Durable

Fire resistant

Very little maintenance

Molded to any shape

Can be sprayed and filled in cracks

Strong in compression

When reinforcement is added it is good in compression and tension also.

Ingredients of concrete

Cement

Sand or fire aggregate

Course aggregate

Water

Admixtures (in case of special conditions)

Properties of cement concrete

Properties of cement may be considered through two states

Fresh state

Hardened state

Fresh state

Workability

Hardened state

Permeability of concrete

Permeability of concrete depends on cement content grading aggregate quality of water, mixing compaction and curing of concrete.

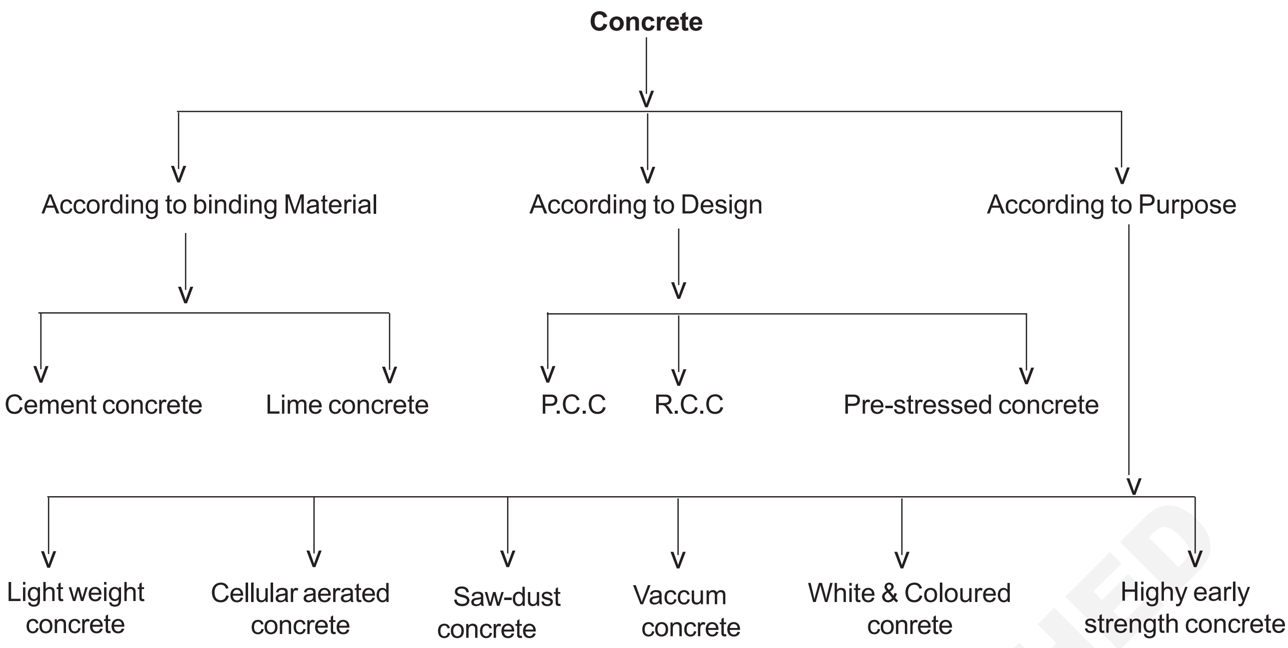
Durability of concrete

High compressive strength

Free from corrosion

Hardness increase with age

Economical



Recommended mixes of concrete

S.No.	Proportion of concrete mix	Maximum size of aggregate	Maximum size of aggregate
1	1:1:2	12 to 20mm	Heavily loaded R.C.C column and R.C.C. arches of long span
2	1:2:2	12 to 20mm	Heavily loaded R.C.C column and R.C.C. arches of long span
3	1:2:2	12 to 20mm	Small precast members of concrete such as poles for fencing Long piles water tight construction
4	1:1$^{1/2}$:3	20 mm	Water retaining structures, piles, precast product etc.
5	1:2:3 or 1:2/3:31/3	20 mm	Water tank, concrete deposited under water, bridge construction and sewers. For all general RCC work in building
6	1:2:1/2:3 1/2	25 mm	Foot path and road work
7	1:2:4	40 mm	For all general RCC work in building such as stair, beam, column etc
8	1:3:6	50 mm	Mass concrete work in culvert, retaining wall etc.
9	1:4.:8 or 1:5:10 or 1:6:12	60 mm	Mass concrete work for heavy wall foundation footing etc

Recommended mixes of concrete

S.No.	Proportion of concrete mix	Maximum size of aggregate	Maximum size of aggregate
Grade of concrete	M10	1:3:6	Compressive strength 10N / mm2
	M15	1:2:4	Compressive strength 15N / mm2
	M20	1:1:5:3	Compressive strength 20N / mm2
	M25	1:1:2	Compressive strength 25N / mm2

Grade of concrete	Total quantity of dry aggregates by mass per 50kg of cement to be taken as the sum of individual masses of fine and coarse aggregate Maximum (Kg)	Proportion of fine aggregate to coarse aggregate (by mass)	Quantity of water per 50kg of cement mix-litres
M5	800	Generally 1:2 but subject to an upper limit of 1:1:5 and lower limit of 2.5	60
M 7.5	675		45
M 10	480		34
M 15	390		32
M 20	250		30

Grading of concrete : In order to obtain concrete of denser quality the fine and coarse aggregate are properly graded

- gradation of fine aggregates as determined by sieve analysis
- gradation of aggregates effects on workability uniform and finishing quality of concrete
- grading of fine aggregate is expressed in terms of BIS test sieve nos 480,240,120,60,30 and 15

Water cement ratio : It is the ratio of water to cement and is expressed as the ratio of weight or volume of water to the weight of the cement to the concrete mixture.

Workability : The term workability is used to describe ease on difficulty in which concrete is handled, transported and placed between the forms with minimum less homogeneity workability some easily determine by slump test.

Mixing the material of concrete : The process of rolling, folding and spreading of particles is known as mixing of concrete

Mixing of ingredients : To impart uniform colour

Distribute various sizes of particles uniformly and evenly

To spread evenly the binding material over every particles of aggregate.

To impart required consistency to concrete

Ingredients of concrete are mixed by following methods

Recommended slumps of concrete

S.No	Type of concrete	Slump (mm)
1	Concrete for road construction	20 to 40
2	Concrete for top of kerb, parapet, slabs, walls, etc.	40 to 50
3	Concrete for canal lining	70 to 80
4	Concrete for arch and side wall of tunnel	90 to 100
5	Normal R.C.C work	80 to 150
6	Mass concrete	25 to 50
7	Concrete to be vibrated	10 to 25

Classification of concrete mixture

S.No	Slump	Nature of concrete mix
1	No slump	Stiff and extra stiff mix
2	From 10mm to 30 mm	Poorly mobile mix
3	From 40 to 150 mm	Mobile mix
4	Over 150 mm	Cat mix

Hand mixing

Machine mixing

Hand mixing

- Ingredients are measured and mixed in dry state
- Mixed on a water tight platform so as not to avoid loss of water
- Water is then added in correct concrete quantity and wet mixing is done
- Mix throughly till the concrete becomes uniform in colour and consistency
- It is preferred to add about 8 to 10 percent extra cement considering lesser efficiency of hand mixing.

Machine mixing

Mixing the ingredients by a machine

Ensures a better and more uniform concrete

Ensure thorough mixing

Cement consumption less than hand mixing

Transportation and placing of concrete

Transportation is the transporting the concrete and placing the concrete on the form work with suitable equipments or machines. The important precautions should take care

No chance of water should be added the concrete during its transportation

No segregation of aggregate

Precautions in placing of concrete

Clean the form work properly

Desirable to deposit the concrete as near as partible to its final position

Large quantity of concrete should not be deposited at a time

Concrete should be dropped vertically from a reasonable height.

Concrete should be deposited horizontal layers of 150 mm

As far possible concrete should be placed in single thickness

Concrete should thoroughly worked around the reinforcement

Concrete should be placed on the form work as soon as possible.

During placing it should be seen that all edges and corners of concrete surface remains unbroken

Placing of concrete should be carried out without obstruction of construction joint

Consolidation of concrete

"Consolidation or compaction is the process which expels entrapped air from freshly placed concrete and packs the aggregate particles together so all to increase the density of concrete".

Purpose of consolidation

Eliminate air bubbles

To give maximum density to concrete

Presence of 50% of voids reduces 30% strength of concrete

Methods of consolidation

Hand consolidation

For unimportant works

By ramming

By tamping

By rodding

Vibrator

These are mechanical devices. There are four types

Internal vibrator

Surface vibrator

Form vibrator

Vibrator table

Curing of concrete

It is the process of keeping the set concrete damp for some days in order to enable the concrete gain more strength

For Portland cement 7 to 14 days

Period of curring depends atmospheric condition and type of cement

Methods of curing

By ponding : Employed for flat surface

By using wet sacks/sprinling water frequently : Coloumns and similar members, sloping element

By stem : Used for precast concrete

Alternating current : Current is passing through freshly laid concrete for 24 hrs.

By sealing curing compound in the concrete surface:

By chemical water : Sprinkled over surface

Effects of improper curing

Durability decreased

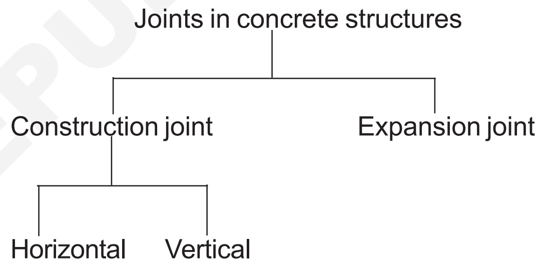
Compressive and structural strength decreased

Weathering resistance decreased

Resistance to atmospheric chemicals and chlorides decreased

Shrinkage cracks are formed

Thermal cracks are formed



Joints in concrete structures

Construction joint

When construction is stopped at the end of a day or other reasons when large concrete is done.

Inclined or curved member right angle to the axis

Expansion or contraction joint

Concrete structures length exceed 12m

Joint filler elastic material compressible, rigid

Dowels, keys-transfer load

Quality control of concrete

The process of keeping the specification provided according to the design concept. Field organisation are of three types:

Field organisation (3 types)

1 Grades of concrete

Inspection of form work

Reinforcement

Insulation of all embedded parts

2 Control over concrete material

Batch

Mixing

3 Placing

Compacting

Related operations

Highest possible density is obtained by

Air bubble should be eliminated

Cement particle should be smallest size

Compact fully

Cured sufficiently

Cubical particles of aggregate should be used.

Water cement ratio should be kept low

Advantages of quality control

Improved utilization of scarce resources

Minimise failures

Lower the cost of construction

Structure becomes durable

Underwater concreting

It may be required in case of deep foundation and marine works.

The placing of concrete under water is usually confined to plain concrete construction because loss of cement and segregation of concrete.

Methods of underwater concrete

By tremie: Tremie is the name given to a steel pipe of 150mm to 300mm dia and sufficiently long to reach the bed of water.

By ship of bottom opening bucket: In this method cubical hinged bottom bucket or cylindrical bucket equipped with a rolling gate of a ship is used for concreting under water.

Placing in Bags : The method is only suited for placing the concrete in rather shallow water

Prepacked concrete: Prepacked aggregates are packed in position and cement mortar of required proportions are grouted in it.

Under water concreting : Any concreting operation done at a temperature below 5^0C

Effects of cold weather concrete

Setting time is delayed-retard the development of strength

Early freezing of concrete results loss of properties of concrete

Stresses due to temperature differential occurs

Hot weather concreting : Any operation of concreting done to atmospheric temperature above 40^0C.

Effects of hot weather concrete

Accelerating setting

Reduction in setting

Increased tendency to cracking

Rapid evaporation during curing

Difficulty in controlling the air content

Guniting

The guniting is the most effective process of repairing concrete work which has damaged due to inferior work

Used for providing impervious layer

A mixture of cement and sand (1:3) in a cement gun is used to deposit with a pressure of 20-30N/cm^2

General precautions in cement concrete

Cement should be fresh

Aggregates should be well graded

Free from clay, silt, dirt

Water should free from harmful chemicals and foreign materials

While preparing rigid impervious of water tight platform should be used

Ingredients should be measured correctly

Care taken to avoid bleeding and segregation

Formwork should be cleaned and moister with water

Before concreting shuttering and centering should be checked

Laid concrete should be tamped thoroughly

Suitable expansion and contraction joints should be provided

Concrete should be laid within 30 minute

Defects in concrete

1 Cracks

Cracks in concrete may occur due to the following causes:

Excess water

Early loses of water

Alkali aggregate reaction

Corrosion of steel

Freezing of water

2 Crazing

Results from difference in shrinkage between the surface and the interior

3 Sulphate deterioration

Caused by the soil containing sulphates or sulphate water

4 Efflorescence

Appearance of fluffy white patches on the structure caused by poorly washed aggregates

Salty water used in making concrete

5 Segregation

Separation of course aggregate from fine aggregate

Separation of paste from course aggregate

Causes of segregation are as follows

Drops concrete from heights

Badly design mixes

Concrete comes over long distances - pumping, belt conveyour

Over vibration

6 Bleeding

Flow of mixing water within or emergence to the surface

From freshly placed concrete

Usually due to excess vibration imparted to concrete

7 Laitance

Cement and water slurry coming on top and setting on the surface

Special type of concrete

Concrete as a structural material has to fulfill different function depending on the situation

Low density concrete is using for partition wall cladding etc.

High density concrete is used for radiation shielding in

Radiation shielding in nuclear contained structures

Following are the various special types of concrete.

1 Light weight concrete

Densities as low as 400kg/m3 compared to 2400kg/m3 of ordinary concrete

2 Cellular concrete

Gas or air bubbles are introduced into the plastic-cement mortar mix to produce a material with a cellular structure.

3 No- fines concrete

This type is composed of cement course aggregate and water only

4 Heavy weight concrete

Using high density aggregate produced from magnetic and hematite (iron ore) density of concrete varying from 3400 to 4000 kg/m^3

5 Ready mixed concrete

Mixed at a central batching plant and delivered at the site by suitable transport vehicle

6 Vacuum concrete

This consists of withdrawing some of the excess water and air not required for hydration of the cement by means of vacuum subsequent to placing of concrete

7 Resin concrete

Concrete can be made tougher and stronger by admixing extra resins like araldite cpirex etc.

8 Ferro cement concrete

May be considered as a type of thin reinforced concrete construction where cement mortar-matrix is reinforcement with many layers of continuous and relatively small diameter wire-meshes. While the mortar provides the mass, the wire-mesh imparts tensile strength and ductility to the material

9 Pre stressed concrete

It is the concrete in which high compressive stresses are artificially induced before its use. In reinforced concrete members, the prestress is commonly introduced by tensioning the steel reinforcement

10 Gap graded concrete

Provided the specific surface of the aggregate (C.A. and FA) is kept constant, it has been found that a wide difference in grading affect the workability. Not necessary to continuous grading in order to obtain a minimum of air voids.

11 Colored concrete

The concrete can be made coloured by addition of suitable coloring pigments to the extent of about 8 to 10% of the weight of cement

Colored concrete is used for manufacture of items for public welfare ornamental finishes in buildings preparing park lanes, separating lines of traffic of road surface, underground pedestrian crossings etc.

12 Polymer concrete

It is highly impermeable and resistant to attack by acid alkalies and other chemicals

Addition of polymers improvement in compressive strenth fatigue resistance, impact resistance, toughness and durability

13 Sulphur impregnated concrete

It consists of a mixture of sulphur coarse aggregate and fine aggregate there being no cement and water.

14 Fibre reinforced concrete

Addition of small diameter small length randomly distributed fibres to increase tensile strength of P.C.C

Fibres suitable for reinforcing concrete have been produced from steel, glass and organic polymers.

Timber and wood products

Objectives: At the end of this lesson you shall be able to
- **define timber**
- **classify trees**
- **explain and indicate the parts of structure of trees**
- **describe the process of seasoning**
- **list out the qualities and uses of timber**
- **explain wood based products.**

Introduction

Wood used for structural purposes is known as timber. There is a lot of demand for primary species of timber like, teak, deodhar, sissco, sal, etc.

In order to enhance and economize the utilization of wood, many wood-based products have been developed in a big way like veneers, plywood, hard board, particle board, etc.

Definition

The products of wood from felled trees suitable for construction purposes are called Timber.

Classification of trees

According to their manner of growth, the tree may be divided into two main classes;

i Exogenous tree, (a) Conifer or evergreen trees,(soft wood) (b) Deciduous or broad-leaf trees.(hard wood) e.g. Deodar, chir, Kail, shishum, teak, etc.

ii Endogenous trees. e.g. canes, bamboos, palms, etc.

Structure and growth of tree (Fig 1)

Basically, a tree consists of the following three parts; (i) Trunk, (ii) crown, (iii) roots.

The trunk supports the crown and supplies water and nutrients from the roots to the leaves through branches and from the leaves back to the roots.

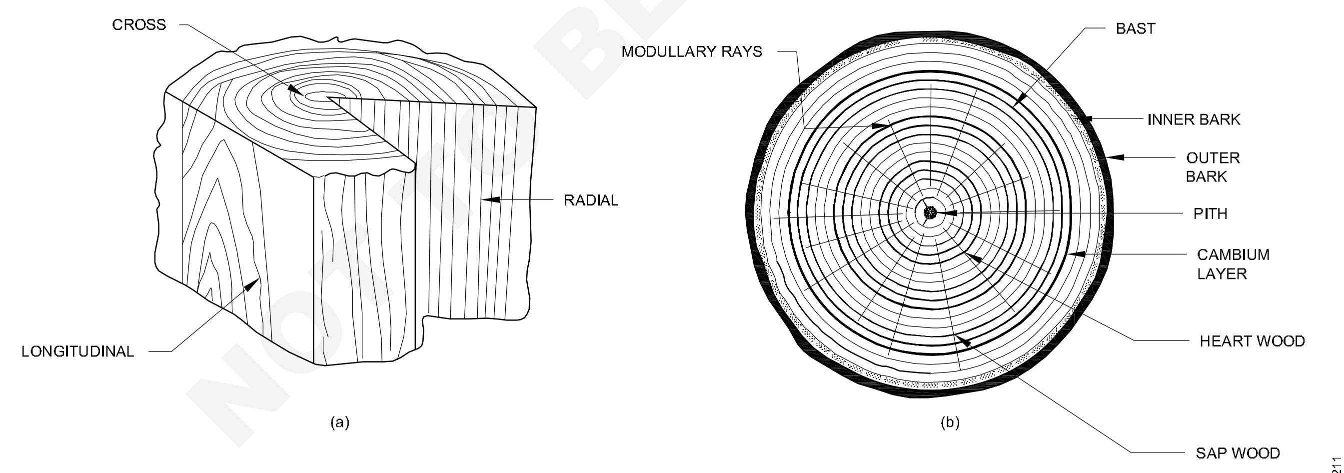
The roots are meant to implant the trees in the soil, to absorb moisture and the mineral substances it contains and to supply them to the trunk

Seasoning of timber

When a tree is newly felled it contains about 50% or more of its own dry weight as water. The water is in the form of sap and moisture.

It is the process of drying timber or removing moisture or sap, present in a freshly felled timber, under more or less controlled conditions.

Fig 1



CROSS SECTION OF A TREE

Object of seasoning of timber

To allow timber to burn readily if used as fuel

To decrease the weight of timber and there by to lower the cost of transport and handling

To impart hardness stiffness strength and electrical resistance to timber.

To maintain the shape and size of the components of the timber articles

To make timber easily workable and to facilitate operations during conversion

To make timber fit for receiving treatment of paints preservatives, varnishes etc.

To make timber safe from the attack of fungs and insects.

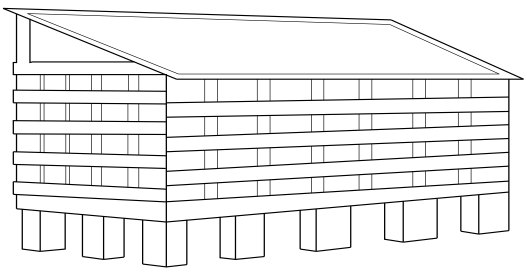
Seasoning can be broadly divided into the following two categories

1 **Natural seasoning**

2 **Artificial seasoning**

Natural seasoning : In this method done by stacking timber with space between them for free circulation of air they should be kept clean off the ground and protect from sun and rain. The timber should be turned frequently if possible. It takes 2-4 years, then timber is ready for use in carpentry or joinerys (Fig 2).

Fig 2



SHED FOR AIR SEASONING OF TIMBER

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Aritificial seasoning

Various method of artificial seasoning are

Boiling

Chemical seasoning

Electrical seasoning

Water seasoning

Kiln seasoning

Boiling

In this method timber is immersed in water and water is then boiled for about 3-4 hrs .Timber is then taken out and dried very slowly. Inplace of boiling water timber may be exposed to the action of hot steam.

Chemical seasoning

This method is also known as salt seasoning. In this method the timber is immersed in a solution of suitable salt. It is then taken out and seasoned in the ordinary way.

Electrical seasoning

In this method high frequency alternating current is used for seasoning. Green timber offers less resistance to the flow of current. The resistance increase as the wood dries internally which also the production of heat.

Water seasoning

In this method following procedure is also adopted

The timber is cut into pieces of suitable sizes

This pieces are immersed wholly in water preferably in running water of stream. The care should be taken to see that timber is not partially immersed

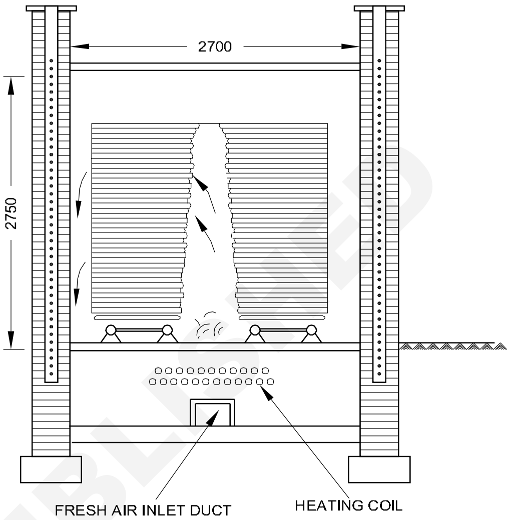
The timber is taken out after a period of about 3-4 weeks During this period the sap contained in timber is washed away by water

The timber is taken out of water and allowed to dry under shed having free circulation of air.

Kiln seasoning (Fig 3)

Kiln seasoning is carried out in an airtight chamber or oven. The process of seasoning is as follows:

Fig 3



COMPARTMENT KILN

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The timber is arranged inside the chamber such that space are left for free circulation of air.

The air which is fully saturated with moisture and which is heated to a temperature of about 35^0C-38^0C is then forced inside the chamber by suitable arrangements

This forced air is allowed to circulate round the timber pieces. As air is fully saturated with moisture the evaporation from the surfaces of timber pieces is prevented. The heat gradually reaches inside the timber pieces

The relative humidity is now gradually received

The temperature is then raised and maintained till the desired degree of moisture content is attained.

Depending upon the mode of construction and operation, the kilns are of two type namely

Stationery kilns

Progressive kiln (Fig 4)

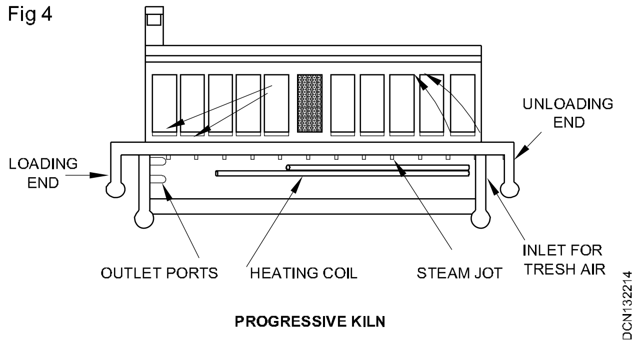
Uses of Timbers

a. It is used for door and window frames, shutters of doors and windows, roofing materials, etc.

b. It is used for form work of cement concrete, centering of an arch, scaffolding, etc.

c. It is used for making furniture, agricultural instrument etc.

Fig 4



PROGRESSIVE KILN

Defects in timber

Natural defects occurs in all kinds of timber depending upon the climate condition and soil upon which they grow.

Following are the common natural defects in timber.

1 Heart shake & Ring shakes

2 Star shakes

3 Cup shakes

4 Radial shakes

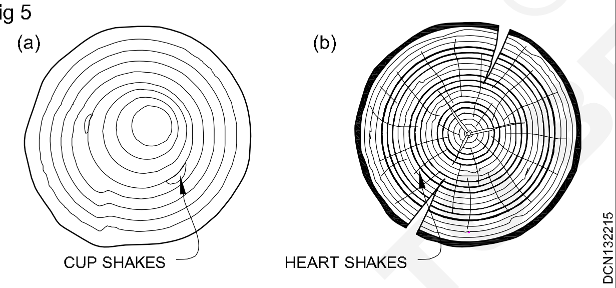
5 Knots

6 Druxiness.

Cup shakes (Fig 5a)

These are caused by the rupture of tissues in a circular direction. It is a curved cracks and it separate partially one annual ring from the other. It developes due to non-uniform growth on due to excessive bending of growing tree during cyclonic weather. It covers only a potion of ring. It maynot be harmful.

Fig 5



Heart shakes (Fig 5b)

These cracks occur in a cetre of a tree and they extend from pith to sapwood in the direction of medullary rays This crakcs occur due to shrinkage of interior part of the tree which is approaching maturity it divide tree the cross section into two to four parts

Ring shakes (Fig 6a)

When cup shakes cover the entire ring they are known as the ring shakes.

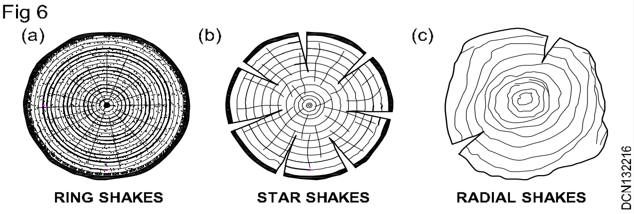
Star shakes (Fig 6b)

These are cracks which extends from bark towards sap wood. They are wider on the outside and narrow on the inside ends. They are formed due to the extreme heat or severe frost during the growth of tree.

Radial shakes(Fig 6c)

They are similar to star shakes but they are fine and numerous. They occur when tree is exposed to seasoning after being felled down. They run for a short distance from bark towards the centre. Then follow direction of annual ring and ultimately run towards the pith.

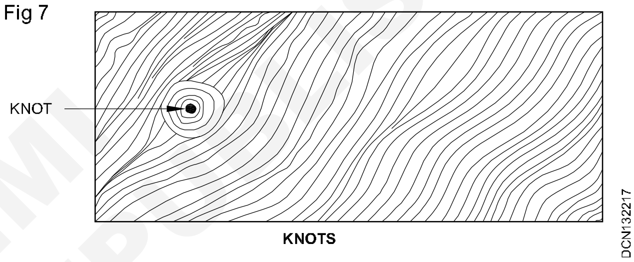
Fig 6



Knots (Fig 7)

These are the bases of branches which are broken or cut off from the tree. The portion from which the branch is removed ultimately results in the formation of dark hard rings known as the knots. As continuity of wood fibres is broken by knots they form a source of weakness.

Fig 7



KNOTS

The classification of knots on basis of size

Pin knot : Size diameter upto 6.5mm

Small knot : Size diameter between 6.5 and 20mm

Medium knot : Size diameter between 20mm and 40mm

Large knot : Size diameter greater than 40mm

Classification of knots on basis of their form and quality

Dead knot	Decayed knot	Live knot
Loose knot	Round knot	Tight knot

Druxiness

This defects is indicated by white decayed spots in a healthy wood. They are formed by the access of fungi.

Further the defects occuring in the timber are grouped into the following five divisions

Defects due to conversion

Defects due to fungs

Defects due to insects

Defects due to natural forms

Defects due to seasoning

Defects due to natural causes

The main natural causes for defects in timber.

Abnormal growth **Rupture tissues**

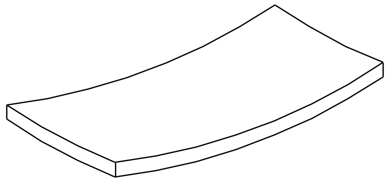
Defects due to seasoning

Following defects occur in the seasoning of wood

Bow	Cup
Case-hardening	Check
Split	Collapse
Honey combing	Radial shakes
Twist	Warp

Bow : This defects is indicated by the curvature formed in the direction of length of timber as shown in figure (Fig 8)

Fig 8



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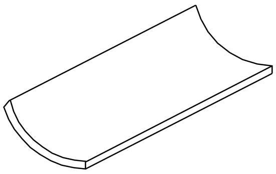
Cup : This defect is indicated by the curvature formed in the transverse direction of timber as shown in fig (Fig 9)

Fig 9



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Case- hardening

The exposed surface of timber dries very rapidly. It there fore shrinks and is under compression. The interior surface which has not completely dried is under tension. This defect is known as case hardening.

Check - A check is crake which separates fibres of wood. It does not extent from one end to the other.

Split

When a check extends from one end to the other is known as split.

Collapse

Due to uneven shrinkage the wood sometimes flattens during drying. This is known as the collapse.

Honey - combing

Due to status developed during the various radial and circular cracks develop in the interior portion of timber. The defect so developed is known as the honey-combing.

Radial shakes

Radial shakes are explained earlier.

Twist

When a piece of timber has spirally distorted along its length. It is known as twist.

Warp

When a piece of timber has twisted out of shape it is said to have warped.

Factors of Quality of good timber

1 Environmental conditions of the locality.

2 Maturity of the tree.

3 Method of seasoning.

4 Nature of the soil

5 Process of preservation and

6 Time of felling

Qualities of good timber

Following are the qualities of good timber

Appearance

A freshly cut surface of timber should exhibit hard and shining apperance.

Colour

The colour of timber should preferably dark. The light colour usually indicate timber with low strength

Defects

A timber should be free from serious defects such as dead knots, flaws, shakes etc.

Durability

A good timber should be durable. It should be capable of resisting the action of fungi insects, chemical, physical agencies and mechanical agencies.

Market forms of timber

The timber is converted into suitable commercial size.

Following are various forms in which the timber is available in the market

Batten

This is a timber piece whose breadth and thickness do not exceed 50mm.

Baulk

It is a roughly squared timber piece and it is obtained by removing barks and sapwood. One of the cross- sectional dimension exceeds 50mm while the other exceeds 200mm

Board

It is a plank i.e. a timber piece with parallel sides. Its thickness is less than 50mm and width exceeds 150mm

Deal

It is a piece of soft wood Its thickness varies from 50mm -100mm and its width does not exceed 230mm.

End

This is a small piece of batten, deal, scantling etc.

Log

It is trunk of the tree obtained after removal of branches.

Plank

It is a timber piece with parallel sides.Its thickness is less than 50mm and its width exceeds 50mm.

Pole

It is sound long log of wood. Its diameter does not exceed 200mm. It is also known as Spar.

Quartering

It is a square piece of timber the length of side being 50mm - 150mm.

Scantling

It is a timber piece whose breadth and thickness exceed 50mm but are less than 200mm in length. These are the pieces of miscellaneous size of timber sawn out of a log.

Wood Products

Following are the industrial form of timber

Veneers

Ply woods

Fibre boards

Impreg timbers

Compreg timbers

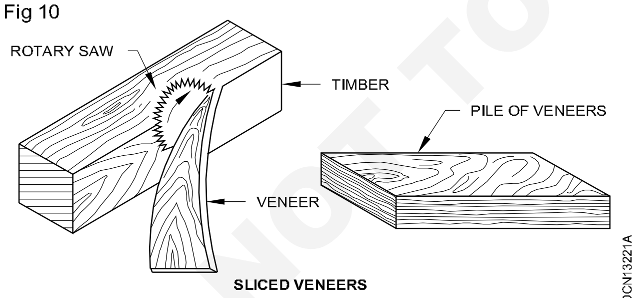
Laminated board

Veneers (Fig 10)

There are the thin sheets of wood of superior quality. The thickness of wood varies from 0.4mm to 6mm or more. They are obtained by rotating a log wood against a sharp knife of rotary cutter or saw.

Indian timber which are suitable for veneers, teak,rosewood,mahogony etc.

Fig 10



SLICED VENEERS

Ply wood

Ply woods boards which are prepared from thin layers of wood or veneers 3 or more veneers are one above and they are held in position by applications of suitable adhesives while being glued the pressure may be applied on veneers. The ply woods are used various purposes such as ceiling, doors, furniture partitions etc.

Fibre boards : These are rigid or reconstructed wood boards and they are also known as pressed wood. The thickness varies from 3mm-12mm They are available in length varying 3m -4.5m and its width varying from 1.2m-1.8m.

Depending upon their form and composition the fibre boards are classified as insulating boards, laminated boards, medium hard boards, hard boards and super hard boards. They are also available under various trade name such as Euraka, Indianite, Masonite etc.

Impreg timbers

The timber which is fully or partially covered with resin is known as the impreg timber. The usual resin phenol formaldehyde which is soluable in water. The veneers of thin strips of woods are taken and they are immersed in resin .

The resin fills space between wood cell and by chemical reaction a consolidate mass developed. It is then cured at a temperature of about 150°C-160°C. It is available under trade names are Formica, Sunglass, Sunmica etc.

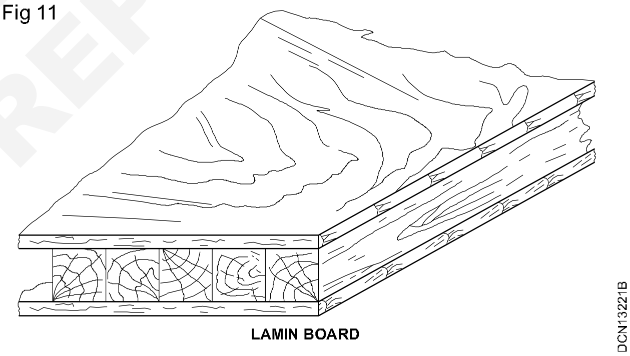
Compreg timbers

The process of preparing compreg timbers is same as that of impreg timbers except that curing is carried out under pressure. The strength and durability of compreg timbers are more as compared to the impreg timber.

Laminated board

The laminated boards are light, strong and do not split or crack easily as shown in (Fig 11)

Fig 11



LAMIN BOARD

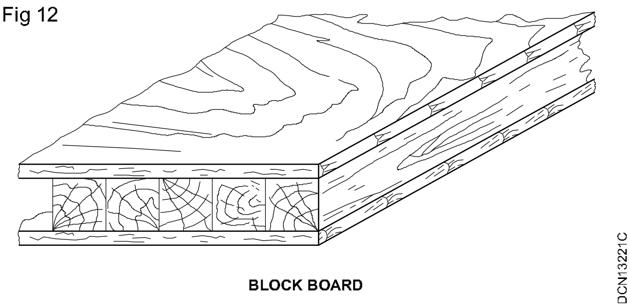
Uses

They are used for walls, ceilings, partitions and packing cases.

Block board:- (Fig 12)

In this case core consists of smaller timber block upto 25mm in width. These blocks are cemented edge to edge and on each face plies upto 3mm thickness are glued.

Fig 12

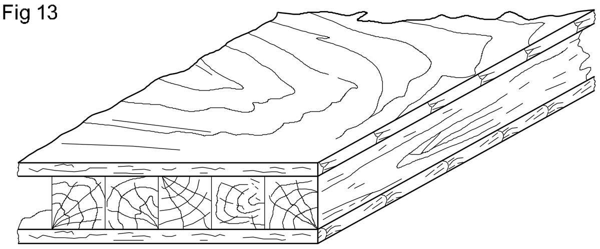


BLOCK BOARD

Uses : Block-board are extensively used for construction of railway carriages, bus bodies, marine, river crafts and for furniture making, partitions, paneling, prefabricated houses.

Batten board (Fig 13) : Batten boards are light and strong

Fig 13



BATTEN BOARD

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Uses

These boards are used for door panels, table, tops etc.

For internal finish, wall panelling, floor , flush doors

Fire sound insulation in large commercial buildings and cinema houses.

For suspended ceilings and dado.

Making partitions and finishing cover to furniture.

Hard board : These boards are hard pressed and hence are more compact, strong durable.

They impart internal appearance and finish to a structure

They are least affected by change in temperature and humidity of surroundings.

Mahagony : Its colour is shining reddish brown. It takes a good polish It is easy to work. It is durable under water. Its weight after seasoning is about 7200 N/mm^3

Indian Timber Trees

Iron wood	Jack
Mahagony	Mango
Mulbery	Oak
Pine	Red colour
Rose wood and black wood	Sal
Sandal	Tamarind
Teak	Toon
Bamboo	Benteak

Sandal : Its colour is white or red. It give out pleasant smell. Its weight after seasoning is about 9300N/m3. It is found in Assam, Nagpur and Bengal.

Bamboo : It is an endogenous tree it is flexible strong and durable. It is found in most of the part of the country

Benteak : It is strong and take up a smooth surface.Its weight after seasoning at 12% moisture content is 6750 N/m3. It is found in Kerala, Madras and Maharashtra.

Teak : Its colour is deep yellow to dark brown it is moderately hard. It is durable and fire resistant. It can be easily seasoned and worked. It takes up a good polish. It is not attacked by white ants and dry rot. It most valuable timber tree of the world. Its weight after seasoning at 20% moisture content is about 6250N/m3. It is found in central India and southern India. It is used for house construction Railway carriages, flooring, furnitures etc.

Fire proof reinforced plastic (FRP)

Objectives: At the end of this lesson you shall be able to
- **explain FRP fires**
- **explain regarding the smoke and the amount of smoke generated.**

FRP fire resistance (Fiberglass reinforced plastic and fires) : While the fiberglass reinforcements used in corrosion resistant laminates will not burn, most thermoset resins used as the matrix for “FRP” laminates will support combustion. Even the “fire retardant” resins will burn vigorously when fire is supported by an outside source. The rate of flame spread is somewhat lower for these fire retardant resins. Fire retardant thermoset resins typically contain halogens or bromine molecules. When combustion occurs, these additives suppress or smother the flame and the laminate becomes self-extinguishing.

What about smoke?

When the more common thermoset resins (polyesters, epoxies, vinyl ester, etc), used for fiberglass reinforced plastic composites burn, large amount of heavy, black, dense smoke can be generated. The carbon chains in these resins contribute to that smoke. There is no difference in the density of the smoke generated between a non-fire retardant resin and a fire retardant resin. The only difference is that the amount of smoke may be less when fire retardant resins are used, and the fire is not supported by an external source.

Although some facilities can experience more damage from the smoke rather than the actual fire, such as in electronics plant, for most facilities the fire itself and the damage it can cause, is of far greater concern that smoke. As one plant engineer of a major chemical plant told us one time. “When we have a fire in a chemical plant, we are allowed to have smoke” In those cases of typically wide-open spaces, or facilities with low occupancy, the smoke generated is the least of the problems when a chemical plant or refinery catches on fire.

How much smoke will be generated?

ASTM E-84 test results for polyesters, vinyl ester, and epoxies typically yield smoke generation values in excess of "750". It can be said unequivocally that if FRP composite pipe and FRP ductwork is exposed to a "raging fire", there will be a lot of smoke generated. The ASTM test can only provide a hint of how much smoke.

Inquiries to all of the major manufacturers of resin system used for corrosion resistant applications have solicited written responses that they have no, and know of no, polyester and vinyl ester thermoset resin systems that will generate, by themselves, smoke generation values under 350. If you are going to be specifying flame spread and smoke generation levels, we recommend that you consult with either a knowledgeable fabricator, or one of the resin manufacturers.

Medium density fire board (MDF)

Objectives: At the end of this lesson you shall be able to
- **define physical properties of MDF**
- **state the types of MDF and the comparison with natural wood**
- **state advantages and disadvantages of MDF**
- **state the application and safety concerns of MDF**
- **explain veneered MDF.**

Physical properties

Over time, the term MDF has become a generic name for any dry process fibre board. MDF is typically made up of 82% wood fibre, 9% urea - formaldehyde resin glue, 8% water and 1% paraffin wax and the density is typically between 500 kg/m^3 (31 lb/ft^3) and 1,000 kg/m^3 (62 lb/ft^3). The range of density and classification as light, standard, or high density board is a misonorner and confusing. The density of the board, when evaluated in relation to the density of the fibre that goes into making the panel, is important. A thick MDF panel at a density of 700-720 kg/m^3 may be considered as high density in the case of softwood fibre panels, whereas a panel of the same density made of hard wood fibres is not regarded as so. The evolution of the various types of MDF has been driven by differing need for specific applications.

Types

There are different kinds of MDF (sometimes labeled by colour)

- Ultralight MDF plate (ULDF)
- Moisture resistant is typically green
- Fire retardant MDF is typically red or blue

Although similar manufacturing processes are used in making all types of fibreboard, MDF has a typical density of 600-800 kg/m^3 or 0.002-0.029 lb/in^3, in contrast to particle board (160-450 kg/m^3) and to high density fibreboard (600-1,450 kg/m^3).

Comparison with natural woods

MDF does not contain knots or rings, making it more uniform than natural woods during cutting and in service. However, MDF is not entirely isotropic, since the fibres are pressed tightly together through the sheet. Typical MDF has a hard, flat, smooth surface that makes it ideal for veneering, as there is no underlying grain to telegraph through the thin veneer as with plywood. A so called "Premium" MDF is available that features more uniform density throughout the thickness of the panel.

MDF may be glued, doweled or laminated. Typical fasteners are T-nuts and pan-head machine screws. Smooth - shank nails do not hold well, and neither do fine-pitch screws, especially in the edge. Special screws are available with a coarse thread pitch, but sheet-metal screws also work well. Like natural wood, MDF may split when woodscrews are installed without pilot holes.

Benefits

- Is an excellent substrate for veneers.
- Some varieties are less expensive than many natural woods
- Isotropic (its properties are the same in all directions as a result of no grain), so no tendency to split.
- Consistent in strength and size
- Shapes well.
- Stable dimensions (won't expand or contract like wood)
- Easy to finish (i.e. paint)

Drawbacks

- Denser than plywood or chipboard (the resins are heavy)
- Low grade MDF may swell and break when saturated with water.
- May warp or expand if not sealed.
- May release formaldehyde, which is a known human carcinogen and may cause allergy, eye and lung irritation when cutting and sanding.
- Dulls blades more quickly than many woods. Use of tungsten carbide edges cutting tools is almost mandatory, as high speed steel dulls too quickly.
- Though it does not have a grain in the plane of the board, it does have one into the board., Screwing into the edge of a borad will generally cause it to split in a fashion similar to delaminating.

- Subject to significant shrinkage in low humidity environments.
- Trim (e.g baseboards) comes pre-primed, but this is insufficient for fine finish painting. Painting with latex paints is difficult due to rapid water absorption. Most finishes appear uneven and nail holes tend to pucker.

Applications (Fig 1)

Fig 1

Loudspeaker enclosure being constructed out of MDF

MDF is often used in school projects because of its flexibility. Slatwall Panels made from MDF are used in the shop fitting industry. MDF is primarily used for internal use applications due to its poor moisture resistance it is available in raw form with fine sanded surface or with decorative overlay.

MDF is also usable for furniture such as cabinets, because of its strong surface.

Safety concerns

When MDF is cut, a large quantity of dust particles are released into the air. It's important a respirator is worn and that the material is cut in a controlled and ventilated environment. It's a good particle to seal the exposed edges to limit the emissions from the binders contained in this material.

Formaldehyde resins are commonly used to bind together the fibres in MDF, and testing has testing has consistently revealed that MDF products emit free formaldehyde and other volatile organic compounds that pose health risks at concentrations considered unsafe, for at least several months after manufacture. Urea-formaldehyde is always being slowly released from the edges and surface of MDF. When painting, it is a good idea to coat all sides of the finished piece in order to seal in the free formaldehyde. Wax and oil finishes may be used as finishes but they are less effective at sealing in the free formaldehyde.

Whether these constant emissions of formaldehyde reach harmful levels in real -world environments is not yet fully determined. The primary concern is for the industries using formaldehyde. As far back as 1987, the U.S EPA classified it as a "probable human carcinogen" and, after more studies, the WHO International Agency for Research on Cancer (IARC), in 1995, also classified it as a "probable human carcinogen". Further information and evaluation of all known data led the IARC to reclassify formaldehyde as a "known human carcinogen" associated with nasal sinus cancer and nasopharyngeal cancer, and possibly with leukaemia in June 2004.

Veneered MDF

Veneered MDF provides many of the advantages of MDF with a decorative wood veneer surface layer. In modern construction, spurred by high costs of hardwoods, manufacturers have been adopting this approach to achieve a high quality finishing wrap covering over a standard MDF board. One common type uses oak veneer. Making veneered MDF is a complex procedure, which involves talking an extremely thin slice of hardwood (approx 1-2 mm thick) and then through high pressure and stretching methods wrapping them around the profiled MDF boards. This is only possible with very simple profiles because otherwise when the thin wood layer has dried out, it will break at the point of bends and angles.

Tar, bitumen, asphalt

Objectives: At the end of this lesson you shall be able to
- **state tar in type and uses**
- **state bitumen and forms of bitumen**
- **state asphalt and is type.**

Tar

Tar is a dark back liquid with high viscosity.

Tar is classified into the following three types

1 Coal tar

2 Mineral tar

3 Wood tar

1 Coal tar : Coal tar is prepared by heating coal in closed iron vessels. The escaping gases and allowed to pass through tube which are not cool by circulation of water. Coal tar gets deposited in these tubes.

Coal tar is used for making macadam roads, preserving timber etc.

2 Mineral tar : Mineral tar is obtained by distilling bituminous Sholes

3 Wood tar : This tar is obtained by distillation of pines and similar other resinous trees. It posses strong preservative property.

2 Bitumen

Bitumen is the binding material which is present in asphalt. it is also called as mineral tar. It is obtained by partial distillation of crude petroleum. It is chemically a hydro - carbon. It is insoluble in water. It is completely dissolves in carbon disulphide.

- Bitumen is black or brown in colour.
- It is obtained solid or semi-solid state.

Forms of bitumen

i Bitumen emulsion

It is liquid product containing bitumen to a great extent is an aqueous medium.

ii Blown bitumen

It is a special type of bitumen which is obtained by passing air under pressure at a high temperature. This bitumen used as roofing and damp - proofing felts in the manufacturer of pipe asphalts and joint fillers and also or heat insulating materials

iii Cut -back bitumen

It is obtained by fluxing asphaltic bitumen in pressure of same suitable liquid distillates of coal tar or petroleum.

iv Plastic bitumen

It consists of bitumen, thinner, and suitably inert filler. It is used for filling cracks in masonry structures, for stopping leakages.

v Straight run bitumen.

When the bitumen is being distilled to a definite viscosity or penetration without further treatment, it is known as straight run bitumen.

Asphalt

Asphalt is a mechanical mixture of inert mineral matter like alumina, lime, silica, etc.

Classification of asphalt

Asphalt is classified into two

1 Natural asphalt

2 Residual asphalt

1 Natural asphalt

Natural asphalt is further subdivided into two groups

i Lake asphalt

ii Rock asphalt

i Late asphalt

- Lake asphalt is obtained from lakes at Trinidad and Bermudez (South America)
- It contains about 40 to 70% of pure bitumen. 30% water content. The rest is impurities it is refined and impurities are removed.
- This refined lake asphalt is used for road and pavement construction.

ii Rock asphalt

Rock asphalt is obtained from rocks at Switzerland, France. It contain about 10 to 15% of pure bitumen. The rest consists of calamitous materials.

It is used to put on the road surface and also used for roofing sheet, paving file etc.

2 Residual asphalt

- This is also known as artificial asphalt
- It is obtained by the fractional distillation of crude petroleum oils with an asphaltic base. This solid substance is the residual asphalt.

Forms of asphalt

1 Asphaltic cement

- It is prepared by blowing air through melted asphalt at high temperature.
- It is highly resistant to varying climatic conditions.
- It is used for flooring, roofing, water-proofing and filler in expansion joints in concrete.

2 Asphaltic emulsion

Asphaltic emulsion is produced by mixing asphalt with 50 to 60% water in presence of 1% of emulsifying agent.

After the evaporation of water, the emulsion breaths and form a water proofing layer. This can be applied in cold condition.

3 Cut - back asphalt

Cut - back asphalt is a liquid asphalt. This is prepared by dissolving asphalt in a volatile solvent. This asphalt can be applied at normal temperature in cold condition. This asphalt is used to prepare bituminous points for repairing roofs etc.

4 Mastic asphalt

Mastic asphalt is produced by heating asphalt with sand and mineral fillers. It is a void less impermeable mass. This asphalt may either be in solid or semi-solid state. This asphalt is used as a damp proofing material and water proofing.

Properties of asphalt

1 It is a water proof material

2 It is non-inflammable

3 It is not affected by acids

4 It is reasonably elastic

5 It is good insulator of electricity and sound

Uses of asphalt

1 Asphalt is used as damp proof course

2 It is used basement of the building

3 It is used preparing points

4 It is used as construction of road metal and pavement.

Protective Material - Paints & Varnishes

Objectives: At the end of this lesson you shall be able to
- **define timber**
- **classify trees**
- **explain and indicate the parts of structure of trees**
- **describe the process of seasoning**
- **list out the qualities and uses of timber**
- **explain wood based products.**

Definition

The Materials are used for the protective the surface of structure are known as protective materials.

Types of Materials used

Paint

Varnish

Distemper

White wash

Colour wash

Termite proof materials

Paint

The paint are coating of fluid material and they are applied over the surface of timber and metal.

Characteristics of an ideal paint

It should posses good spreading power

It should be fairly cheap and economical

It can easily and freely applied

It should dry in reasonable time

Colour should last for a long time

It should hard and durable

Ingredients of oil borne paints

A base

A vehicle or carrier

Drier

Colouring pigment

A solvent

Base

A base is a solid substance is a fine state of division and it forms the bulk of paint. It determine character of paint and it imparts durability to painted surface.

Commonly used bases are

White lead	Red lead	Zinc white
Oxide of iron	Titanium white	Aluminium white
Lithophone	Antimony white	

Vehicle or carrier

Vehicle are liquid substance which hold the ingredients of a paint in a liquid suspension.Vehicles employed are

Linseed oil Poppy oil Tung oil Nut oil

Driers

These are substance accelerate the process of drying. Drier absorb oxygen from air and transfer it to linseed oil which gets hardened. Some of the driers

a) Litharge b) Red lead c) Sulphate of Manganese

Colouring pigments

Colouring pigments gives desired colour besides the base.

Pigments are Graphite lamp black

Indigo Prussian blue

Umber

Chrome green

Copper sulphate

Solvent

The function of solvent is to make the paint thin so that it can easily applied on the surface. It helps the paint to penerate through the porous surface. The most commonly used solvents is spirit ot turpentine.

Types of paint

Aluminium - Gas tank, hot water pipes , radiater oil tank

Anti corrosive paint - An corrosive metal - iron

Asbestos paint - Acidic gases and steam

Bituminous paint - Iron work under water

Cellulose paint- Surface contact with high cold and heat

Cement paint- Plastered surface

Colloidal paint - Walls

Emulsion paint - Wood, metal, plastered surface

Enamel paint- Wall surface, wood, metal

Graphite paint- Iron surface contact with ammonia, chlorine sulphar gas etc, mines and under ground railway

Inodorous paint

Luminous paint - Dials of watch

Oil paint - Redecorate the surface

Plastic paint- Show room auditorium

Varnish

The term varnish in used to indicate the solution of resinous substance prepared either in alcohal, oil or turpentine.

Characteristics

It should not shrink or show cracks after drying

The protecting film developed by varnish should be tough , hard and durable

It should dry rapidly

It should not fade

Ingredients

Resins or resinous substance

Driers

Solvents

Resins- Copal, lac or shellac and rosin amber mastic gum, dammar etc.

Driers - Litharge, white copper and lead acetate

Solvent - boiled oil, spirit of wine, turpentine wood naphta

Types of varnish

Depending upon solvent varnishes are :

Oil varnish

Spirit varnish

Turpentine varnish

Water varnish

Distemper

The main ingredients are whiting or chalk and water and glue or casein. It provides a smooth to plastered surface. They are available in market under different trade names and variety of colours. They are cheaper than paint and varnish.

White wash

It contains fresh lime, water, and gum lime is toxic for germs. It reflects light and increase brightness of surface. It is used interior wall and ceiling.

Colour wash

It prepared by adding colouring pigment to white wash.Applied on outer wall and inner wall.

Termite proof materials

Termite are white ants found in abundance in tropical and subtropical countries. They are very fast in eating wood, cellulosic and non-cellulosic materials. The treatment which is given to prevent or control the growth of termites in a building is known as termite proofing.

Type of Termites

Dry Wood termites - in humid coastal region.

Subterranean termites - in connection with soil.

Metal and alloys

Objectives: At the end of this lesson you shall be able to
- **state Types of steel reinforcement.**
- **describe steel for pre-stressed concrete**
- **identify the types of rolled steel sections.**

Definition : The substance which are extracted from ores through various refining method are called metals

Classification of metals

Metals are classified into two

Ferrous metals

Non ferrous metals

Ferrous metals : Main element of ferrous metals iron, the iron ores are compound of iron with non-metallic elements and certain impurities such as carbon, manganese, phosphorous, silicon and sulphur. Important varities of iron ore are Haematite, limonite, magnetite pyrite and siderite.

Non-ferrous metals : The metal which do not contain iron ores as main constituent are called non ferrous metals.

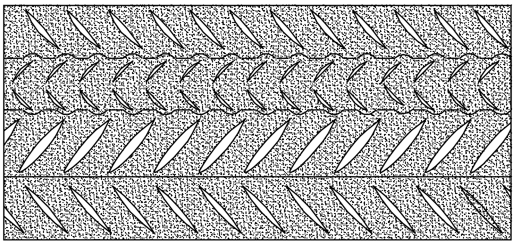
Types of ferrous metals

- Pig iron
- Cast iron
- Wrought iron
- Steel

TYPES OF STEEL REINFORCEMENT: Steel rods used for reinforcement concrete work should be of specified tensile strength, and they should develop good bond strengths with concrete. There are different types of steel, like, mild steel, tor-steel, TMT bars, etc.; and one should be able to identify them by sight. Steel rods of different diameters are used for R.C. work. In order to identify the sizes easily, only standard sizes should be used in building units. The following types of bars are commonly used in reinforced concrete construction.

1 Hot rolled bars, there are four types, (i) Hot rolled plain round mild steel bars (MS bars); (ii) Hot rolled ribbed mild steel bars (generally not recommended for use);(iii) Hot rolled high strength deformed bars (bars like Tistrong bars by Tisco) also called as HYSD bars (high strength got by micro alloying).(Fig 1)

Fig 1

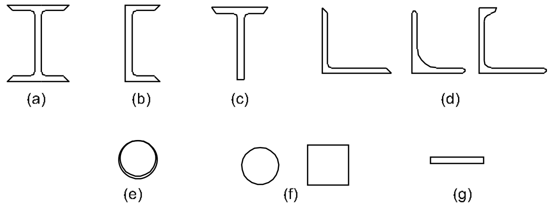


HIGH YIELD STRENGTH DEFERMED BARS

DCN132311

2 Hot rolled cold twisted deformed bars like Tor steel (CTD) bars (high strength got by cold twisting) (Fig 2)

Fig 2



ROLLED STRUCTURAL SHAPES

DCN132312

3 Thermo-mechanically Treated (TMT) bars (high strength got by controlled cooling)

4 Cold drawn steel wire fabric (welded wire fabric)

Market forms of Steel

SNo.	Form of Steel	Types	Uses
1	Angle section	Equal angle section unequal angle section	Structural steel work
2	Channel section	Junior channel (ISJC) Medium channel(ISMC)	Structural member
3	Corrugated sheets	G.I. Sheets	Roof covering
4	Expanded sheets		Reinforcing concrete in foundations, roads, floors, bidges lathing material partions
5	Flat bars	Width 10mm to 400mm and thickness 3mm to 40mm	Steel grill works
6	I Sections	Junior beams (ISJB) Light beams (ISLB)medium beams (ISMB)wide flange beams (ISWB)Heavy beams (ISHB)	Suitable for beams lintels, columns etc
7	Plates	Thickness 5mm to 50mm	Structural steel work
8	Ribbed torsteel	Dia 6mm to 50mm	Reinforcement in concrete structure
9	Round bars	Dia 5mm to 250mm	Reinforcement in concrete structures and for steel grill work
10	Square bars	Side 5mm to 250mm	Construction of steel grill work
11	T Sections		Steel roof truss and for built up section
12	Miscellaneous section	Acute angle sections, Obtuse angle sections, rail section, trough section, Z section	Structural steel work.

Types of non ferrous metals: Following are the right non-ferrous metals which are sued in engineering field are

- Aluminium
- Cobalt
- Copper
- Lead
- Manganese
- Nickel
- Tin
- Zinc

Alloys

Definition : Alloys is an intimate mixture of two or more metals

Process of making alloys

- The more infusible metal melted fast in fire clay crucible
- The other metals then added subsequently in order to their infusibility.
- The contents are continuously stirred to form a homogeneous mass
- The molten mixture is cast in suitable moulds and allowed to cool.

- The product obtained is called alloy
- The metal which is present in the alloy in largest proportion is called base material and the other metals are called alloying elements.

Important Alloys

Duralumin : This is the important alloy of aluminium

Aluminium - 94%

Copper - 4%

Manganese - 0.5 %

Magnessium - 0.5 %

Silicon - 0.5%

Iron - 0.5%

Brass : This is an alloy of copper and zinc

Copper - 60%

Zinc - 40%

Bronze : This is an alloy of copper and tin

Bell metal	Copper	- 82%
	tin	- 18%
Gun metal	Copper	- 88%
	Tin	- 10%
	Zinc	- 2%

Dow metal

Magnesium - 88%

Aluminium - 12%

Manganese - 0.1%

Nickel silver or german silver

Copper - 50 to 80%

Tin - 10 to 30%

Zinc - 20 to 30%

Steel Alloys

Chrome - molybdenum steel

Chrome - nickel stainless steel

Chrome - nickel steel

Chromium steel

Chromium - vanadium steel

Cobalt steel

Copper steel

Manganese steel

Molybdenum steel

Nickel - chromium- molybdenum steel

Nickel steel

Tungsten steel

Vanadium steel

Nickel -molybdenum steel

Plastics

Objectives: At the end of this lesson you shall be able to
- **explain briefly the history of plastic**
- **state the composition of plastic**
- **define polymerization**
- **state the classification of pasties and explain**
- **state the moulding compounds of plastic and fabrication process involved in the fabrication of plastics**
- **explain properties of plastics**
- **state the use of plastics**
- **pvc pies and pipes of other materials and advantages of PVC pipes.**

Brief history of plastic : Plastic is one of the recent engineering material which is available in the market all over the world. After the long research by the scientists the birth of plastic in industry took place in the 19th century.

The development of plastic industry may be grouped into three stages.

1 The main objective of the first stage of development was mainly to initiate or copy the natural plastics. In 1865 camphor and alcohol mixed with nitro-cellulose, and the result of the product is known as parasite, which is the name of the scientist. This is used for gear wheels, dory knobs etc.

2 The second stage is comprised in first twenty years or so of this century. In this stage the plastic industry scientifically scrutinized and local foundation for further scientific development in this field. In 1909 Dr.L.Bakeland invented a product named as Bakelite which was found to be strong and hard material.

3 The final stage includes present trend and its main aim was improving the old plastic and producing new varieties of plastics. In 1924 the scientist pollats prepared a produce from urea and formaldehyde. It was transparent like glass, and it was un breakable. The same was produced in different attractive colours.

Composition : Plastic is organic substance and it consists of natural or synthetic benders or without moulding compounds. In general plastics are compounds of carbon with other elements like hydrogen, nitrogen of carbon and oxygen.

The finished product of plastic is rigid and stable at normal temperature, plastics are organic substances and they can flam when required heat and pressure are applied at the same stage of manufacture.

Polymerization : The substance containing of one primary chemical are known as monomers or monoliths. They are synthesized to form polymers by the process known as polymerization. The properties like strength, rigidity, elasticity are unproved by polymerization.

The following are the two methods of polymerization.

1 Addition polymerization

2 Condensation polymerization.

1 Addition polymerization

In this method, different molecules join together, and the molecular weight of the resulting polymer is equal to the some of the molecular weight of the reacting molecular. This process involves three stages.

i Beginning of the process

ii Expansion of the chain

iii End process

The polymers obtained in this method are polyethylene, polypropylene, polyvinylchloride, polystyrene, polyarcylates etc.

2 Condensation polymerization : In this method, low molecular substances are removed from high molecular substances formed from a large number of identical or different molecular. The reaction proceeds with an evolution of ammonia, hydrogen chloride and similar other low molecular substances.

The polymers obtained by this method are phenol formaldehyde, carbonate, melamide*, melamine formaldehyde etc.

Classification of plastics

They are classified according to their:

1 Behaviour with respect to heating

2 Structure and

3 Physical and mechanical properties

1 Behaviour with respect to heating : According to this classification plastics are divided into two groups.

1 Thermo plastic

2 Thermo setting

1 Thermo- plastic

The thermo plaster or heat non - convertible group is the general term applied to plastics which become soft when heated and hard when cooled. The process of softening and hardening may be repeated for an indefinite time, provided the temperature during heat is not so high as to cause chemical decomposition. So it is possible to shape and reshape these plastics by means by heat and temperature. The advantage of this variety plastics is that the scrap obtained from old and worn-out articles can be effectively used again.

2 Thermo setting : The thermo setting or heat convertible group is the term applied to plastics which be come rigid when moulded at a suitable temperature and pressure. When they are heated in temperature ranging 127° to 177°C, It sets permanently and further application of heat does not alter their from or soften. But at 343°C charring occurs. This charring is a peculiar characteristic of organic substances.

The thermo setting plastics are soluble in alcohol and in certain organic solvents, when they are in thermo plastic stage. This property is used for making paints and varnishes.

The thermo plastics are durable strong and hard. They are available in many beautiful colours. They are mainly applied in engineering application plastics.

2 Structure : As per classification, plastics are divided into two groups.

1 Homogeneous plastic

2 Heterogeneous plastic

1 Homogeneous plastic

The plastics of this group contains carbon atoms and they exhibits homogeneous structure.

2 Heterogeneous plastic : In this plastic it contains carbon and oxygen, nitrogen and other elements and they exhibit Heterogeneous structure.

3 Physical and mechanical properties : According to this, plastics are divided into four groups.

i Rigid plastics

ii Semi- rigid plastics

iii Soft plastics

iv Elastomers

i Rigid plastics : These plastics possess a high modulus of elasticity and they retain their slope under exterior stresses applied at normal or moderately increased temperature.

ii Semi-rigid plastics : These plastics have a medium modulus of elasticity and the elongation under pressure completely disappears when pressure is removed.

iii Soft plastics : These plastics have a lam modulus of elasticity and the elongation under pressure disappears sonly when the pressure is removed.

iv Elastomers : These plastics are of soft and elastic materials having low modulus of elasticity. The deformation is in tension and the deformation disappears rapidly at room temperature.

Resins :The plastics are grouped in to two groups, based on their behaviour according to heating, resins or benders are also broadly divided into the following groups.

1 Thermo plastic resins

2 Thermo setting resins

1 Thermo plastic resins

i Alkyd : These resins are made from glycerin and ophthalmic anhydride. The cool slowly and possess electricity properties. They are used for preparing this felons of plastics.

ii Celluloses : These are derived from various cellulose compounds like cellulose acetate, cellulose nitrate etc. Plastics made from this are like glass. They are tough, strong and posses electrical properties. Possible to obtain all types of colours.

iii Coumarone - indene : These resins are soft in very small temperature. They are brittle and used for floor tiles, rubber manufacture etc.

iv Methyl methocrylate : This is known as acrylic. It is derived from coal petroleum and water. It transmits ultra-violet waves of light. It can be acts, sawn or turned it acts as good electrical insulator. Plastics prepared from this are used for safety glass, artificial jewels, roof lights, lightening fittings, bath and sink units etc.

v Styrene : This is the product form ethylene which is made from petroleum . It is light an weight and transmits ultra- violet waves of light. It possess very high electric resistance. It is used as emulators at radio frequencies in wireless and television industry.

vi Vinyl : It is prepared by passing acetylene gas through acetic acid or dry hydrogen chloride. It is used for wire and cable for coatings polyethylene is a vinyl resin which is tough and flexible and used for cable causing.

2 Thermo setting resins

i Casein : Casein is a phosphor protein and is derived by the precipitation of milk with acids. If has bright attractive appearance but not strong. It is used for buckles, buttons, etc.

ii Melamine -formaldehyde : It is obtained from calcium carbide, melamine when reacted with formaldehyde, forms this resin. It possess excellent resistance to electrical arcs. It is used for electrical insulators, glass reinforced plastics etc.

iii Phenol formaldehyde : Phenol is a carbolic acid it is extracted resin prepared from this lightly resistant to heat. It possess both mechanical and electrical properties. It is used for paints, varnishes, preparation of laminated products, electrical fitting, w.c. seats etc.

iv Phenol farfuraldehyde :Farfuraldehyde vapours when reacted with phenol, from resin. It is darie colour and resists very high temperature.

v Urea formaldehyde : Urea is prepared from calcium cyanamide or a mixture of liquid carbon dioxide and liquid ammonia. Urea reacted with formaldehyde produce this resin. It is not easily attached by dilute acids and alkalies oil, chemicals, water etc. Plastics made from this resin are unidely* used for making adhesives for wood, lighting fixtures, like lamps, reflectors etc.

To give desired finished plastic articles, certain moulding compounds are to added to plastics. Following are the such moulding compounds.

1 Catalysts

2 Fillers

3 Hardeners

4 Lubricants

5 Pigments

6 Plasticizers

7 Solvents

In plastic fabrication following are the process involved in the fabrication of plastic articles.

1 Blowing

2 Calendaring

3 Casting

4 Laminating

5 Moulding (compression moulding - extrusion moulding)

Properties of plastics

1 **Appearance :** Some plastics are completing transparent in appearance.

2 **Chemical resistance :**Plastics are great resistance to moisture, chemicals and solvents. Many plastics are found to be corrosion resistance and hence they are used to convey chemicals.

3 **Dimensional stability :**This property of plastic is very satisfactory with that of other common engineering materials.

4 **Ductility :** It is lacks in ductility and may fail with out warning.

5 **Durability :** Plastic and are quite durable. It possess sufficient surface hardness.

6 **Electric insulation :** Plastics are for superior to ordinary electric insulators

7 **Finishing :** Any surface treatment can be given to plastics. It is easy to have technical control during manufacture. It results to man production with uniformity of surface finish.

8 **Fire -resistance :** Plastics are organic in nature and hence all plastics re combustible. Cellulose acetate burns slowly. Polyvinyl chloride plastics are non - inflammable. Phenol formaldehyde and urea formaldehyde resist fire and they are used as fire - proofing materials.

9 **Fixing :** Plastics can be fixed easily in position and they can be bolted, clamps, drilled, glued, threaded simply push fitted in position.

10 **Humidity :** The properties of plastics are governed to same extent by humidity, plastics which do not contain water attracting groups like polyvinyl chloride plastics offer great resistance to moisture.

11 **Maintenance :** It is easy to maintain plastic surfaces and they do not require any protective coat of paints.

12 **Melting point :** Most of plastics have low melting point and some of plastics have 50°C. In general it can be said that the co-efficient of thermal expansion of plastics is ten times than that of steel.

13 **Optical property :** Several types of plastics are transparent and translucent .

14 **Sound absorption :** This material has absorption coefficient of about 0.67

15 **Strength :** Plastics are reasonably strong. Plastic members can be used as tensile members.

16 **Thermal property :** The thermal conductivity of plastics is low and it can be compared with wood. Foamed or expanded plastics are among the loading thermal insulators.

17 **Weather resistance :** Only limited varieties of plastics can be exposed to weather.

18 **Weight :** Plastics, whether thermoplastic or thermo setting have low specific gravity, the a usage being 1.30 to 1.40. The light weight of plastic reduces the transport cost and easy to fixing .

Uses of plastics

The typical uses of plastics in building are summarized as follows.

1 Bath and sack writs

2 Cistern ball floats

3 Corrugated and plain sheets

4 Decorative laminated and mouldings

5 Electrical conduits

6 Films for water proofing, damp - proofing and concrete curring

7 Electrical insulators

8 Floor files

9 Foams for thermal insulation

10 Joint less flooring

11 Lighting fixtures

12 Over heads water tanks

13 Paints and varnishes

14 Pipes to corry cold water

15 Roof lights

16 Safety glass

17 Wall tiles

18 Water resistant adhesives etc

The advantages of PVC pipes

1 They have good insulating properties and hence the water passing through this is not affected by the out side temperature.

2 The have no problems of incrustation .

3 They permit high smooth and undionanished flam of water.

4 They possess high Hazen Williams constant.

5 They prove to be economical as compared to other pipe conventional materials.

6 They provide resistance to a variety of chemicals.

Disadvantages of PVC pipes

1 They are liable to creep phenomena, when installed above ground level.

2 They can not be used in high temperature.

3 They do not have same strength as cost iron or galvanized iron pipes.

4 They possess higher co-efficient of expansion.

Precautions to be taken in the design and installation of PVC pipes.

1 The design of PVC pipes should accommodate adequate provisions of air vents etc.

2 The fittings such as tees, elbows, caps etc used in PVC piping system fit well with the pipes.

3 After installation the PVC pipes should be tested.

4 The turbulent flow of water through PVC pipes should be avoided.

5 The trances for laying PVC pipes should be as narrow as possible.

6 They are available in different colours. It is advisable to avoid red and black colours.

7 Should be used freely to eliminate external stresses

8 They should not be used at places likely to be heavy loading.

9 The should not be bent too much.

- The properties of various types of plastics make them suitable for wide range of engineering applications. The development of plastic industry is very recent and have much scope for research.
- Most of plastics possess low heat resistance
- Plastics are not very low
- Plastics exhibits high creep
- Plastics have high co-efficient of thermal expansion
- It varies from 25 x 10^{-6} to 120 x 10^{-6} as compared to 10 x 10^{-6} of steel.

Sequence of construction of a building

Objectives: At the end of this lesson you shall be able to
- **parts of a building**
- **list the sequence of construction**
- **explain the levels of different parts of building**
- **draw and indicate the parts.**

Introduction : A Building consist of sub-structure and superstructure. Foundation, Plinth, walls, floors and roofs are the main structural components of the building. Each of these components is an essential part of a building and requires due consideration in design and construction for their functional performance.

Parts of a building : The sectional view of a building shows all constructional details from the foundation level to the top of roof such as total height and different levels i.e. depth of foundation, plinth level ground floor level, thickness of wall, window sill level, floor to ceiling height, window / door height, chajja level, roof top level, parapet level and coping.

The sequence is listed form foundation

1 Foundation	2 Plinth
3 Plinth course	4 Sill
5 Door & window	6 Lintel
7 Floors	8 Roof
9 Parapet	10 Coping

1 **Foundation** : It is the lowest artificially prepared part, below the surface of the surrounding ground, which is in direct contact with sub-starter and transmits, all the loads to the sub-soil.

2 **Plinth** : It is the middle of the structure, above the surface of the surrounding ground up to the surface of the floor, immediately above the ground.

3 **Plinth course** : It is top most course at plinth level which is finished flush with the surface of ground floor.

4 **Sill** : It is the horizontal member comprising concrete, stone or wood to give support to the vertical members of wooden window. It helps in shedding rain water from face of wall.

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4 **Sill** : It is the horizontal member comprising concrete, stone or wood to give support to the vertical members of wooden window. It helps in shedding rain water from face of wall.

5 **Door & window** : Door is a frame work of wood, steel, glass. The purpose of door to give access to the users of the structure and free movement into and outside the structure. The door provide a good ventilation. Windows are constructed for providing light and ventilation in the building.

6 **Lintel** : A horizontal member of stone, wood, brick, steel, rein forced brick, R.C.C etc above the opening to support the masonry or load above, it is called lintel.

7 **Floors** : Floors are horizontal elements of a building structure which divide the building into different levels for the purpose of creating more accommodation.

8 **Roof** : A root is the uppermost part of a building which is supported on structural members and covered with a roofing material. The main function of a roof is to enclose the building and to protect the same from the damaging effects of weather such as rains, wind, snow etc.

9 **Parapet** : It is the wall built around a flat roof which acts as a protective wall for the users of the terrace. In case of pitched roof, the parapet wall is used to conceal to gutter at coves level.

10 **Coping** : The coping is covering of bricks or stones which is placed on the exposed top of on external wall to prevent seepage of water through joints of top most course in a wall.

Parts of a building (Fig 1)

Buildings: Building is not only a "SHELTER" but:

1 Energy saving

2 Efficiency improving

3 Environment friendly

4 Users friendly

5 Building can be defined as the three dimensional shape or form in the space, resting on the earth, secured to the earth by foundation for stability.

Different stages in the life of building

Planning: Decides the initial form

Designing: Decides the final form

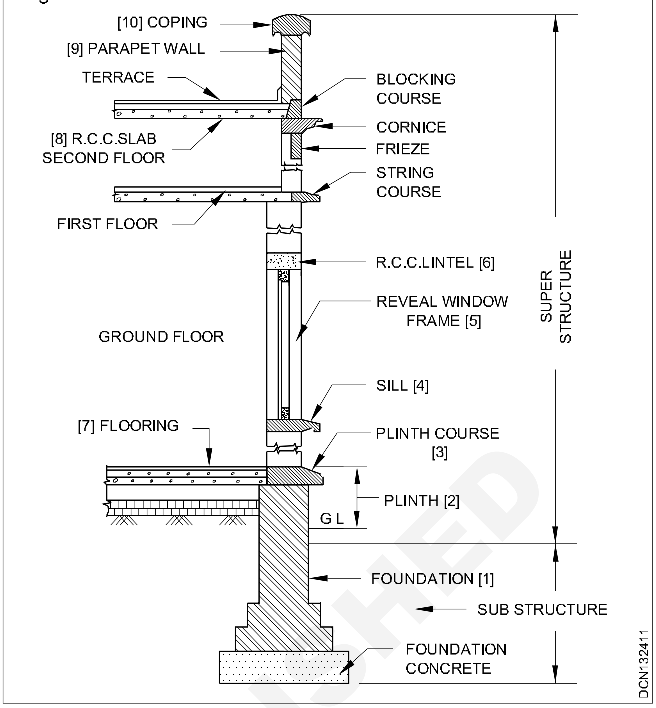
Drawing: Tool to convert requirements into reality.

Construction: Conversion of two dimensional drawing into three dimensional structure. It is engineering in action, hence needs Construction Management.

Occupation: Environment Design Evaluation is essential after occupation to assess achievements in Planning, Designing and Construction by observing behavior of user and by obtaining user's views.

Maintenance and preservation: Preparation of maintenance programme to maintain livability throughout the life of the building by observing effect of Sun, Rain, Wind, and Human Behavior on building materials and construction.

Fig 1



Masonry

Objectives: At the end of this lesson you shall be able to

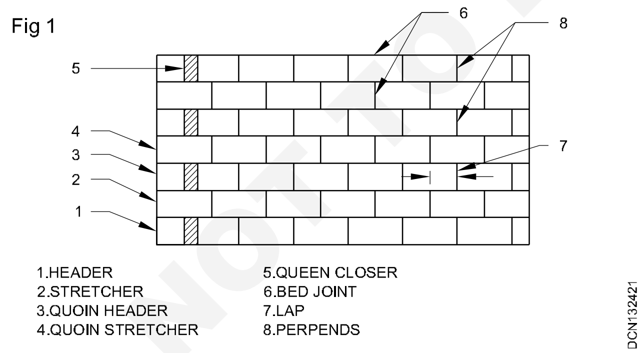
- **define masonry**
- **identify the components of masonry**
- **explain the materials required for masonry**
- **list out the classification of masonry.**

Masonry : Masonry is the art of binding building blocks (stone, brick, or other building blocks) with binding material or an assemblage of masonry units properly bonded together with mortar.

Components of masonry

Technical Terms (Fig 1)

Fig 1



Stretcher : A brick laid with its length parallel to the face of the wall

Header : A brick laid with its breadth or width parallel to the face of wall

Bed : The lower surface of the brick when laid flat

Bed joint : The horizontal layer of mortar up on which the bricks are laid

Perpends : The vertical joints separating the bricks in either length or cross direction.

Lap : The horizontal distance between the vertical joints in successive course.

Closer : A piece of brick which is used to close up the bond at the end of brick courses.

Queen closer : Cutting the brick longitudinally in two equal parts

Materials required for a masonry

Masonry units

Masonry units shall confirm to accepted standards. Masonry units may be of the following types :

a Common burnt clay bricks

b Stones (in regular sized units)

c Sand lime bricks and

d Concrete blocks

Mortar

Where specified for normal masonry and in all cases for load bearing masonry walls, mortar shall be sampled and tested for flow and water retention .

Classification

The masonry is generally classified as follows.

1 Stone masonry

2 Brick masonry

3 Hollow block concrete masonry

4 Reinforced masonry and

5 Composite masonry

Stone Masonry

Objectives: At the end of this lesson you shall be able to
- **define stone masonry**
- **state the general principles of construction of stone masonry**
- **describe the five types of ashlar masonry**
- **explain types of stone masonry joints.**

Introduction : In ancient times most of the building construction was done in stone masonry. Stones are available in large quantity but not in all parts of India. Stones are used for the construction of walls ,pillars, lintels, arches footings etc.' of the building. Most common types of stones available in India for stone masonry are granite, sand stone, limestone, marbles, slates etc., Usually lime and cement mortar are used in the stone masonry.

Definition : The art of building the structures with stone is called stone masonry.

General principles of construction of stone masonry

- Stones shall be hard, tough, compact and durable.
- Stone should be laid on their natural bed.
- Proper bond should be maintained.
- Masonry should be raised uniformly otherwise too things or recesses or steps should be provided.
- The hearting of masonry should be properly filled with stones and spalls or snicks with mortar.
- Vertical faces should be checked with plumb rule.
- The masonry should not be subjected to tensile stress.
- When construction is to be done over old surface it should be well cleaned and wetted before starting the work.
- The stones should be wetted before used to avoid absorption of water from mortar.
- The exposed joints should be pointed.
- The entire masonry should cure for two weeks.
- Through stones should be used at every 1.5m height.

Materials required for stone masonry

1 Stone

2 Mortar

1 Stone: Stones should be hard, durable, tough and free from any defect. **Eg** : Basalt, Granite, Laterite, Marble, Quartzite Sandstone, Slate.

2 Mortar: Mortar is used to keep the stones in position. Selection of mortar depends on strength required load coming and resistance desired for weathering agencies. **Eg**: Lime mortar, Cement mortar, Lime cement mortar, Cement lime mortar.

Rubble Masonry

In the rubble masonry the blocks of stones used are either undressed or rough dressed. The strength obtained from

1 Quality of mortar

2 Using of through stone in certain intervals

3 Filling up mortar thoroughly between the facing.

Ashlar Masonry

In ashlar masonry regular stones of square or rectangular shape with accurate bed joints are used.

CLASSIFICATION OF STONE MASONRY

Stone Masonry

Rubble Masonry

1 Coursed Rubble

2 Uncoursed Rubble

3 Random Rubble

4 Dry Rubble

5 Polygonal Rubble

6 Flint Rubble Course

Ashlar Masonry

1 Ashlar Fine

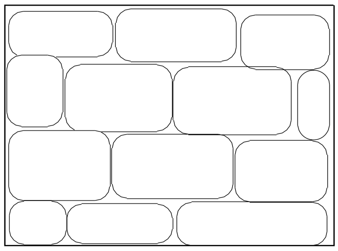
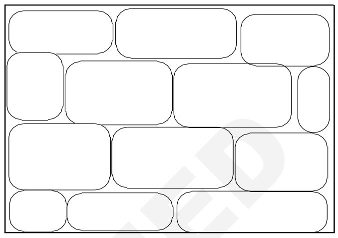
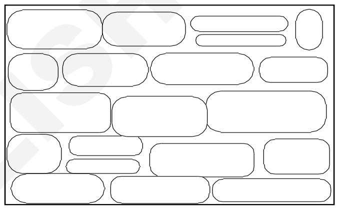
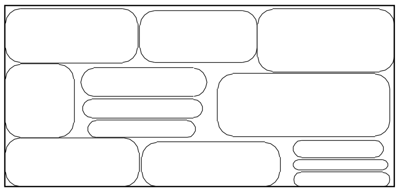
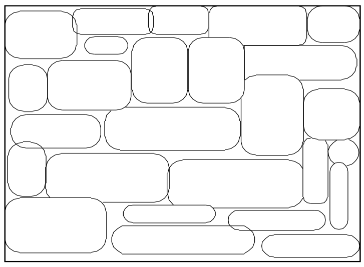
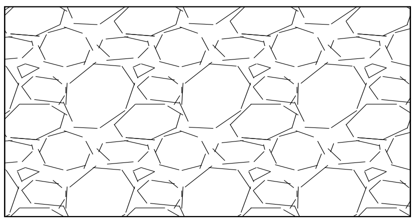
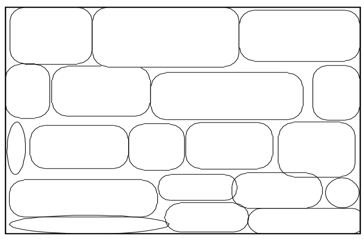
2 Ashlar Rough Tooled

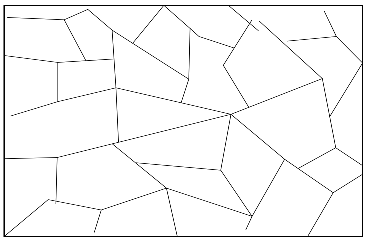
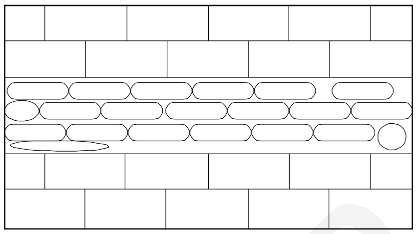
3 Ashlar Rock or Quarry Faced

4 Ashlar Chamfered

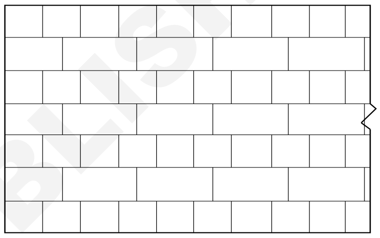
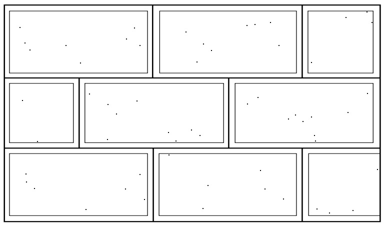
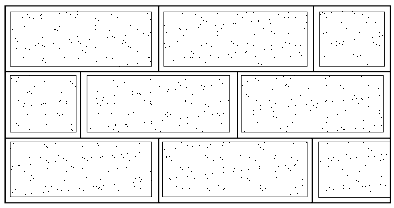
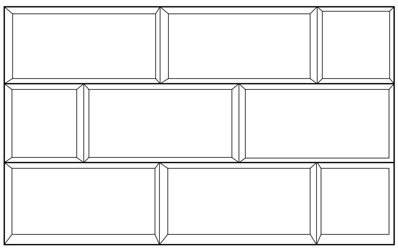
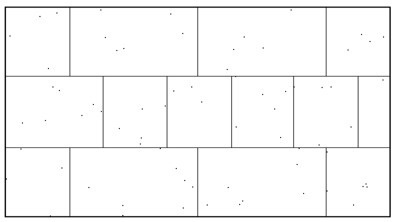
5 Ashlar Block in course masonry

RUBBLE MASONRY

SI No	Name of masonry	Description	Figure
1	Coursed rubble masonry	Heights of stones vary from 50mm to 200mm. Stones inparticular course are of equal heights. Used for public buildings, residential buildings etc.,	
1a	Coursed rubble (1st sort)	Face stones are hammer dressed, bushings do not project more than 40mm, mortar joint does not exceed 10mm.	
1b	Coursed rubble (2nd sort)	Stones are of different heights, two stones are to be used to make up the height of one course mortar joint 12mm.	
1c	Coursed rubble (3rd sort)	Minimum height 50mm,only three stones are to be used to make up the height of one course, mortar joint is 16mm.	
2	Un coursed rubble masonry	Stones are used as they are available from the quarry, course is not regularly, and the thickness of mortar joint is 12mm. This masonry is used in compound wall, go downs, garages etc.,	
3	Random rubble masonry	The stones are irregular size and shape but arranged so as to have good appearance, so more skill is required. Mortar joint does not exceed 6mm. Used for residential building, compound wall etc.,	
4	Dry rubble masonry	Similar in construction to the coursed rubble masonry3rd sort except that no mortar is used. It require more skill in construction Used for compound wall ,pitching on bridge approaches ,retaining wall etc.	

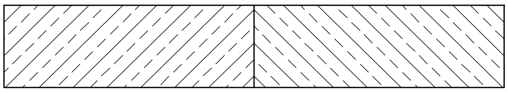
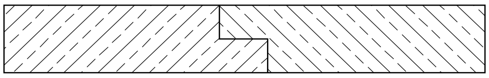
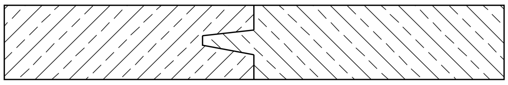
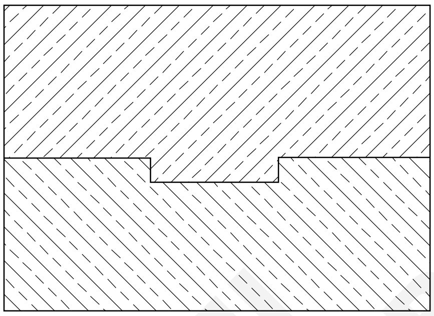
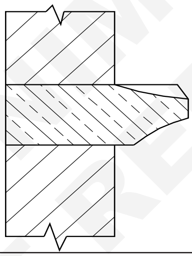
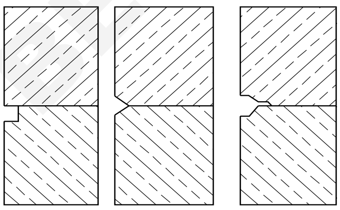
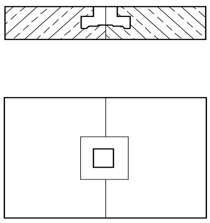
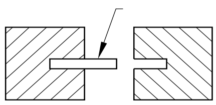
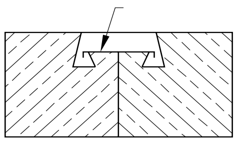
5	Polygonal Rubble Masonry	Stones are hammer dressed. Stones are selected for face work are dressed in a irregular polygonal shape. More skill required for the construction. Used for face work.	
6	Flint Rubble Masonry	Stones used are flint which is irregularly shaped nodules of silica. Face arrangements may be coursed or uncoursed. Strength is increased by introducing lacing course.Used at place where flints are available readily	

ASHLAR MASONRY

Sl no	Name of masonry	Description	Figure
1	Ashlar Fine	The beds, sides ,and faces are finely chisel dressed. The stones are arranged in proper bond. Thickness of mortar joints does not exceed 3mm.It gives smooth appearance ,but it is very costly. Used for superior work.	
2	Ashlar rough tooled (Bastard ashlar)	Beds and sides are finely chisel dressed. Faces made rough.Thickness of mortar joints does not exceed 6mm. A strip is provided around the perimeter. Used only for exposed surface.	
3	Ashlar rock or quarry faced	All the faces and sides except exposed face is left as received from quarry. Only bushings are removed. A strip is provided around the perimeter.	
4	Ashlar chamferred	A strip is provided 25mm wide, it is chamfered or beveled at an angle of 45° using chisel . Another strip 12mm wide remaining exposed face of the stone. Remaining part just like received from quarry. It gives neat appearance.	
5	Ashlar block in course masonry	It occupies a position between the rubble masonry and ashlar masonry. Faces are hammer dressed. Thickness mortar joint does not exceed 6mm. It is used for retaining walls, sea walls, railway stations, temples bridges etc.,	

JOINTS IN STONE MASONRY : In order to increase the length, breadth, thickness of stone in masonry or to secure the stones firmly with each other, joints are required.

TYPES OF JOINTS IN STONE MASONRY

NO	TYPE OF JOINTS	FIGURE	USES
1	Butt joint		Most common joint used in ordinary works .
2	Rebated joint or Lapped joint		Used arch work, coping of gable tops.
3	Tongued and grooved joint or joggled joint		Joint require more labour make expensive . Used only in some portions of ashlar masonry.
4	Tabled joint		This joint prevent lateral movement. Used in structures like sea wall where lateral pressure is more.
5	Saddled or rusticated joint		Used to protect the joint of cornice.
6	Rusticated joint		These joints are used for plinth, quoin, outer wall of lower storey.
7	Plugged joint		This used for coping cornice etc.
8	Dowelled joint		In some end portions of ashlar masonry at places where joggled joint is needed we can use this joint.
9	Cramped joint		It prevent the tendency of stone joint to pull apart. This joint is used instead of dowel joint

Brick masonry

objectives : At the end of this lesson you shall be able to,
- **define brick masonry & bond**
- **state the general principles of bonding in brick masonry**
- **explain special bricks used in brick masonry**
- **explain the types of bonds used in brick masonry**
- **describe types of brick masonry**
- **points to be observed while supervising the brickwork**
- **differentiate brick masonry & stone masonry**

Introduction

The techniques of laying various types of bricks, together with the different kinds of mortar used in the construction of thick walls, all require a different craft operation.

In dry weather all bricks must be well soaked in water before use and the top of old wall should be wetted before the commencement of work. The soaking and wetting is done to remove dust and prevent the bricks absorbing too much water from the mortar.

Definition

An art of building which the structure with bricks bonded with mortar is called brick masonry. A bond is an arrangement of bricks in layers by which no continuous vertical joints.

Principles of Bonding

1 The amount of lap should be minimum of ¼ th brick along the length of the wall and ½ brick across the thickness of wall.(Ref. components of masonry)

2 The brick should be uniform size to get uniform lap

3 The structure should be used in facing

4 Hearting should carry out with headers only.

5 Use of brickbats should avoid as far as possible.

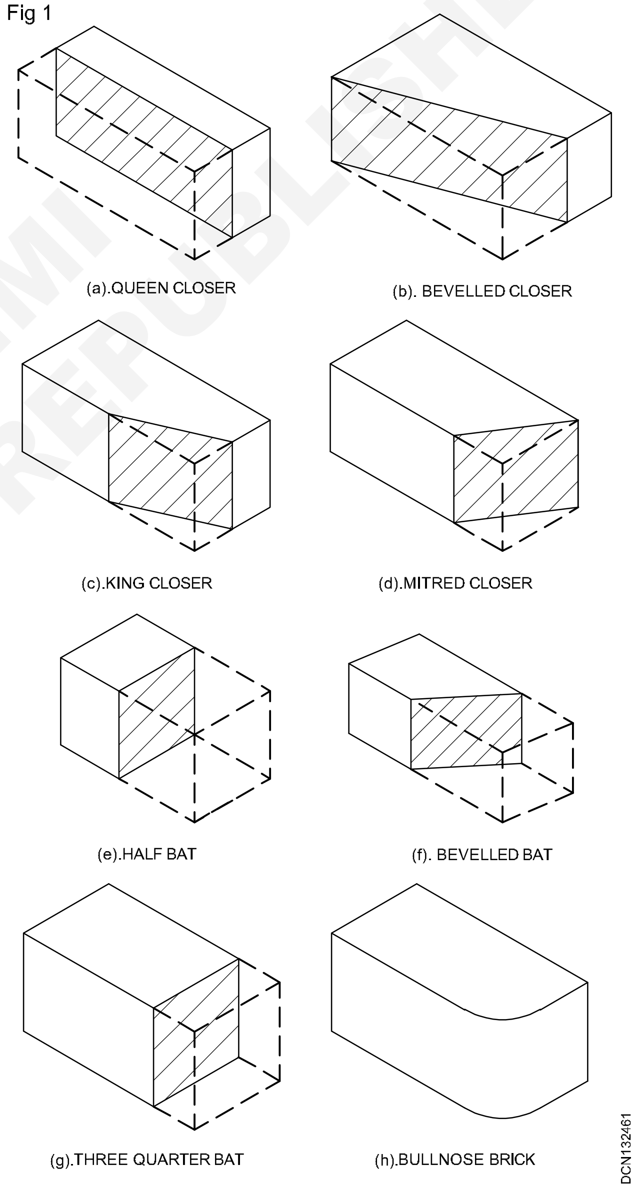
6 The vertical joints in alternate courses should be along it perpend.

Special bricks

Closer - A piece of brick which is used to close up the bond at the end of brick courses.

- **Queen closer** : Cutting the brick longitudinally in two equal parts(Fia 1a).
- **King closer**: Cutting a triangular portion of the brick such that half a header and half a stretcher are ob tained on the adjoining cut face (Fia 1b).
- **Bevelled closer:** Cutting a triangular portion of half the width but of full length(Fia 1c).
- **Mitred closer**:- Cutting a triangular portion of the brick through its width an angle of 45° to 60° with the length of the brick(Fia 1d).
- **Half Bat** : The portion made by cutting the standard brick across their length,i.e,quarter bat,half bat, three quarter bat (Fig 1 e).
- **Bullnose** :A brick moulded with a rounded angle (Fia f).
- **Cow nose**: A brick moulded with a double bull nose on end.
- **Bevelled Bat :**The portion cut 3/4 of length of brick one side and 1/2 of the length on other side.(Fig 1g)

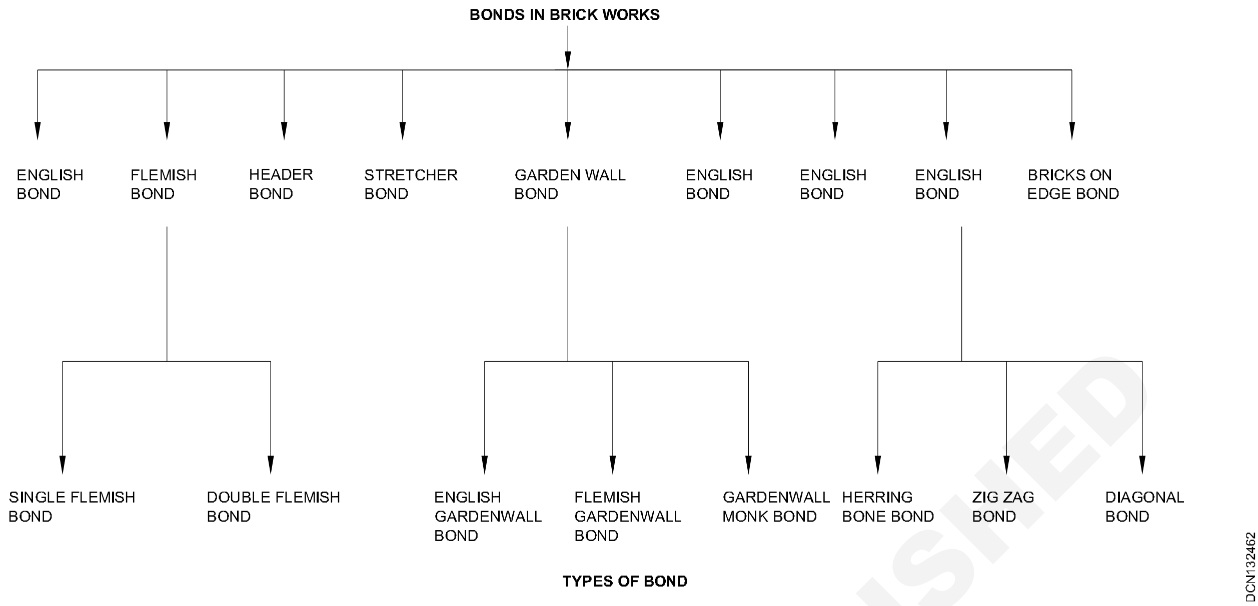
Fig 1

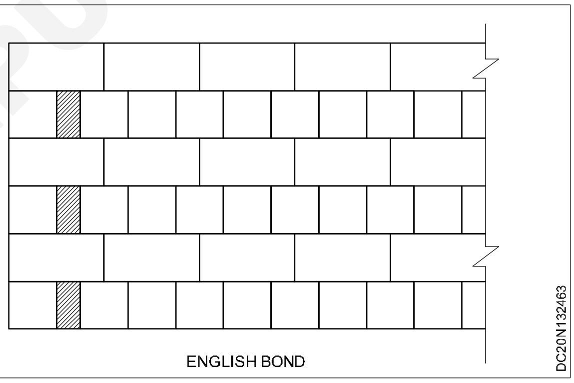
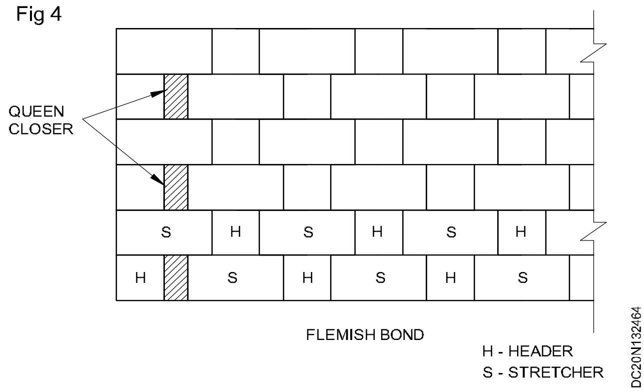


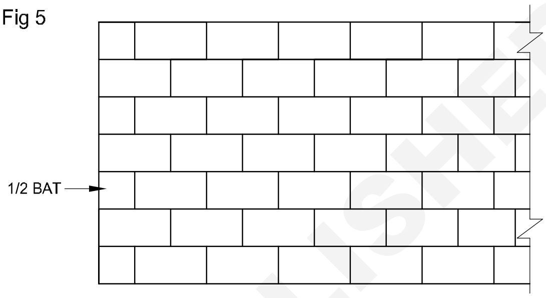
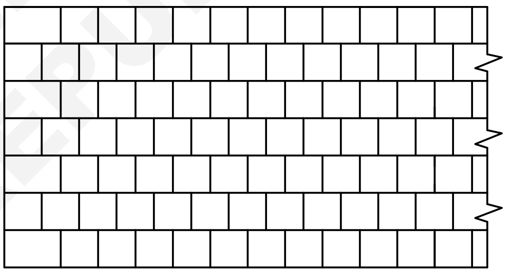
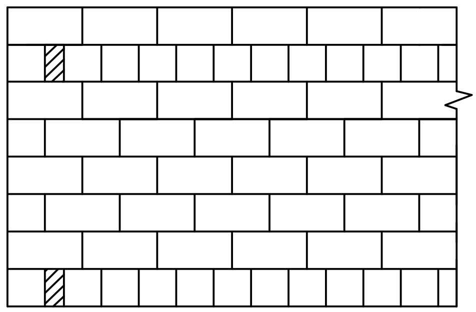
Types of Bond

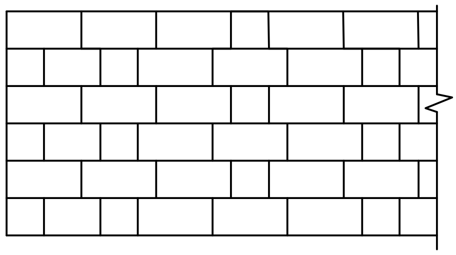
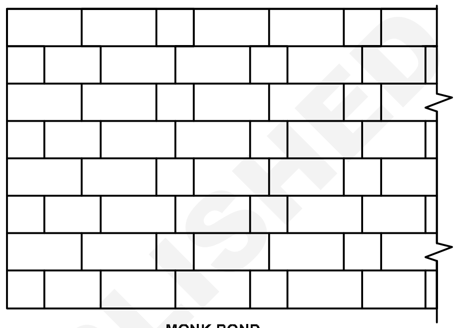
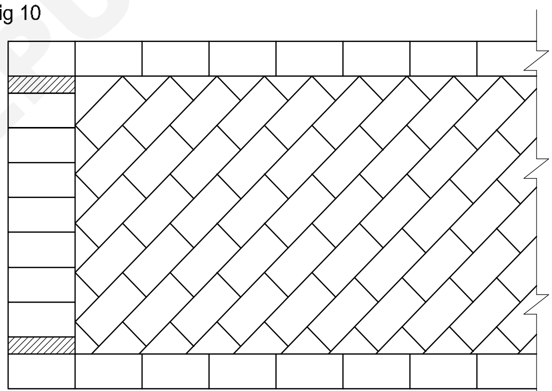
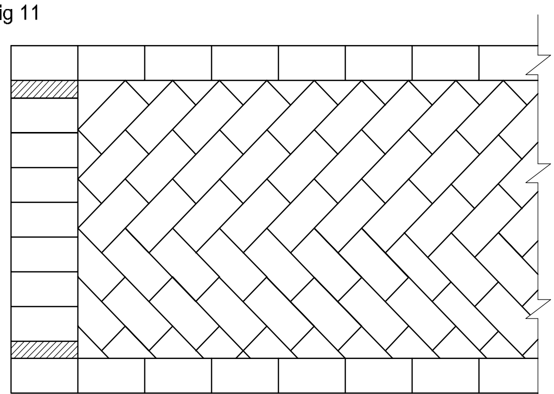
Bonds in brick works

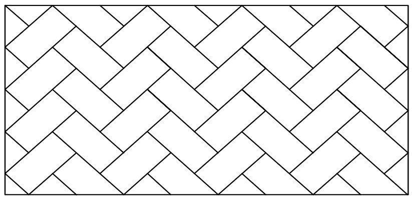
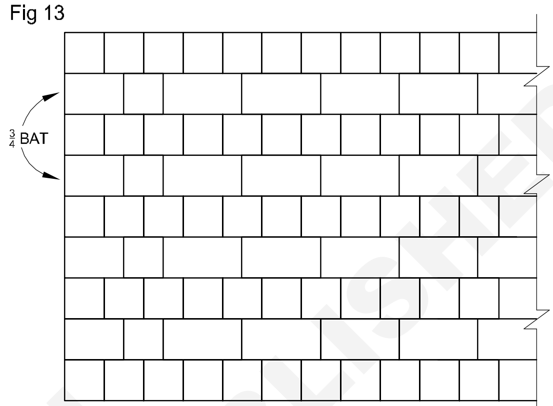
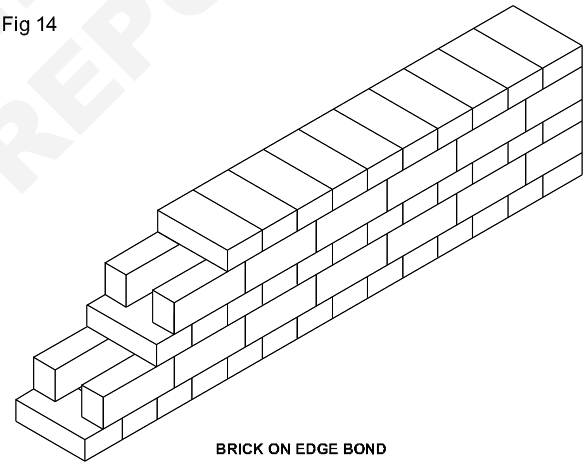
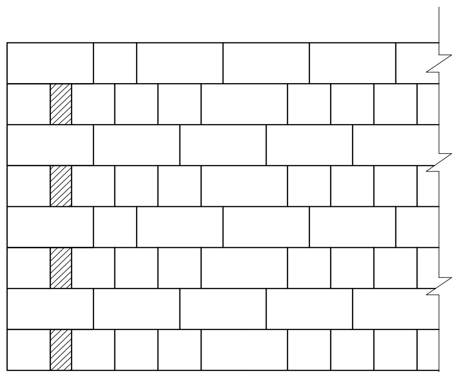
Fig 2

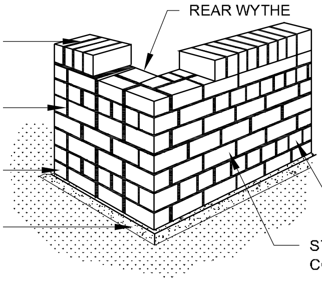
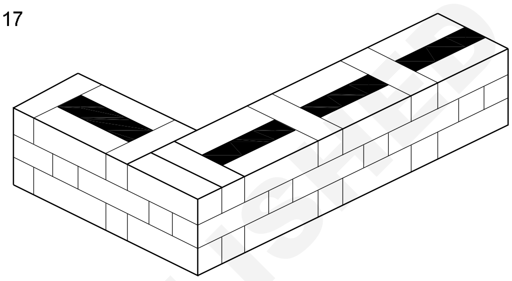


<table>
<tr><th>Name of bond</th><th>Features and uses</th><th>Figure</th></tr>
<tr><td>English bond</td><td>Alternate courses consists of headers and stretchers (Fig 3).
Queen closer put next to the quoin header to get lap.
Each alternate headers centrally
supported on stretchers.
Continuous vertical joints are not formed excepted stopped ends.
Header course should never start with a queen closer.
Queen closers are not required in tretcher course.
Minimum lap should be ¼ th brick.
1,2,3...thick wall same look on both faces Multiple of half thick wall not in same look in facing and backing.</td><td>Fig 3

</td></tr>
<tr><td>Flemish bond</td><td>In every course headers and stretchers are placed alternatively.(Fig 4)
A queen closer is put next to the quoin header.
Every header is centrally supported over a stretcher below it.
In thin board short continuous vertical joints are formed.
Brickbats are to be used in the un even multiple of half brick.</td><td>Fig 4

</td></tr>
</table>

Name of bond	Features and uses	Figure
a) Single flemish bond b) Double flemish bond	a) The facing elevation is Flemish bond but backing and hearting are of English bond b) The headers and stretchers are placed alternatively in facing as well as backing. Uses:- 1. For structural work or load bearing walls 2. Having pleasing appearance.	
Stretcher bond	1. All the bricks are arranged in stretcher course. (Fig 5) 2. It does not develop proper internal bond 3.Introduce a ½ bat at alternate course for get proper lap.	Fig 5  STRETCHER BOND DC20N132465
Header bond	1. All the bricks are arranged in header course. (Fig 6) 2. Overlap is kept equal to half brick width achieved by using ¾ bats. Uses : For circular wall For circular manhole	Fig 6  HEADER BOND DCN132466
Garden wall a) English garden wall bond	1. One header course is provide to two or five stretcher course. 2.Quoin headers are placed in alternate bond course and queen closer is placed next to the quoin header in header course to develop lap 3. The wall is one brick wall thick and the bond height is 2m (Fig 7). Uses:-The bond is used for Garden walls and compound wall.	Fig 7  GARDEN-WALL ENGLISH BOND DCN132467

Name of bond	Features and uses	Figure
b) Flemish garden wall bond	1. Each course contain one header to three or five stretcher 2. A ¾ th bat is placed next to the quoin header. 3. A header is placed centrally over each middle stretcher.	Fig 8  GARDEN-WALL FLEMISH BOND DCN132468
c) monk bond	1. Each course contain one header to two stretchers 2. The header rest on the joint between two headers. 3. A 3/4Th bat is placed next to the quoin header. (Fig 9)	Fig 9  MONK BOND DCN132469
6. Raking bond	1. Courses are inclined 2. Inclination should be in opposite direction in alternate courses. 3. Brick are laid at 45°	
a) Diagonal bond	Bricks are laid longitudinally, Useful for 2-4 brick thick.(Fig 10)	Fig 10  PLAN SHOWING ARRANGEMENT OF BRICK IN DIAGONAL BOND DC20N13246A
b) Herring bone bond	Brick are laid at 45° from the centre in both the direction, Useful for ornamental finish.(Fig 11)	Fig 11  HERRING BONE BOND DCN13246B

Name of bond	Features and uses	Figure
c) Zig-zag bond	Bricks are laid at 45° in zig-zag fashion and used for flooring (Fig 12)	Fig 12  ZIG-ZAG BOND
Dutch bond	1. Alternate courses of headers and stretchers. (Fig 13) 2. The quoin of stretcher course is ¾ bat. 3. A header is introduced next to the ¾ bat in every alternate stretcher course. Uses:- Corner of wall can be strengthened.	Fig 13  DUTCH BOND
Brick on edge bond	1. Bricks are laid as headers and stretchers in alternate courses.(Fig 14) 2. Headers are laid on bed and stretchers are laid on edge. 3. Continuous cavity is formed. Uses:- Used for garden wall, compound wall, partition wallet.	Fig 14  BRICK ON EDGE BOND
English cross bond	1. Alternate courses are of headers and stretchers. (Fig 15) 2. The queen closers are placed next to the quoin header. 3. A header is introduced next to the alternate quoin stretcher. Uses:- This bond adds the beauty of wall	Fig 15  ENGLISH CROSS BOND

Name of bond	Features and uses	Figure
Facing bond	1. A header course is placed after several stretcher course.(Fig 16) Uses:- Used when facing and backing brick are varying size.	Fig 16 
Rat trap bond	1. Locally made bricks having thick ness less than 10cm are used. (Fig 17) 2. all the bricks are laid on edge. 3. Alternate headers and stretchers are used in same course. 4. A cavity is formed inside the course. 5. It is strong ,sound and heat proof.	Fig 17  RAT TRAP BOND

Comparision of English bond with Flemish bond

Features	English Bond	Flemish Bond
Arrangement of brick	a. Headers and stretchers are laid in alternate courses b. Each alternate header is centrally supported over a stretcher	a. Headers and stretchers are laid alternatively in each course. b. Every header is centrally supported over a stretcherbelow it.
Strength	Strongest type of bond	Weakest bond for all walls
Appearance	Provides rough appearance	Provides good appearance
Skill	Requires less skill	Requires more skill
Material cost	Costly, brick bats are not used	Economical, as brick bats are used.
Mortar	More mortar required	More mortar required for additional joints.

Bonds at connections (Fig 18)

The walls in different directions are united together at certain places, which are called connections.

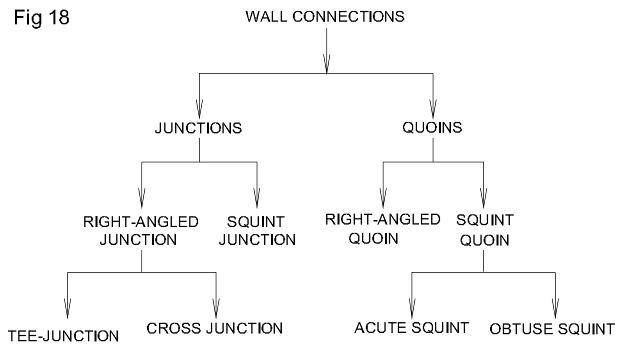
Requirements to be satisfied by bond at connections are:-

1 Vertical joints should not be continuous.

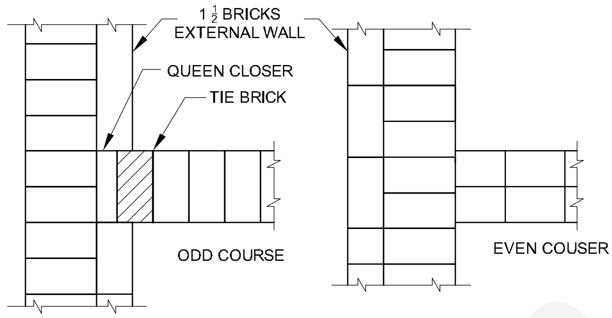
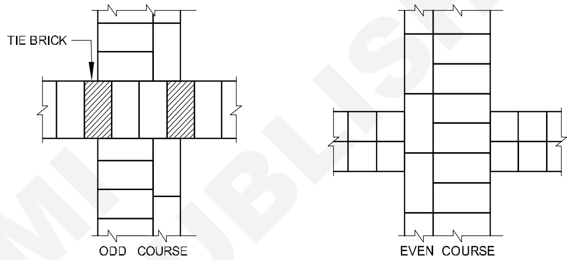
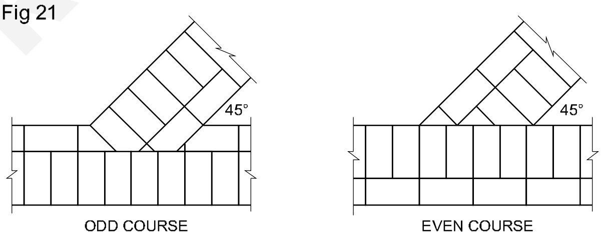
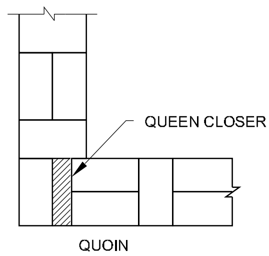
2 Broken bricks to be used minimum.

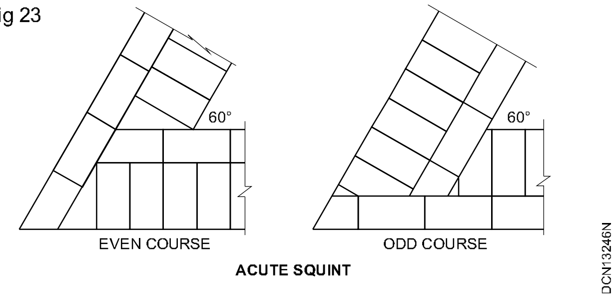
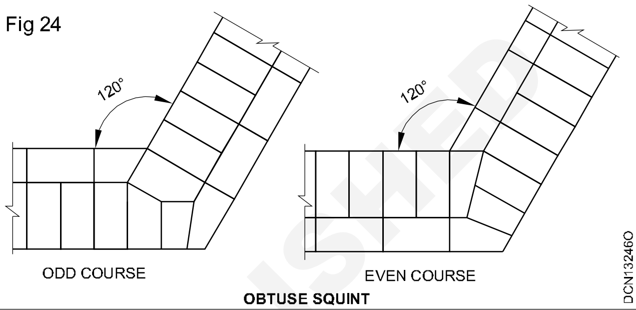
3 Connection should be strong enough to resist differential settlement.

Fig 18



Forms of connections

Forms of connections	Features	Figure
1. Junction		
a) Right angled junction	Two walls meet each other at right angles (Fig 19)	Fig 19  PLANS OF ALTERNATE COURSES T - JUNCTION DC20N13246J
a.i) Tee Junction	Forms the shape of letter 'T'. Header courses of courses of cross wall enters the stretcher course of main wall. Alternate courses simply abutting the main wall.	
a.ii) Cross junction	Two walls cross each other. Alternate courses simply abutting the main wall. Other alternate courses are provided with the bricks in the form of key headers to create necessary lap. (Fig 20)	Fig 20  CROSS JUNCTION DC20N13246K
b) Squint junction	Two walls meet each, other then a right angle. Not common in use (Fig 21)	Fig 21  SQUINT JUNCTION DCN13246L
2 Quoins	Connection formed when a wall takes turn (Fig 22)	Fig 22  ONE BRICK WALL DCN13246M

Forms of connections	Features	Figure
2.a) Right angled quoin 2. b) Squnit quoin	Wall take a turn and makes a right quoin (square quoin) angle. No vertical continuous joints are formed. (Fig 23) Walls takes a turn and make other than a right angle. Enclosed angle on the side of the	Fig 23 
2. b i) Acute squint quoin 2. bii) Obtuse squint quoin	Wall is less than a right angle Enclosed angle on the side of the wall should between 90^0 to 180^0 (Fig 24)	Fig 24 

Defects in brick masonry

Following are the causes of defects in a brick masonry work.

1 Corrosion of embedded fixtures.

2 Crystallization of salts from bricks

3 Shrinkage on drying

4 Sulphate attack

5 Freezing of water

Types of brick masonry

The brickwork is classified according to the quality of mortar, quality of brick, and thickness of mortar joint are as follows.

Types of brickwork	Pecularities
1. Brickwork in mud mortar	a. Intimately mixed sand and clay -mud- is used to fill joints.
	b. Mortar thickness 12mm
	c. Used for cheapest construction of height up to 4m
2. Brickwork in CM or LM I class	a. Cement mortar or lime mortar is used .
	b. Bricks are table moulded of standard shape
	c. The surface and edges are sharp, square and straight.
	d. Mortar joint doesn't exceed 10mm
3. Brickwork in CM or LM II class	a. Cement mortar or lime mortar is used.
	b. Bricks are ground moulded of standard shape and burnt in kilns.
	c. Thickness of mortar joint is 12mm
4. Brickwork in CM or LM III class	a. Cement mortar or lime mortar is used.
	b. Bricks are ground moulded of standard shape and burnt in clamps.
	c. Thickness of mortar joint is 12mm

Points to be observed while supervising the brick work

Following points are to be carefully attended to while supervising the brickwork:

1 The bricks to be used should confirm with the requirements of the specification of the work.

2 The bricks should be saturated with water so as to prevent absorption of moisture from the mortar. This is effectively done by providing a tank at the site of work and by immersing the bricks for a period of at least 2 hours before the bricks are actually placed in position.

3 The bricks should be properly laid on their beds. The mortar should completely cover the bed as well as the sides of bricks. The bricks should be laid with the frog uppermost.

4 The brickwork should be carried out in proper bond.

5 The brickwork should complete with the requirements of the specifications for the work.

6 The mortar to be used for the work should be of quality and of proportion as specified.

7 As far as possible, the brickwork should be raised uniformly. But when this is not possible or when a cross wall is intended to be inserted after sometime, the steps or toothings should be provided.

8 In the brickwork, the brickbats should not be used except as closers. All the brickbats of size less than half- brick should be rejected and not allowed to be used in the construction.

9 The single scaffolding should be adopted to carry out the brickwork at a higher level. The required headers are taken out to create supports for the scaffolding and they should be inserted when the scaffolding is removed.

10 The brickwork should be carried out as per line and level. The vertical faces should be checked by means of a plumb bob and the inclined surfaces, if any should be checked by means of wooden templates.

11 After construction, if cement martor is used the brick work should be cured for a period of about two to three weeks, if lime mortar is used and for a period of about one to two weeks.

Difference between stone masonry and brick masonry

Stone Masonry	Brick Masonry
1. Stones are natural material obtained from quarries.	1. Bricks are artificial material.
2. Dressing of stone is important.	2. Dressing not required only rectangular blocks using
3. Bonding is fair but strength is more	3. Bonding is good. But strength is less.
4. Required skill labour.	4. Less skilled labour
5. Lifting and laying is heavy	5. convenient in lifting and laying.
6. More quantity of mortar need	6. Less quantity of mortar need.
7. Mortar joints are irregular	7. Mortar joints are uniform.
8. Plastering is not required	8. Plastering is required.
9. Fire resistance less	9. Fire resistance more.
10. Wall thickness more than 300 mm	10.100 mm, 200 mm wall easily constructed.
11. Ornamental work costly	11. Cheap and easy construct ornamental works.

Reinforced masonry

Objectives : At the end of this lesson you shall be able to,
- **explain reinforced masonry**
- **describe the features of reinforced masonry walls & columns**
- **explain reinforced masonry lintel & slabs**
- **prepare freehand sketches of reinforced masonry for walls & columns.**

Introduction : Brickwork strengthened by expanded metal, steel-wire mesh, hoop iron, or thin rods embedded in the bed joints .Reinforced masonry is also essentially a wall material. Of course, beams and slabs have been built in reinforced masonry, but with the exception of deep wall beams, it is hard to justify them in comparison with reinforced concrete ones. Reinforced masonry does not require shuttering and expensive element of concrete. The real advantage of reinforced masonry lies in walls subject to bending perpendicular to the wall plane. It combines flexibility of form with good finish and frequently a large cost saving compared with reinforced concrete. Reinforced masonry is thus a cheap, durable, fireproof, easy to construct and in most cases it results in the increase of floor space due to adoption of brickwork of lesser thickness. The reinforced masonry has been used with advantage under the following circumstances.

1 Retaining walls up to 6 m height can be constructed using various types of brick walls and filled hollow blocks, with a drained granular fill. (Fig 1)

2 Reinforced masonry can be used for cantilevering vertically in boundary walls or tall sheds where the walls cannot be restrained at the top.

3 It can also be used in horizontally spanning cladding where it is not possible to prove stability in wind due to arching.

Reinforced masonry walls (Fig 2) : Iron bars or expanded metal mesh is generally provided at every third or fourth course. Before starting the next course the steel fabric is spread flat on the cement mortar and pressed evenly.

Fig 1

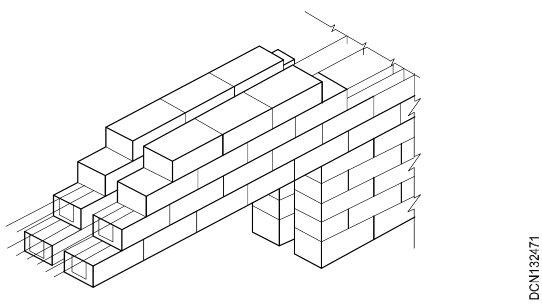
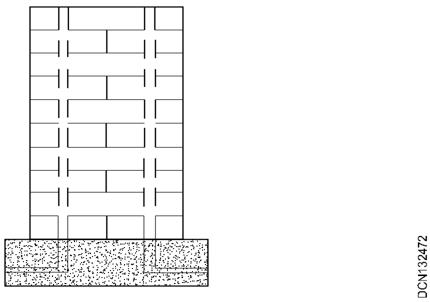


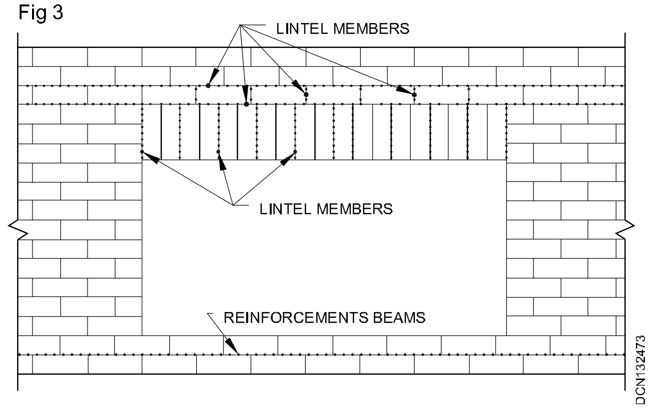
Fig 2



Flat bars of section about 25mmX2mm may be used as hoop iron reinforcement for walls. They are hooked at corners and junctions and usually dipped in tar and sanded immediately so as to increase their resistance against rusting. Generally, one strip is provided for every thickness of half brick. Reinforcement in vertical directions may be provided by using special bricks or blocks. Mild steel bars (6 mm diameter) can also be used as longitudinal reinforcement in walls.

Masonry units used in reinforced masonry (Fig 3) : The properties of masonry units used for reinforced masonry work should complete with the requirements of relevant European standards (EN 771-1-6). Masonry units are classified into the following types: solid, perforated unit, hollow unit, cellular unit, horizontally perforated unit.

Fig 3



Masonry reinforced columns (Fig 4) : The reinforced columns are provided with steel plates of about 6 mm thickness at every fourth course. Vertically reinforcement bars are placed between special type of blocks used for the columns. The steel bars are fixed in the foundation concrete block.

Reinforced masonry lintels (Fig 5) : In case of brick lintels reinforcement in the form of 6 to12 mm diameter bars is provided longitudinally in between in between the vertical joints. Vertical stirrups of 6 mm diameter are provided at every third vertical joint to take up the vertical shear.

Reinforced masonry slab : For the construction of masonry slab, the centering in the form of a platform of wooden planks supported on beams is erected at the required level. The centering is covered with well-beaten earth and fine sand is sprinkled over it. Reinforcement is placed in positions and the bricks are laid in one or two courses. Reinforcement should be properly embedded in mortar. Joints should be properly filled with mortar. The slab is kept wet for a period of two to four weeks for proper curing. After 28 days the centering is removed and top and bottom surfaces of slab are suitable finished

Fig 5

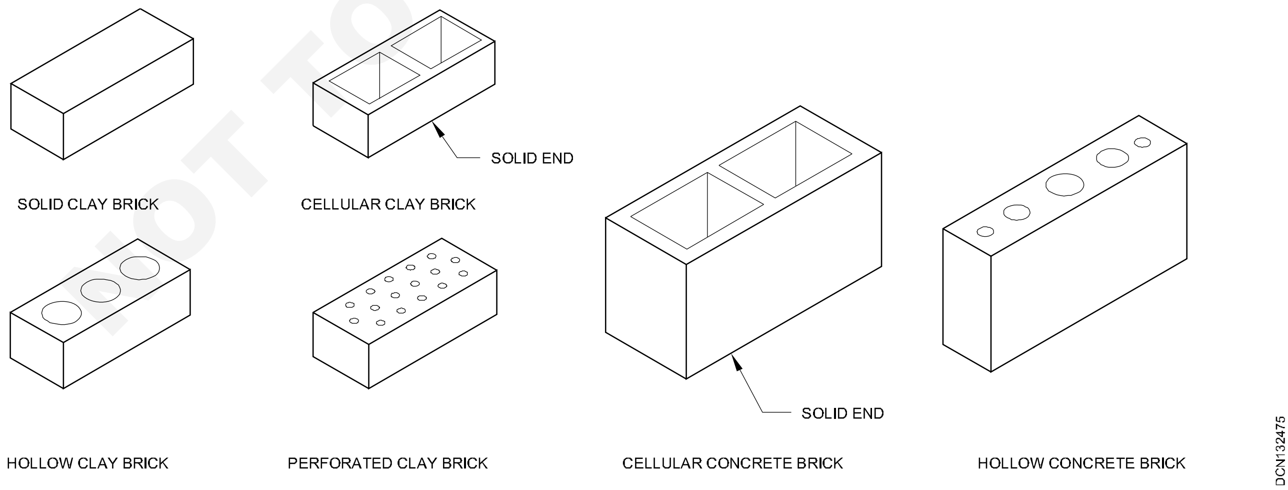
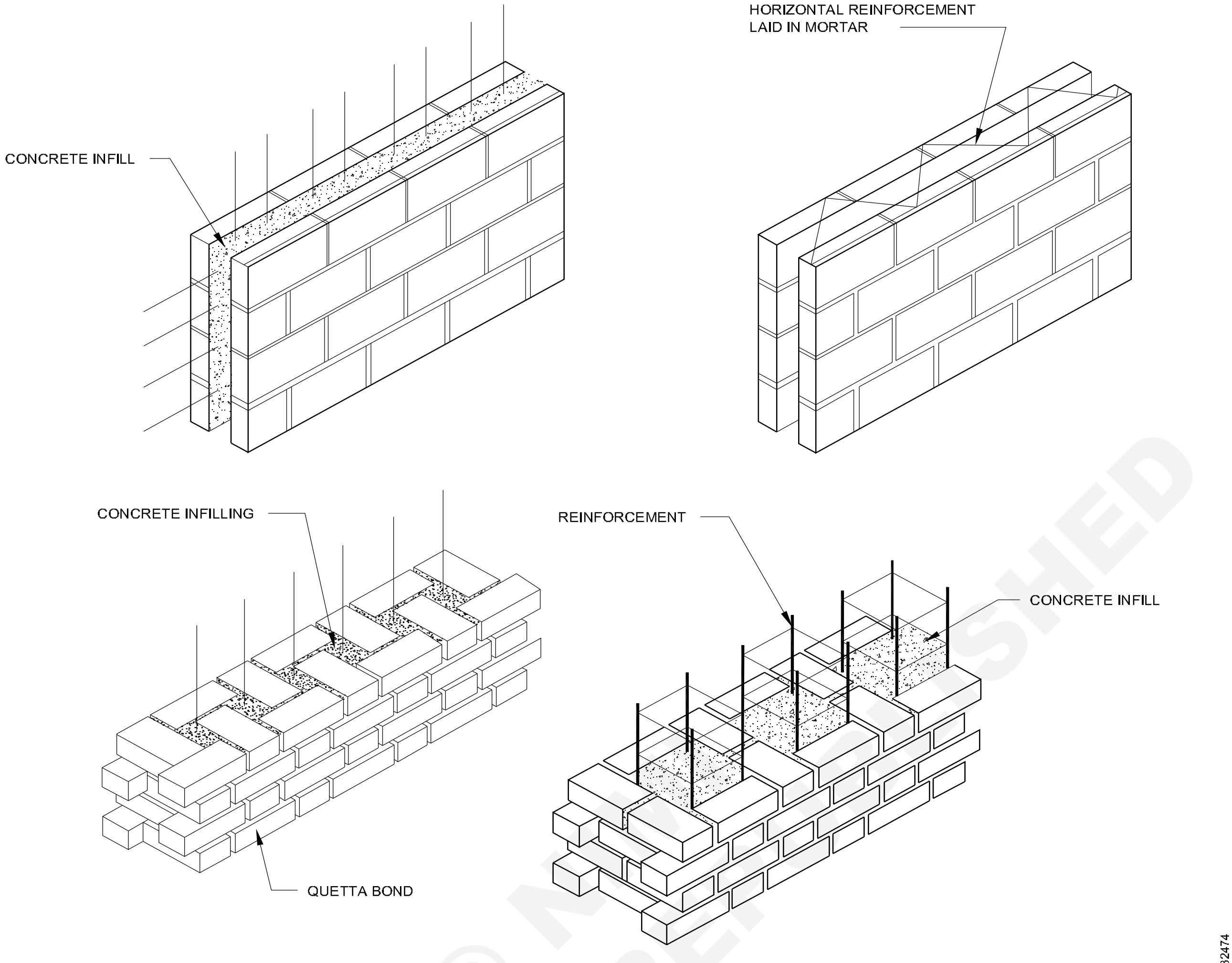


Fig 4



REINFORCED MASONARY WALLS

Composite masonry

Objectives : At the end of this lesson you shall be able to,
- **explain composite masonry**
- **list out the measures adopted for composite masonry**
- **explain usual combinations to obtain composite masonry.**

Introduction : When facing and backing of walls are constructed using different types of materials, the construction so obtained is known as composite masonry. The composite masonry reduces the overall cost of construction. This also makes the structure more durable by providing materials of better quality and good workmanship in the facing so as to minimize the effects of atmospheric influences on the wall.

Measures adopted for composite masonry : This type of construction results in a large number of mortar joints in the inside than at the outside of the wall. This may lead to unequal settlement. The following measures must be adopted to prevent the unequal settlement.

1 Use large number of tough stones.

2 Provide metal cramps, dowels, lead plugs, etc, between facing and backing of the wall.

3 Provide the hearting portions in rich cement mortar.

4 Carry up the facing and backing portions of the wall simultaneously

The usual combinations adopted to obtain composite masonry can be listed as below (Fig 1) : Facing of ashlars and backing of rubble masonry or brickwork figure.

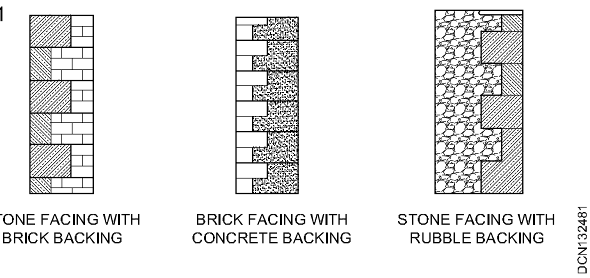
1 Facing of stone slabs and backing of concrete.

2 Facing of brickwork and backing of ashlar masonry.

3 Facing of brickwork and backing of concrete, and

4 Facing of brickwork and backing of hollow concrete blocks.

Fig 1

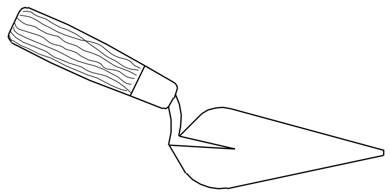


Tools and equipments used in brick masonry

Objectives: At the end of this lesson you shall be able to
- **state the various tools and equipment used in brick work.**

1 **Trowel :** It consists of a blade and shank in to which a wood handle is fixed. It is used for lifting and spreading mortar on to a wall cutting the brick and forming joints (Fig 1)

Fig 1

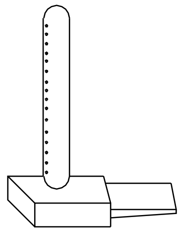


TROWEL

DCN132491

2 **Brick hammer :** This hammer is used for cutting the bricks to the required shape. One edge of hammer is sharp and the other is square. (Fig 2)

Fig 2

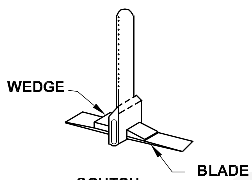


BRICK HAMMER

DCN132492

3 **Scutch :** It is used for cutting soft bricks and dressing the surface of the brick (Fig 3)

Fig 3

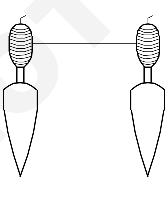


SCUTCH

DCN132493

4 **Line and pin :** The line is wood round two pins. It is used to maintain the correct alignment of courses. (Fig 4)

Fig 4

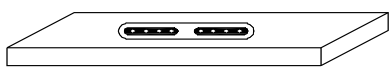


LINE AND PIND

DCN132494

5 **Spirit level :** Sprit level for getting horizontal surfaces. (Fig 5)

Fig 5

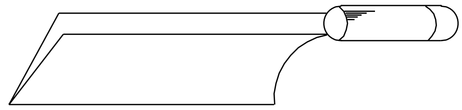


SPIRIT LEVEL

DCN132495

6 **Brick axe :** It is purpose is similar to brick hammer. (Fig 6)

Fig 6

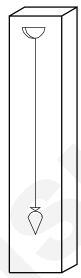


BRICK AXE

DCN132496

7 **Plumb rule :** Plumb rule is used to clock verticality of brick work or stone wall. (Fig 7)

Fig 7

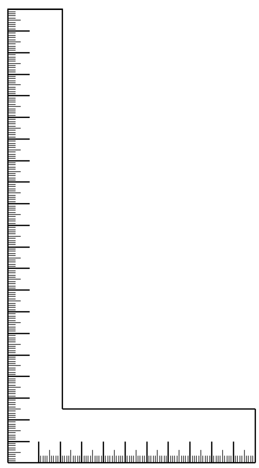


PLUMB RULE

DCN132497

8 **Manson's square :** It is made of steel or wood is used for checking right angle of the wall. (Fig 8)

Fig 8

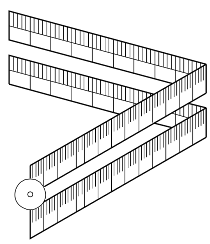


MASON'S SQUARE

DCN132498

9 **Four folded foot rule :** It is used for taking measurements (Fig 9)

Fig 9

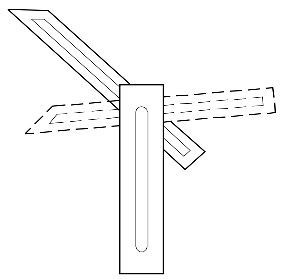


1-METER 4-FOLD RULE

DCN132499

10 Bevel : It is used for setting out angles (Fig 10)

Fig 10



Strength of walls

Objectives: At the end of this lesson you shall be able to
- **explain strength and stability of walls**
- **state the related posts by category.**

The compressive strength of well burned brick combined with the durability, fire resistance and appearance of the material commends it as a walling material for the more permanent buildings.

The sense of solidity and permanence and compressive strength of sound building stone made it the traditional walling material for many larger buildings.

Steel and concrete, which have been used in building since the industrial revolution, are used principally for their very considerable strength as the structural frame members of large buildings where the compressive strength of concrete, separately or in combination with steel, is used for both columns and beams.

In the majority of small buildings, such as houses, the compressive strength of brick and stone in rarely fully utilized because the functional requirements of stability and exclusion of weather dictate a thickness of wall in excess of that required for strength alone. To support the very must loads on the walls of small buildings the thinnest brick or stone wall would be quite adequate.

Related posts by category

Walls

- Rubble walling and random rubble - wall
- Dowels, Cramps - walls- stones.
- Weathering to cornices, cement joggle-stones-walls.
- Cornice and parapet walls, saddle joint-walls-stones.
- Openings to stone walls - lintels.
- Stone masonry walls.
- Vapour barrier, vapour check, external insulation, resistance to the passage of sound.
- Solid walls, mechanical fixing, internal finish.
- Solid walls, adhesive fixing.
- Solid walls: Thermal insulation, internal insulation.
- Brick lintels - walls.
- Prestressed concrete lintels and composite and non-composite lintels - walls.
- Reinforcing rods and casting lintels - walls.
- Head of opening in solid walls and timber lintels.
- Bonding of bricks at rebated jambs - walls.
- Jambs of openings and rebated jambs - walls.
- Openings in solid walls.
- State and tile hanging - walls.
- External weathering to wall of brick and block and rendering.
- Resistance to weather - solid wall of brick.
- Solid walls.
- Cavity wall insulation : Partial fill, insulation materials, insulation thickness, total fill, thermal bridge.
- Resistance to the passage of heat - walls.
- Concrete lintels walls.

Strength of masonry

Objectives: At the end of this lesson you shall be able to
- **explain compressive strength of masonry**
- **explain application - advantages- disadvantages structural limitations of masonry**
- **describe veneer and dry set masonry.**

Verifying compressive strength of masonry (Fig 1) : For masonry under construction, we need to determine compliance with the specified compressive strength of masonry. We have two options for accomplishing this. One is the unit strength method and the other is testing masonry prisms for compressive strength.

The unit strength method verifies the compressive strength of the individual materials and then uses tables to determine compressive strength of the assembly from that information. The MSJC specification in section 1.4B, compressive strength determination, is one source of tables for the unit strength method and the international building Code (IBC) is another. They are set up similarly. They have one table for clay masonry and one for concrete masonry and each give the compressive strength of the assembly based on the strength of the unit and the type of mortar. If the wall is grouted, then the grout simply has to comply with ASTM C476, specification for grout for masonry, or be the same strength as the specified strength of masonry, but not less than a minimum of 2,000 pounds per square inch (psi).

Fig 1

If you do not use tables, you need to know about constructing prisms to verify compliance with design compressive strength. These specimens are built at the job site. Methods for this are outlined in ASTM C 1314, Standard test method for compressive strength of masonry prisms, which entails constructing the prisms, including grouting if applicable, and bag curing them.

Masonry prisms for compressive strength testing are constructed and then cured in plastic bags. Following initial curing, they are shipped to the lab in a rig to prevent damage during movement. (IMG15865)

The construction will be deemed acceptable or not acceptable based on the prism test results, so it's important to do the job right. Prisms are fabricated in moisture-tight-bags. Large black polyethylene bags, like heavy-duty trash bags, are common. units are mortared together, and the resulting prisms are left to cure for 24 to 48 hours. If the construction is to be solidly grouted, the prisms are grouted at this time. Following grouting, the bags are resealed and cured for an additional 48 hours or longer. Prisms are then strapped or clamped together to prevent damage during transport to the testing laboratory. Then they are further cured, removed from the bags two days prior to compressive strength testing, and tested in compression at an age of 28 days or another designated test age. This produced values for strength of masonry to determine whether or not the as-constructed wall meets the design requirements.

Resources : Standard test method for compressive strength of masonry prims, ASTM C1314-12.

Masonry (Fig 2) : This article needs additional citations for verification. Please help improve this article by adding citations to reliable sources. Unsourced material may be challenged and removed. (April 2012) (Learn how and when to remove this template message)

Fig 2

A mason laying mortar on top of a finished course of blocks, prior to placing the next course

Masonry is the building of structures from individual units, which are often laid in and bound together by mortar; the term masonry can also refer to the units themselves. The common materials of masonry construction are brick, building stone such as marble, granite, travertine, and lime stone, cast stone, concrete block, glass block, and cob. Masonry is generally a highly durable form of construction. However, the materials used, the quality of the mortar and workmanship, and the pattern in which the units are assembled can substantially affect the durability of the overall masonry construction. A person who constructs masonry is called a mason or brick layer.

1 Applications
  - Advantages
  - Disadvantages
  - Structural limitations
2 Veneer masonry
3 Dry set masonry
  - Energy dissipation devices
  - Semi - interlocking masonry
4 Brick
  - Uniformity and rusticity
  - Serpentine masonry
5 Concrete block
6 A-jacks
7 Stone work
8 Gabions
9 Bagged concrete
10 Masonry training
11 Passive fire protection (PFP)
12 Mechanical modeling of masonry structure
13 See also
14 References
15 External links

Applications : Masonry is commonly used for walls and buildings. Brick and concrete block are the most common types of masonry in use in industrialized nations and may be either weight- bearing or a veneer. Concrete blocks, especially those with hollow cores, offer various possibilities in masonry construction. They generally provide great compressive strength, and are best suited to structures with light transverse loading when the cores remain unfilled. Filling some or all of the cores with concrete or concrete with steel reinforcement (typically rebar) offers much greater tensile and laterial strength to structures.

Advantages : The use of material such as brick and stones can increase the thermal mass of a building and can protect the building from fire.

Masonry is non - combustible product. Masonry walls are more resistant to projectiles, such as debris from hurricanes or tornadoes.

Disadvantages : Extreme weather, under certain circumstances, can degradation of masonry due to expansion and contractions forces associated with freeze - thaw cycles.

Masonry tends to be heavy and must be built upon a strong foundation, such as reinforced concrete, to avoid setting and cracking.

Other than concrete, masonry construction does not lend itself well to mechanization, and requires more skilled labor then stick-framing.

Masonry consists of loose components and has a low tolerance to oscillation as compared to other materials such as reinforced concrete, plastics, wood, or metals.

Structural limitations : Masonry has high compressive strength under vertical loads but has low tensile strength (against twisting or stretching) unless reinforced. The tensile strength of masonry walls can be increased by thickening the wall, or by building masonry piers (vertical columns or ribs) at intervals. Where practical, steel reinforcements such as windposts can be added.

Veneer masonry : A masonry veneer wall consists of masonry units, usually clay- based bricks, installed on one or both sides of a structurally independent wall usually constructed of wood or masonry. In this context the brick masonry is primarily decorative, not structural. The brick veneer is generally connected to the structural wall by brick ties (metal strips that are attached to the structural wall, as well as the mortar joints of the brick veneer). There is typically an air gap between the brick veneer and the structural wall. As clay- based brick is usually not completely water proof, the structural wall will often have a water- resistant surface (usually tar paper) and weep holes can be left at the base of the brick veneer to drain moisture that accumulates inside the air gap. Concrete blocks, real and cultured stones and veneer adobe are sometimes used in a very similar veneer fashion.

Most insulated buildings that utilize concrete block, brick, adope, stone, veneers or some combination there of feature interior insulation in the form of fiberglass batts between wooden wall studs or in the form of rigid insulation boards covered with plaster or drywall. In most climates this insulation in much more effective on the exterior of the wall, allowing the building interior to take advantage of the aforementioned thermal mass of the masonry. This technique does, however, require some sort of weather - resistant exterior surface over the insulation and consequently, is generally more expensive.

Dry set masonry (Fig 3)

Fig 3

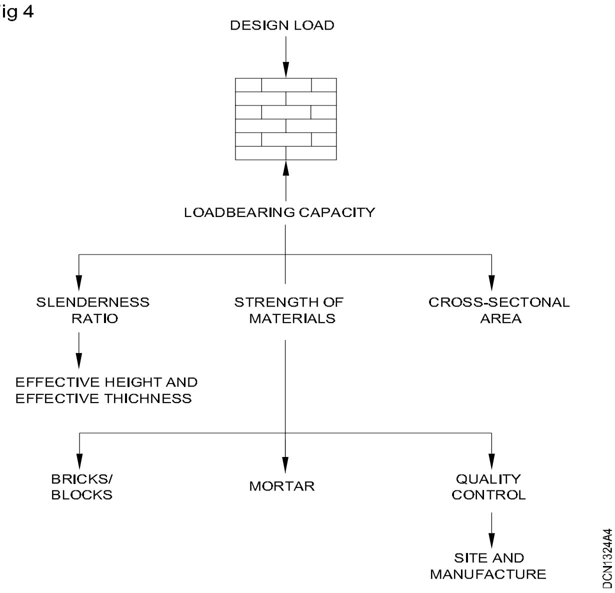
Dry set masonry supports a rusticlog bridge, where it provides a well - drained support for the log (which will increase its service life)

Dry stone : The strength of a masonry wall is not entirely dependent on the bond between the building material and the mortar; the friction between the interlocking blocks of masonry is often strong enough to provide a great deal of strength on its own. The blocks someties have grooves or other surface features added to enhance this interlocking, and some dry set masonry structures forgo mortar altogether.

Compressive strength of brick masonry (Fig 4) : A wall or column carrying a compressive load behaves like any other strut, and its load bearing capacity depends on the compressive strength of the materials, the cross-sectional area and the geometrical properties as expressed by the slenderness ratio.

The compressive strength of a wall depends on the strength of the units used, the bricks or blocks, and the mortar. The assessment of the combined strength of these elements will also be affected by the degree of quality control exercised in manufacture and construction. The slenderness ratio, in turn, depends upon the effective height (or length) and the effective thickness of the wall or column.

Fig 4



Site exploration

Objectives : At the end of this lesson, you shall be able to,
- **define site exploration**
- **state the purposes of exploration**
- **explain preliminary investigation**
- **explain various method of site exploration.**

Introduction

The knowledge of soil characteristics and the factors influencing their properties will help the investigation in the identification of individual soils encountered in soils exploration and in the selection of right type of foundation for the building.

Definition:

For designing a right type of foundation safely and economically, a designer must possess sufficient information about the physical properties and the arrangement of the underlying materials. The field and laboratory investigations required to get this essential information are known as soil/site exploration.

General inspection of site

It is desirable to visit the site of work and inspect the same carefully from the view point of foundation details. The nature and thickness of strata of soil may be estimated by studying the excavation details of near by construciton or by examining the open side of a near by well etc. The general inspection of site of work serves as a guide for determine the type of foundation to be adopted for the proposed work. It also helps in getting the following data

Purposes

Before starting the exploration work, the following data should be collected.

1 The nature, thickness and variation of soil strata in the region.

2 Procuring representative samples for assessing the physical properties of the soil strata encountered, which in turn, will help in the design and mode of construction of the proposed foundations.

3 The seasonal variation in ground water table and their possible effects on the soil strata met.

4 The strength and compressibility values of soil bed.

5 If necessary, the depth of underlying rock bed.

Preliminary Investigation

The following information regarding the proposed site should be collected.

1 The soil condition at different depths.

2 Location of water table and its seasonal variations.

3 The depth of rocks.

4 Behavior of soils at site, which can be known from the type of construction and conditions of the structure in the adjoining properties.

5 The general topographical features of site, viz, site on the top of hill, in a valley, on an abandoned lot, or reclaimed ground etc.

Methods of site exploration

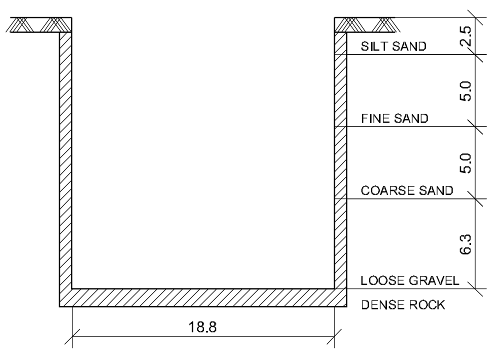
1 Open excavation (test pits) (Fig 1)

1 This method is useful when hard soil is available within a maximum depth of 1.5m

2 A square pit, with side as about 1.50 m ,is excavated up to a depth at which sufficiently hard soil is available

3 A sufficient number of test pits should be dug on the site to know the variation of the ground

Fig 1



TEST PIT

DCN142511

Probing (Fig 2)

1 Probing consists of driving either a hollow tube or a steel rod or an iron rod into the ground

2 This method is possible to examine the ground for a maximum depth of 3 m.

Auger boring (Fig 3)

1 An auger may be of post-hole type or screw type or shell type

2 Auger is worked by applying leverage at the top the auger is driven into the ground and turned like a screw the auger is withdrawn and the material caught in the slit is inspected.

3 With the help of this method, it is possible to inspect the ground for a depth of 6 m to 8 m.

Fig 2

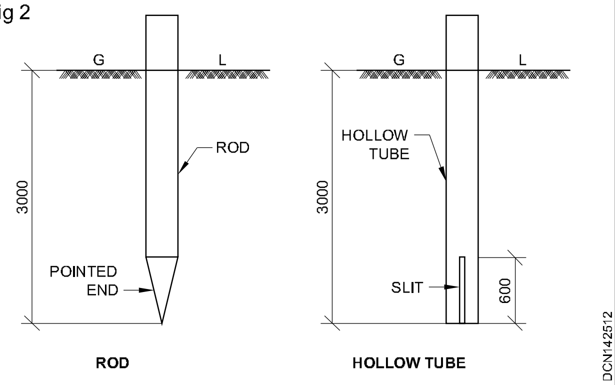


Fig 3

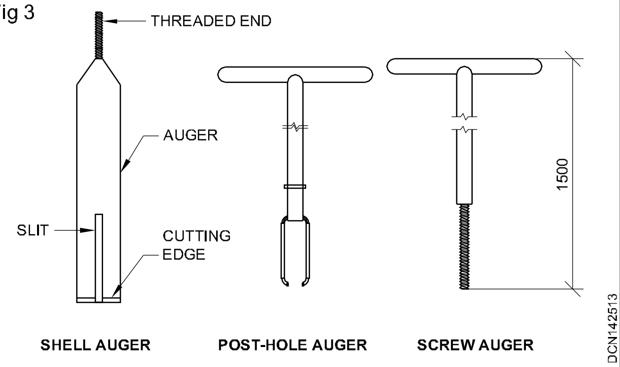
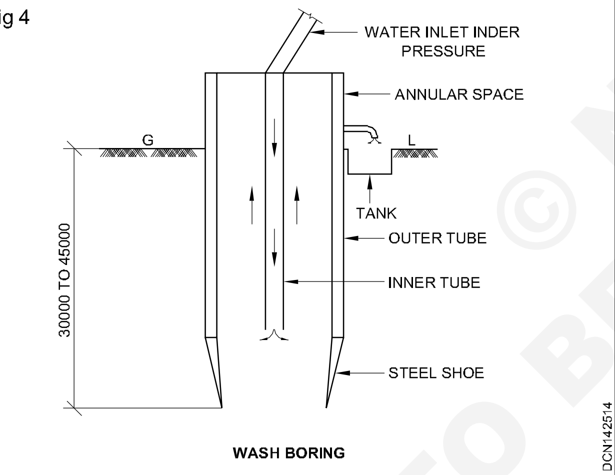


Fig 4



4 **Wash boring (Fig 4)**

The wash boring is the term used to denote a method in which a casing is driven into the ground and the material inside the casing is washed out and brought to the surface for inspection.

5 **Sub-Surface sounding**

1 In this method, the resistance of the soil with depth is measured by means of a tool known as penetro-meter under static or dynamic loading.

2 This test is useful for :

i Finding the depth of bed rock or stratum.

ii Knowing the general exploration of erratic soil profiles and

iii Testing cohesion less soils from which it is difficult to obtain the undisturbed samples.

6 **Deep boring**

1 It becomes essential to carry out deep boring for big important engineering structures such as dams.

2 The machines used for deep boring are as follows.

i Percussion boring machine.

ii Core or rotary drilling machine.

7 **Geophysical method**

1 This method is used when the exploration depth is substantial and the speed of investigation is of primary importance.The method is mainly adopted to as certain the depth at which useful minerals and oils are available.

2 The two most commonly adopted methods are as follows.

i Electrical resistivity method.

ii Seismic refraction method.

Bearing capacity of soil

Objectives : At the end of this lesson, you shall be able to
- **define bearing capacity of soil**
- **explain safe bearing capacity of soil**
- **state ultimate bearing capacity of soil**
- **describe methods for determining the bearing capacity of soil**
- **explain methods of increasing bearing capacity of soil**
- **state the safe bearing capacity of various soil.**

Introduction

Bearing Capacity of soil is used to indicate the maximum load per unit area, which the soil will resist safely without displacement, the load of the structure.

Safe Bearing capacity of soil

It is the maximum pressure, which the soil can carry safely.

Ultimate Bearing capacity of soil

The gross pressure intensity at which the soil fails.

$$\text{Safe Bearing capacity} = \frac{\text{Ultimate bearing capacity}}{\text{Factor of safety}}$$

The basic requirement of any structural components of a building is that it should be strong enough to carry or support all possible type of loads

There are three types of load on the foundations

Design Loads

Dead load

Live load

Wind load

Dead load

This is the load of the material used for the various components of a building such as wall floor roof etc. All permanent loads are thus included in that load. Sometimes a dead load of 10kg/m2 of the floor area is allowed for construction of a partition wall.

The weight of common material are given below:

SI.No.	Materials	Weight in kg/m2
1	Aluminium	2590
2	Bitumen	1440
3	Coal tar	1000
4	Clay (dry)	1440
5	Clay (damp)	1760
6	Earth (dry)	1410-1840
7	Earth (moist)	1600-2000
8	Sand	1540-1600
9	Sand(moist)	1760-2000
10	Alcohol	780
11	Ice	910
12	Nitric Acid(91%)	1540
13	Sulphuric Acid(87%)	1790
14	Vegetable oil	930
15	Water(fresh)	1000
16	Brick	1600-1920
17	Cement(ordinary)	1440
18	Chalk	2240
19	Glass	2400-2720
20	Lime stone	2400-2240
21	Sand stone	2240-2400
22	Steel	7850
23	Timber	650-720
24	Brick masonry	1920
25	Plain concrete	2300
26	Reinforced concrete	2400
27	Cast iron	7200
28	Copper	8590
29	Lead	11360
30	Marble	2700
31	Lime mortar	1740
32	Plaster cement	2080
33	Stone masonry	2500
34	Asbestos cement sheet	12-15.60
35	G.I Sheet(0.5mm thick)	5
36	G.I. Sheet(1.63mm)	13
37	Mangalore tiles	68

Live load

This is the movable load on the floor and hence it is variable. It is also sometimes known as super imposed load. It includes load of person standing on a floor, weight of material temporarily stored on a floor, weight of snow on a roof etc. For the purpose of dressing the live load is converted into equipment dead load. Super imposed load for floors of different types are as follows:

SI.	Material	Load kg/m²
1	Residential building, hospital room and ward and hotel, bed room etc	250
2	Office building, church,school building, art gallories,stairs in residential building retail shop and light garages	400
3	Assembly building, public building dance hall, theatre restaurants, gymnasium, stair in public building light workshop	500
4	Heavy workshop,printing press and factories	750
5	Work houses, book stall, sanitary stores and heavy garages	1000

Wind load

In case of tall building the effect of wind should be considered. The exposed sides and roofs of such building are subjected to wind pressure. And its affect is to reduce the pressure on the foundation on the wind ward side and to increase the pressure on the foundation on the lee-ward side.

The wind pressure will depend on the velocity of the ground. The relation between wind pressure and wind is generally expressed by the formula .

$P = 0.00750^2$

where p = wind pressure v = velocity of wind in km/hour

Bearing capacity of soil

A foundation should be designed to satisfy to essential conditions.

i) It must have some specified safety againce ultimate failure.

ii) The settlement under working load should not exceed the allowable limits for the super structure.

The bearing capacity of soil is defined as the maximum load per unit area which will resist safely without displacement.

The ultimate bearing capacity is defined as the maximum gross pressure at the base of the foundation at which the soil mass fails in shear. Gross pressure is the total pressure at the base of the foundation, due to the weight of the super structure, self weight of the foundation and weight of earth fill if any. The safe bearing capacity may be defined as ultimate bearing capacity divided by factor of safety.

$$\text{Safe bearing capacity} = \frac{\text{Ultimate Bearing capacity}}{\text{Factor of safety}}$$

Factor of safety means only a number to be selected depends on how accurately soil conditions are known. Is generally 2-3 for stable building.

Maximum safe bearing capacity of various soil

Sl No	Description of soil	M.S.B.C in Tone/m
1	Very soft, wet, pasty or muddy clay	5
2	Black cotton soil in dry condition	15
3	Soft clay	10
4	Moist clay and sand clay mixture	15
5	Medium clay	25
6	Compact clay nearly dry	45
7	Fine sand, loose and dry	10
8	Medium sand compact and clay	25
9	Compacts and prevented from spreading	45
10	Loose gravel	25
11	Compact gravel and moorum	45
12	Soft rock	45
13	Laminated rocks such as lime stone and sand stone	165
14	Hard rock without defects such as granite trap	330

Method for determining bearing capacity of soil

The bearing capacity of soil can be determined by any one of the following methods

- Analytical method
- Method of loading
- Method of dropping a weight

Analytical Methods

Rankine's gives an analytical method for determining the ultimate bearing capacity is,

$$Qf = r_0 \frac{(1+\sin\theta)^2}{(1-\sin\theta)^2}$$

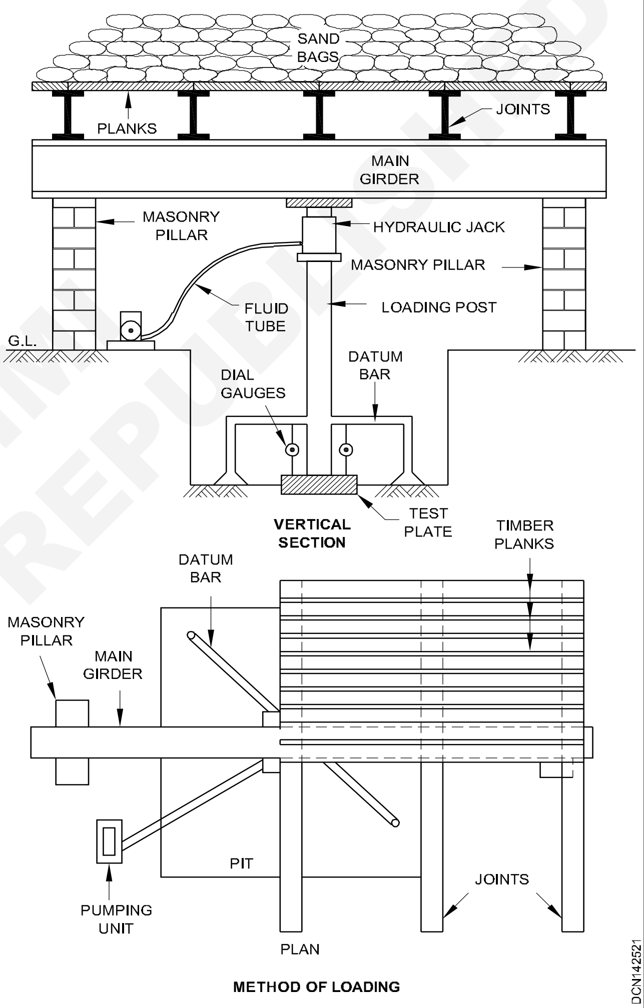
Where Qf = Ultimate bearing capacity

ro = density of soil at depth D

q = The angle of internal friction of soil.

Method of loading (Fig 1)

Fig 1



METHOD OF LOADING

This is a field test to determine the ultimate bearing capacity of soil and the probable settlement under a given loading. The test essentially consists in loading a rigid plate (usually of steel) at the foundation level.

Determine the settlement, corresponding to each load increment. The ultimate bearing capacity is taken as load at which the plate, start sinking at a rapid rate.

The ultimate bearing capacity in tone/m

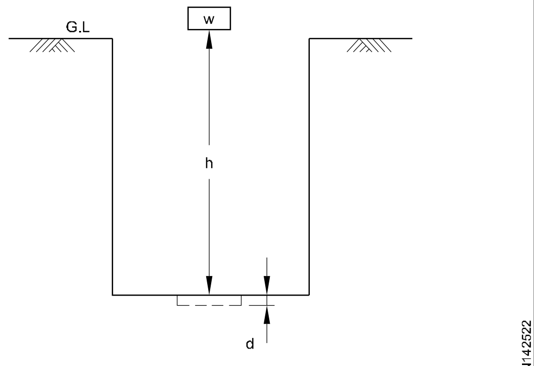
$$\frac{\text{Maximum load in tone}}{\text{The area of steel placement}}$$

Method of dropping a weight (Fig 2)

In this method a substance of known -weight is dropped

Method of dropping a weight

Fig 2



METHOD OF DROPPING A WEIGHT

In this method a substance of known -weight is dropped from a known-height as shown in figure. The depth of impression made by the weight on the soil is noted.

Then the bearing capacity of soil is worked out as follow:

If, R= resistance of soil

w= Weight of the substance

h= height

d= depth of impression

Total energy = wh=Rxd

$$R = \frac{wh}{d}$$

ie, R= ultimate bearing capacity of soil

if A= Cross sectional area of the substance

$\frac{R}{A}$ = Resistance of soil per unit area.

$$\text{Bearing capacity} = \frac{R}{A}$$

$$\text{safe bearing capacity} = \frac{R}{AxF}$$

Where F= factor of safety.

The results obtained by this method are approximate and hence this method is used for minor engineering structure.

Method of improving bearing capacity

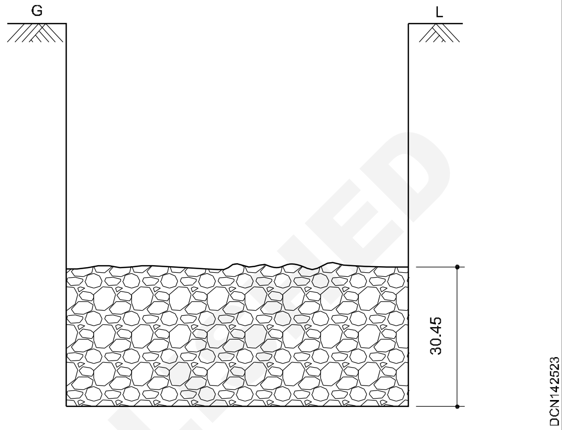
Increasing depth of foundation

It has been found that in granular soil the bearing capacity increase with the depth due to the confining weight of overlying material. It is not economical since the cost of construction increases with the increase in depth. This method is useful when bearing straturm is met at greater depth.

Compacting soil

In this method the width of foundation is increased by about 45cm or 50 and a layer of 30cm - 45cm of rubble is spread over the bottom of the foundation as shown in (Fig 3). This layer of rubble is well rammed. If the material is buried completely, another layer of depth about 15-25cm is laid and it is well rammed. At the end of this process, if the bearing capacity of soil is tested, it is found to have increased considerably. This increasing bearing capacity of soil may then be used for the design purpose.

Fig 3



Drainage of soil

It is a well known fact that the presence of water decreases bearing power of soil. This is because of less shearing strength of soil in presence of excess water. Drainage results in decrease in voids ratios and improvement of bearing power.

Confining the soil (sheet piling):-

The movement of soil under the action of load can be prevented by confining the ground by use of sheet piles. This will results in the increasing of bearing power of soil.

Grouting

Bore holes in sufficient number are driven in the ground the cement grout is then forced under pressure through these bore holes. The cracks or fissures of the rocks are these filled up, resulting in the increase of bearing power of soil.

Chemical Treatment

In this treatment certain chemicals are used in place of cement grout to solidify the soil. But as this process is costly it is adopted only in case of important building.

Causes of failure of foundation and measures to prevent such failure

The unequal settlement of sub soil may be due to

- Unequal distribution of load on foundation.
- Varying bearing power of subsoil.
- Eccentricity of the load

Due to unequal settlement of the subsoil, cracks are formed in the building. This failure can be prevented by

- Foundation should be rest on rock or hard moorum.

- Proper design of the base of footing. So that it can be resist cracking.
- Avoiding eccentric loading

Unequal settlement of masonry

Mortar joint may shrink and compress which may lead to unequal settlement of the masonry.

This failure can be prevented

- Using mortar of proper strength.
- Using thin mortar joint.
- The height of wall to be raised per day should be limited to 1m in lime mortar and 1.5m in cement mortar.
- Properly watering the masonry.

Withdrawal of moisture from the sub soil

This occurs at places where there is considerable variation in the height of water table. When water table falls the soil particles loose cohesion and hence, there is shrinkage of soil, resulting in the cracks to the building. To prevent such failure,drive piles upto the hard rocks.

Lateral pressure on the super structure

The thrust on a pitched roof or arch action, or wind action on the super structure causes wall to overturn.

To prevent such failure, provide a sufficient wide base and to design the foundation for the worst condition.

Horizontal movement of the earth

Very soft soil is liable to give away under the action of load, especially as places such as sloping ground, river banks etc. Hence in such cases it is desirable to construct retaining walls or to drive a sheet piles to prevent the escape of earth.

Transpiration of trees and shurbs

The roots of trees planted near a building may extent upto the foundataion level and may absorb the moisture. This effect is seen in the form of a depression on the ground, and it may lead to crack in the building. To prevent such failure.

- The foundation should be taken sufficiently deep at a minimum depth of 1m is required for this purpose.
- The trees should not be planted near the building with a distance of 8m.

Atmospheric action

Rain and sun are the main atmospheric agents to seriously effect the foundation of a building. Heavy rain or considerable variation in temperature or thrust action may damage the foundation. If the water remains stagnant near the foundation it will remain constantly damp resulting in the decrease in strength of footing or foundation wall. Hence it is always recommended to provide suitable wind protection along the external wall by

- Filling back the foundation trenches with good soil and compacting it.
- Providing a gentle ground slope away from the wall.
- Suitable underground drains should be provided to maintain water table at definite level.

Foundation

Objectives : At the end of this lesson, you shall be able to,

- **define foundation**
- **state types of foundation**
- **explain purpose of foundation**
- **explain various loads on foundation**
- **describe causes of failure of foundation and its remedies.**

The lowest artificially prepared part of the structure, usually located below the ground level, which transmit the load of the superstructure to the ground is known as substructure or foundation.

Types of loads

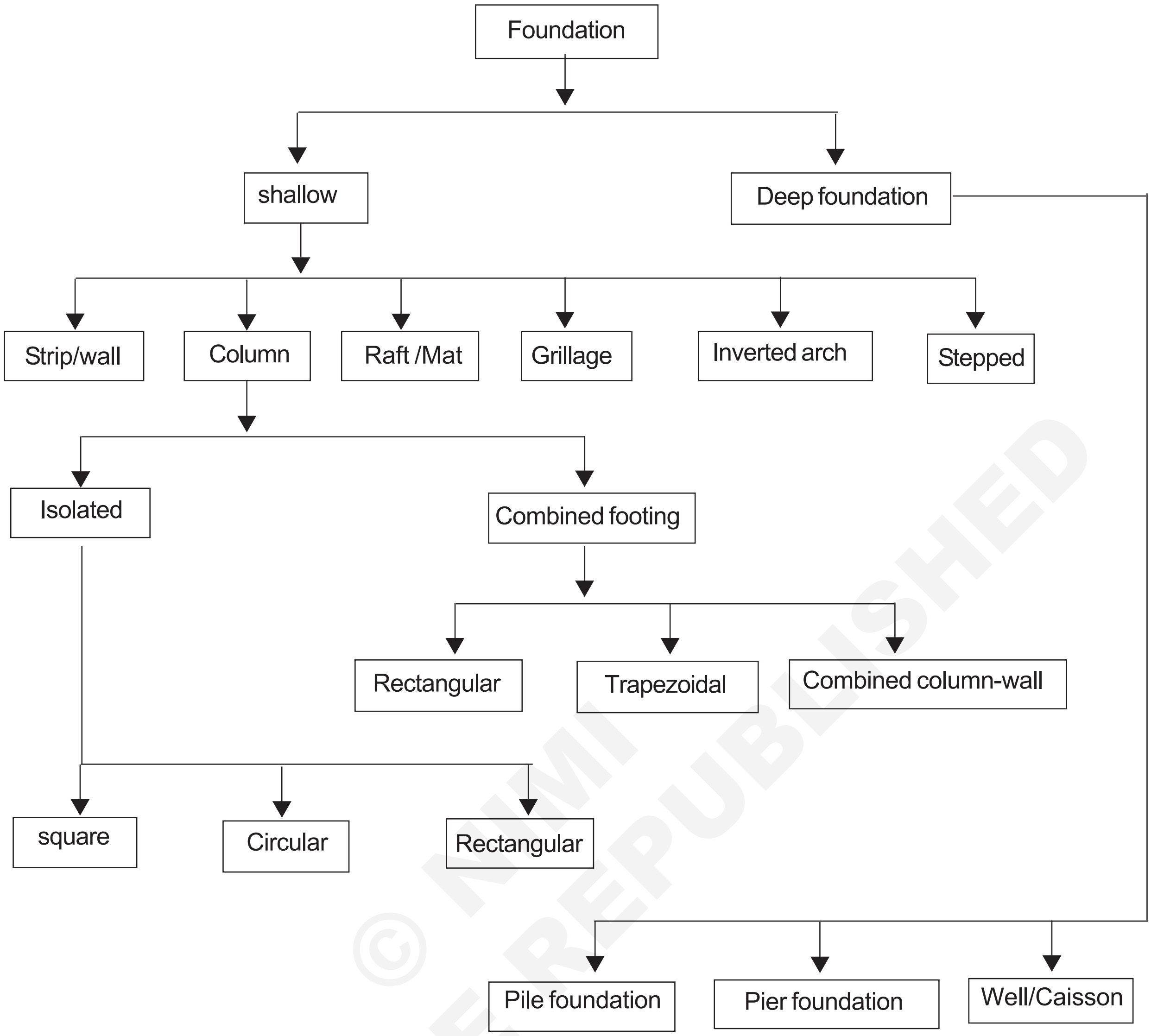
1 Dead load

2 Live load

3 Wind load

4 Snow load

Types of foundations



Causes of failure of foundations and its remedies

Causes	Remedies
1 Unequal settlement of the subsoil	Foundation should rest on rigid strata. Design of foundations should be appropriate to the nature of subsoil.
2 Unequal settlement of the masonry	Using mortar of proper strength. Masonry work should be raised evenly. Proper Curing.
3 Withdrawal of moisture from the subsoil	Provide drive piles up to the hard rock.
4 Lateral pressure on the superstructure	Provide sufficient wide base.
5 Horizontal movement of the earth	Construct retaining walls to prevent the escape of earth.
6 Transpiration of trees and shrubs	Foundations should be sufficiently deep. Trees should not be planted near the building.
7 Atmospheric action	Provide suitable underground drains. Providing gentle ground slope away from the wall.

Shallow foundation

Objectives : At the end of this lesson you shall be able to,
- **define shallow foundation**
- **explain various types of shallow foundation**
- **describe setting out of building on ground.**

Introduction : It is possible to construct foundation of a building at a reasonable shallow depth, the foundations are termed as the shallow foundations.

Definition : The depth of foundation is equal or less than its width, is known as shallow foundation.

Setting out of building on ground

1 Clear the Site.
2 Prepare a plan of setting out on paper.
3 Centre lines of walls to be marked on plan
4 This is to be marked on ground.
5 Mark the centre lines of walls by stretching a string between wooden pegs.
6 Cross walls set by 3, 4,5 method.
7 Corners of building are laid and sides checked by measuring diagonals.
8 Entire width of foundation marked
9 For big projects reference pillars of brick may be constructed.

Shallow foundation : Foundation having its depth less than or equal is its width are known as shallow foundation. Since such foundation are constructed by open excavation.

Hence those foundation having its depth even greater than its width but are constructed by way of open excavation are also come under shallow foundation.

Design of shallow foundation : Following data are required before design of a foundation

a The total load to be transmitted by the wall or pier to the foundation bed.
b The results of trial pit and the corresponding bearing capacity of each strata of soil.

The design of foundation required the three terms,

a Width of foundation.
b Depth of foundation below ground level.
c Depth of concrete block below the masonry rooting.

Width of foundation : The width of foundation should be sufficient enough to bear the super imposed load per unit length on the foundation bed. The width of foundation is obtained by

i Dividing the total load per unit length on foundation bed by safe bearing capacity of the soil.

Thus, width of foundation = $\frac{w}{p}$

Where, w = total load in tone/metre

p = safe bearing capacity of soil in tonne/m^2

ii Width of foundation = 2 (T+J) Where,

T= thickness of wall above the plinth level.

J= the projection of concrete block on the either side of the lowermost masonry footing. which should be atleast 10cm-15cm.

Depth of foundation below ground level : This is generally determined by the rankine's formula. Which gives the maximum depth.

Depth of foundation below the ground level,

$$d = \frac{p}{w}\left[\frac{1-\sin\theta}{1-\sin\theta}\right]^2$$

Where p = total load on soil in kg/m^2

w = wt of soil in kg/m^3

θ = Angle of repose of the soil.

In order that all the shallow foundation should be taken to a minimum depth of 80cm below the natural ground level. Unless hard soil is available within 80cm.

Angle of repose : Angle of repose is the angle 95 the loose soil will make with the horizontal, if allowed to remain free in loose condition. The angle of repose of the soil varies with the type of earth.

Depth of concrete block : The depth of concrete block below the masonry footing is calculated by using the formula

$$d = \sqrt{\frac{3PJ^2}{m}}$$

Where, P = the load on soil in kg/m^2

J= The projection of concrete on either side of the lowermost masonry footing which should be at least 10-15cm.

m= modulus of rupture of concrete in kg/m

The depth of concrete block below the masonry footing is also determined by the formula

$$d = \frac{5}{6}T$$

Where T = thickness of wall above the plinth level.

Types of shallow foundation

A Spread footing

The total load of the structure is transmitted to the base of the structure is spread out to a large area by spread footing.

a Strip footing

Spread footing for a wall is known as strip footing.

b Pad footing

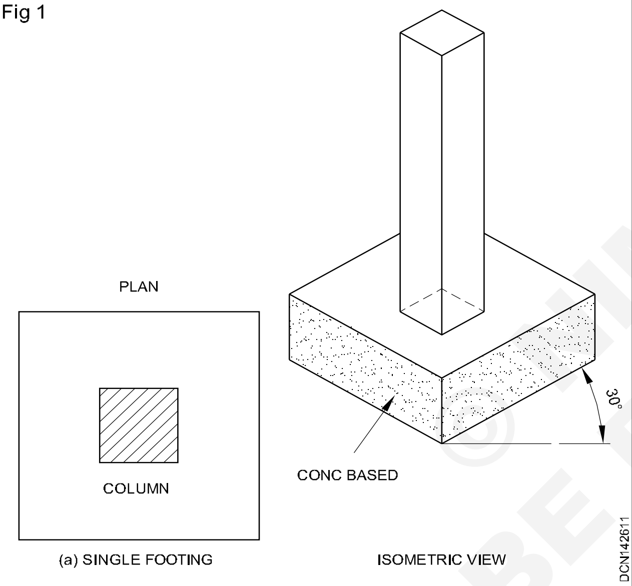
The spread footing for a single column is known as pad footing or isolated footing.

The spread footing may be of the following types

i Single footing

Fig 1 shows the single footing for a column in which the loaded area (bxb) of the column has been spread to the size (BxB) through a single spread.

Fig 1



ii **Stepped footing** : The Fig 2 shows the stepped footing for a heavily loaded column which require greater spread. The base of the column is made of concrete.

iii **Sloped footing** : Fig 3 shows the sloped footing made in concrete base of non uniform thickness. Greater thickness at its bottom, smaller thickness at the top.

iv **Wall footing without step** :Fig 4 shows the stepped footing for a wall consisting of concrete base without step.

v **Stepped footing for a wall :** Fig 5 shows the masonry wall have stepped footing with a concrete base.

vi **Grillage foundation :** A grillage foundation is a special type of isolated footing. Generally provided for heavily loaded steel stanchions or column, specially in those location where bearing capacity of soil is poor. The depth of foundation is limited from 1-1.5m. The load of the column or stanchion is distributed or spread to a very large area by means of layers of tiers of joist, each tier being placed at right angle to the next tier.

Grillage foundation are of two types:-

Steel grillage foundation

Timber grillage foundation

Fig 2

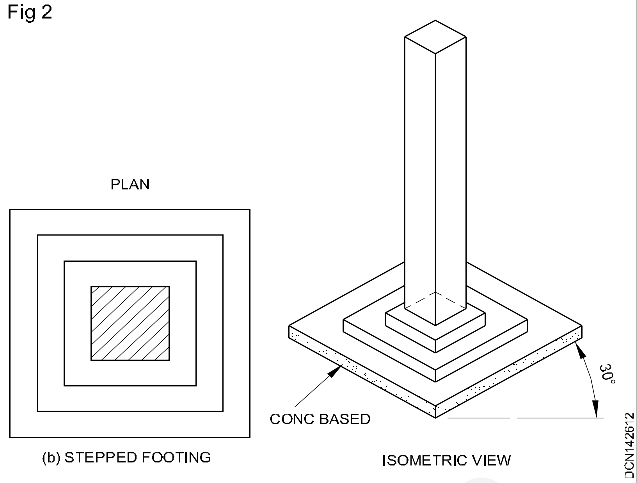


Fig 3

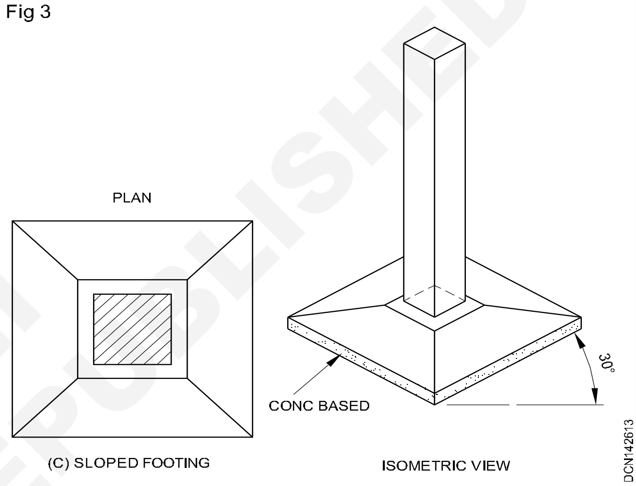
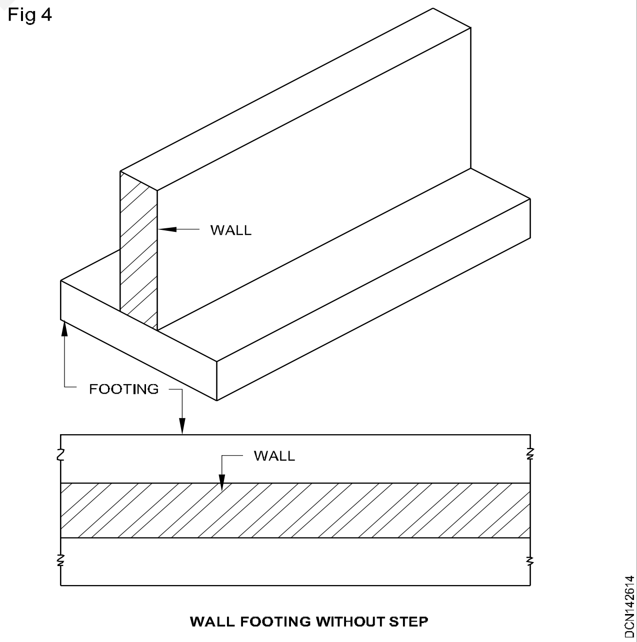
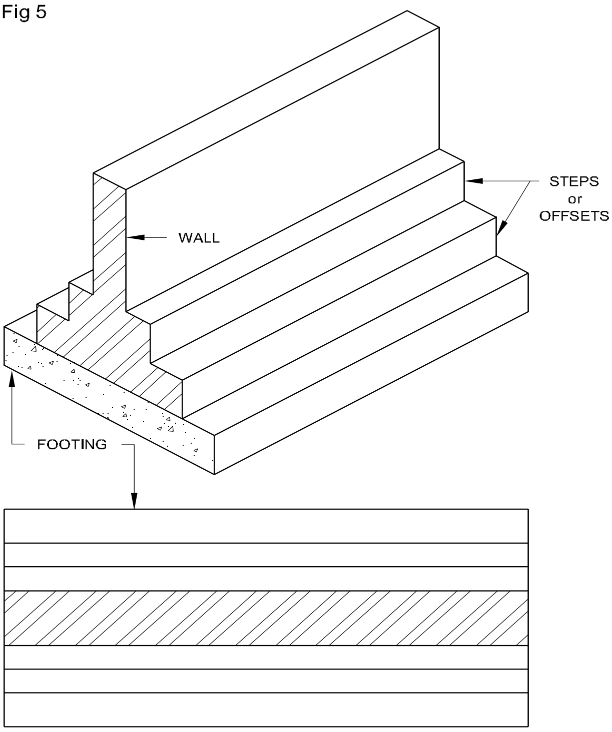


Fig 4



Steel grillage foundation : Steel grillage foundation is constructed of steel beams, structurally known as rolled steel joist (RSJ) provided in two or more tiers. In case of double tier grillage (which is commonly provided) the top tier of grillage beams is laid at right angle to the Bottom tier. The joists or beams of each tier are held in position by 20mm diameter pipe separators (tie rod 20mm diameter) as shown in Fig 6..

Fig 5

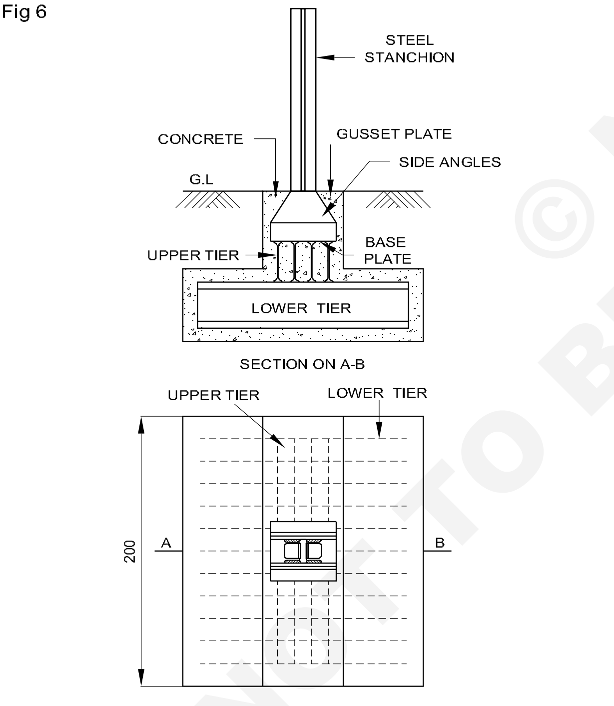


(b) STEPPED FOOTING

SPREAD FOOTINGS FOR WALLS

DCN142615

Fig 6



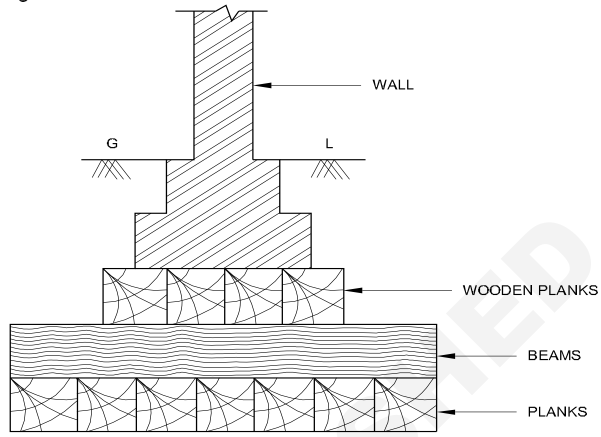
GRILLAGE FOUNDATION

DCN142616

The grillage beams are embedded in concrete. Generally, the minimum clearance of 8cm is kept between the grillage beams. So that the concrete can be easily poured ,properly compacted. However the distance between the flanges should not exceed 30cm or 1 1/2 times the flange width. So that the filled concrete acts monolithically with the beams. It should prevent their corrosion. A minimum concrete cover of 10cm is kept on the outerside of the external beams as well as upper flanges of top tier.

Timber grillage foundation (Fig 7) : Temporary grillage foundation in the form of timber beams may be provided to timber columns, posts or walls etc. They can be design for supporting light building. In water logged areas. The loading on the soil is limited is 5.5 tone/m. The grillage takes the form of a platform of wooden planks arranged in 2 layers at rectangle to each other. The two layers of planks are separated by rectangular section of timber placed at centre to centre distance of about 3.5cm-40cm.

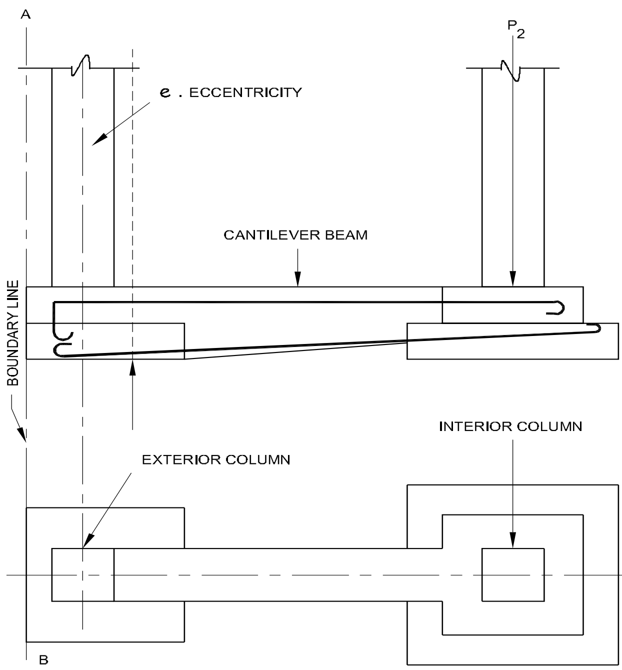
Fig 7



DCN142617

B Strap footing or cantilever footing (Fig 8) : A strap footing comprises of two or more footings of individual columns, connected by a beam called a strap. When a column is near or right next to a property limit, its foundation cannot extended beyond the property line, and if the distance between this columns and the adjoining column is large, in that case strap footing may be provided. The strap beam connecting the spread footings of the two columns do not remain in contact with soil and does not transfer any pressure to the soil. The function of strap beam is to transfer the load of heavily loaded outer column to the inner column. In doing so the strap beam is subjected to bending moment and shear force and it should be suitably designed to withstand these.

Fig 8



STRAP FOOTING

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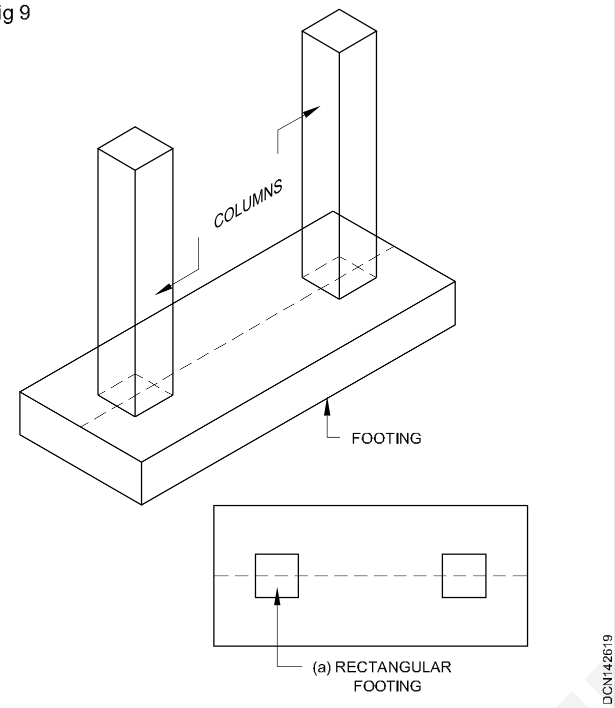
iii Combined footing

Rectangular footing (Fig 9) : A spread footing which supports two columns is termed has combined footing. If the footing supports more than two columns it is known as continuous footing.

Fig 9



A combined footing is provided under the following circumstances

1 When the columns are very near to each other so that their footings overlap.

2 When the bearing capacity of soil is less requiring more area under individual footing.

3 When the end column is near a property line so that its footing spread in that direction.

A combined footing may be rectangular or trapezoidal in plan. The aim is to get uniform pressure distribution under the footing. For this the centre of gravity of the footing area should coincide with centre of gravity of the combined load of two columns. If the outer column, near the properly line carries heavier load, provision of trapezoidal column becomes essential to bring the c.g of the footing in line with the c.g of the two column loads. In other cases rectangular footing may be prefered. (Fig 10)

IV Mat or raft foundation : Generally a raft or mat foundation is used when the bearing capacity of soil is very poor and when it is required to distribute heavy concentrated load over a large area. The raft foundation is useful where there is a possibility of unequal settlement to occur. The raft foundation consist of thick R.C.C slab covering whole area in the form of a mat. If the required area of footing exceeds half the total area of the structures, raft foundation is used. Raft foundation is also used for increasing the area of foundation to neutralise the hydrostatic uplifts. (Fig 11)

Fig 10

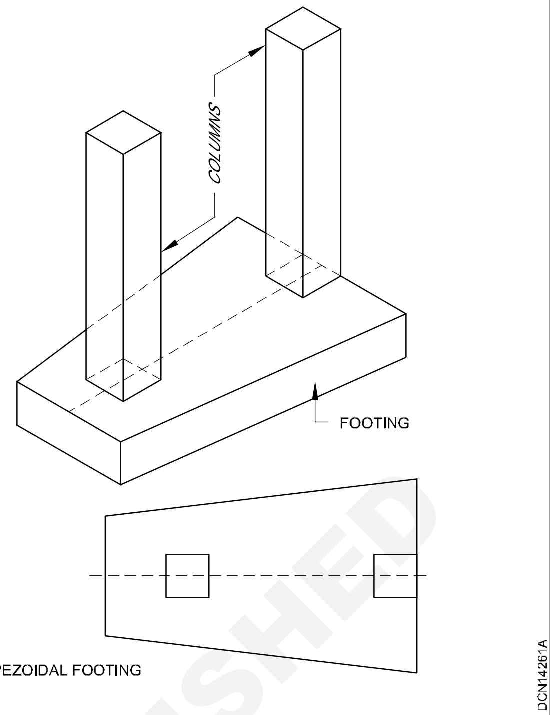
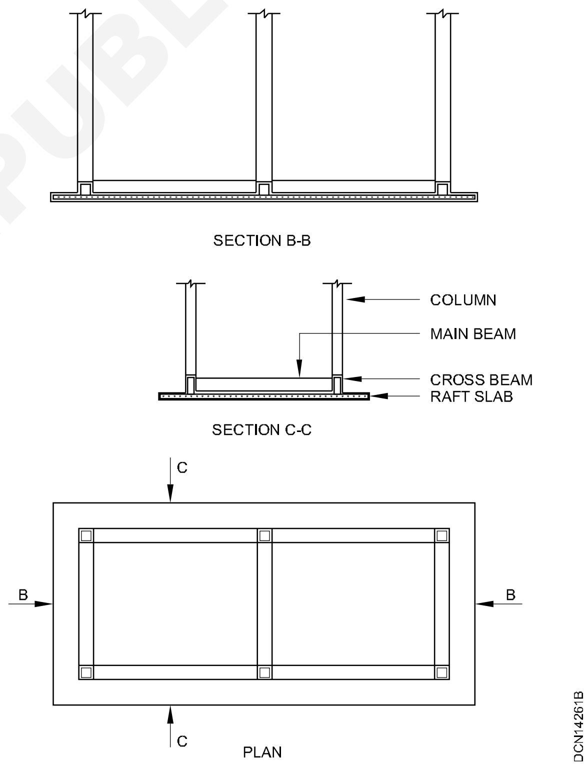


Fig 11



v Inverted arch foundation : The foundation which consist of inverted arches between the pier are known as inverted arch foundation. The rise of the arch is about 1/5th -1/10th of the span. The load transmitted to the soil through inverted arch. These are suitable for the construction of bridges, reservoirs, tanks etc. Now a days this type of foundation is rarely used in India.

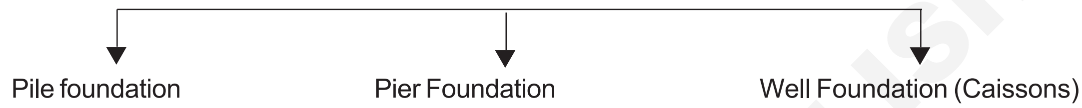
Deep foundation

Objectives : At the end of this lesson, you shall be able to
- **define deep foundation**
- **state classification of deep foundation**
- **explain pile foundation**
- **identifies various types of piles**
- **describe pier foundation**
- **explain well foundation (caisson).**

Introduction : This construction is adopted when the loose soil extends to a great depth. The load of the structure is transmitted by the piles to hard stratum below or it is resisted by the friction developed on the sides of piles.

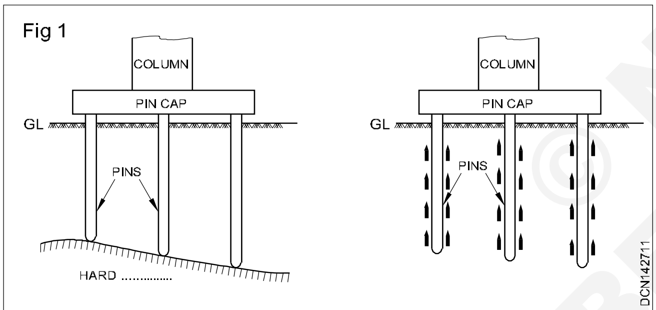
Definition : The depth of foundation is greater than its width is called deep foundation.

Classification of deep Foundation



A Pile Foundation (Fig 1) : Pile is a long vertical load transferring member which may be of timber, steel or concrete.

Fig 1



1 The loads are taken to a low level by means of columns in the soil.

2 It may be adopted where no firm bearing strata exists at reasonable depth and the loading is uneven

3 The pumping of subsoil water is too costly for keeping the foundation trench in dry condition.

4 This foundation is to be adopted for the structures in the area where canals ,deep drainage lines, etc. are to be constructed

Pile : Following are the situation in which a pile foundation is preferred:-

a When the load coming from the structure is very high and concentrated.

b When the other type of foundation cannot be provided due to heavy cost and site difficulties.

c When the water table is very near to the ground level and may defect the other type of foundation.

d When due to heavy inflow seepage, it is not possible to execute the trenches and keep them dry.

e Where there are chances of construction of irrigation canal in the near by area, which causes seepage of water in the foundation.

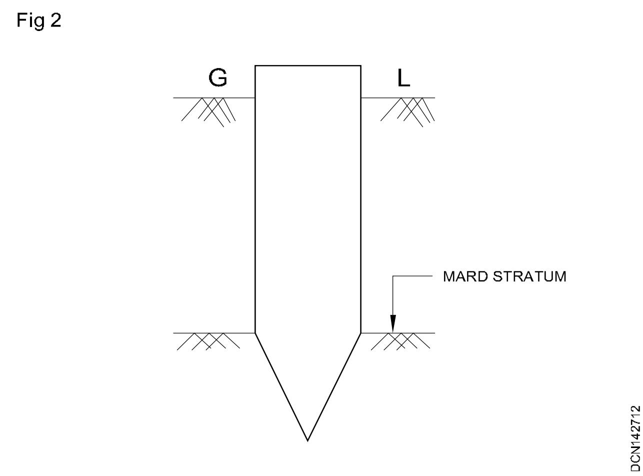
f When hard bearing strata is at a greater depth.

Classification of piles

a Classification according to foundation:-

1 **End bearing piles** (Fig 2) : Piles whose lower end rest on hard rock (hard stratum) is known as end bearing piles. These piles are used to transfer heavy load through water or soft soil to a suitable hard stratum.

Fig 2



2 **Friction piles (Fig 3) :** The piles which support the structure load due to friction between the piles and surrounding soil are known as friction piles. Such piles are generally use in granular soil when the depth of hard strata is very great.

3 **Compaction piles (Fig 4) :** Compaction piles are used to compact loose granular soil thus increasing their

bearing capacity. The compaction piles themselves do not carry any load. Hence they may be made of weaker materials like timber, bamboo sticks etc. Sometimes they may be made of sand only. The pile tube driven to compact the soil, is gradually taken out and sand is filled in its place thus forming a sand pile.

Types of pile

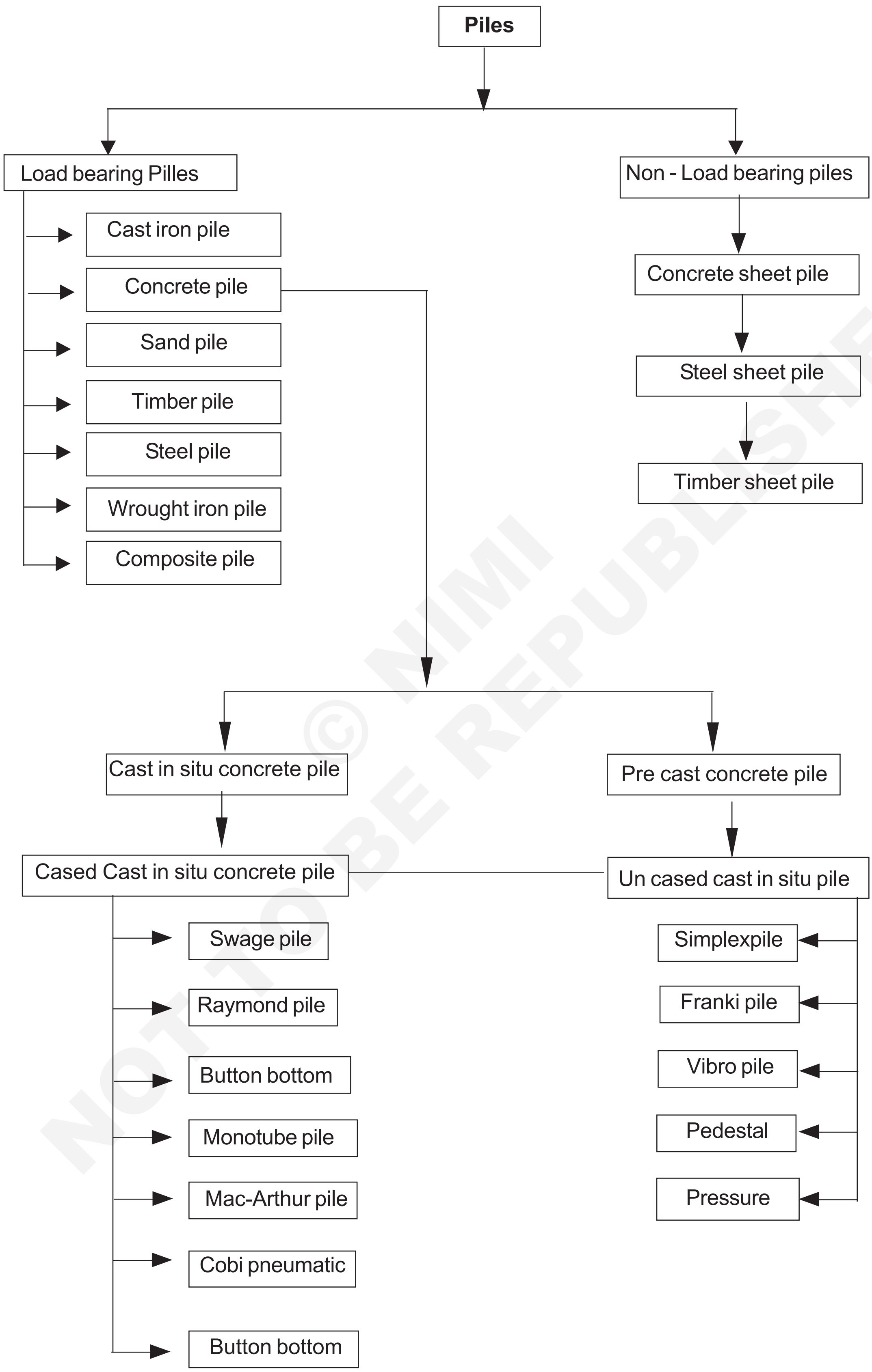
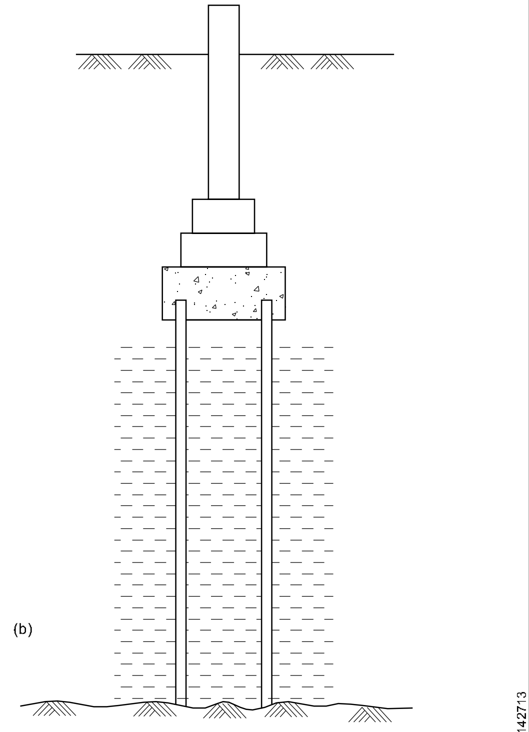
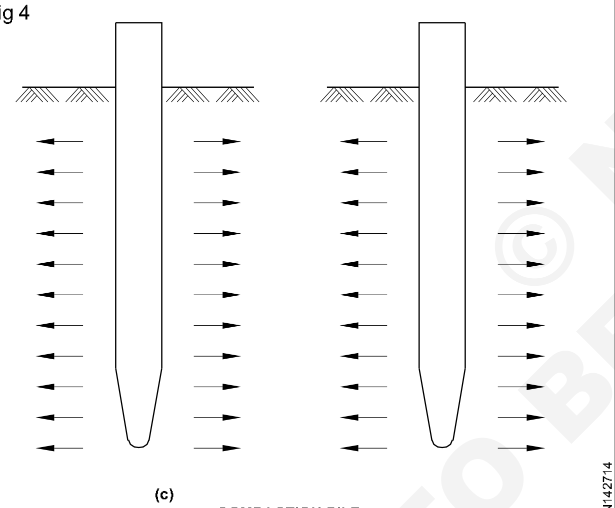


Fig 3



FRICTION PILES

Fig 4



(c)
COMPACTION PILE

4 **Tension or uplift pile :** The tension piles anchor down the structures subjected to uplifts due to hydrostatic pressure or due to overturning moment.

5 **Anchor piles :** These piles provide anchorage against the horizontal pull from sheet piling or other pulling force.

6 **Sheet piles :** The piles are differ from bearing pile and friction pile. In that they are rarely used to furnish vertical supports, but are used to retain the soil that is, liable to escape laterally when subjected to pressure or to enclose the area required for some foundation. And protect it from the action of running water or leakage.

7 **Fender piles and dolphins :** These piles are used to protect the concrete deck or other water front structures against impact from ship or other floating objects.

8 **Batter piles** : These piles are driven at an inclination to resist large horizontal or inclined forces.

b Classification according to materials used

1 Concrete piles

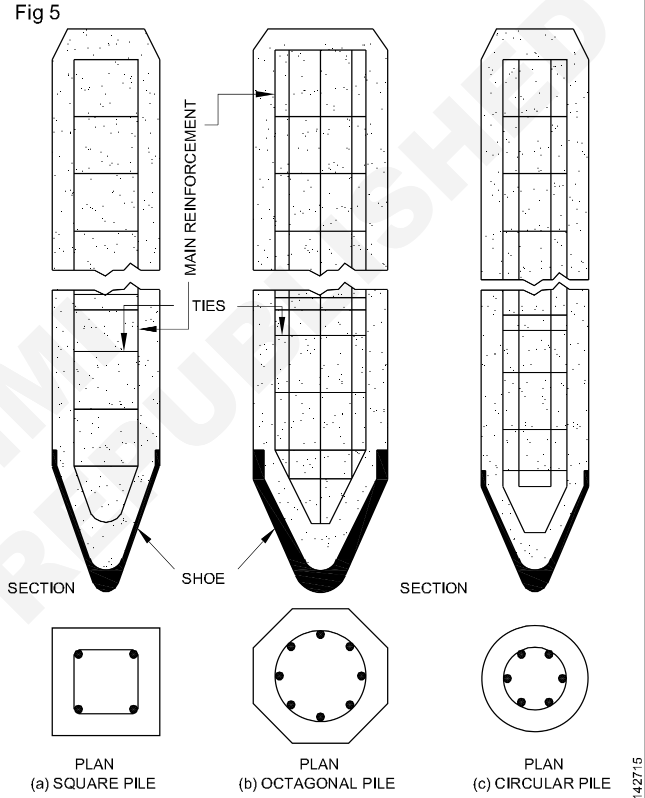
2 Timber piles

3 Steel piles

4 Composite piles

1 **Cement concrete piles (Fig 5) :** Cement concrete possess excellent compressive strength. R.C.C piles are becoming more popular and they are fast replacing piles of other material. R.C.C piles are divided into two groups.

Fig 5



PRECAST CONCRETE PILES

i **Pre cast concrete piles (Fig 5) :** Pre-cast concrete piles are those which are manufactured in a factory or at a place away from the construction site and then driven into the ground at the place required. They may be square and octagonal piles are cast in horizontal form. The round piles are cast in vertical forms. The size of the piles may be 30cm-50cm and the length may be much as 18m or moré.

The reinforcement may consist of longitudinal steel bars of 20-40 mm in diameter 4-8 No's with lateral ties of 5-10mm wires spaced at 10cm-30cm c/c from bottom to middle respectively. A concrete cover of atleast 50mm is provided as shown in figure. At the toe of the piles a steel shoe is generally provided. The steel shoe protect the toe and helps the pile in penetrating into the ground during the driving. Pre-casting piles are useful in carrying fairly heavy loads through soft materials to tinner strata.

Advantages of pre-cast concrete piles

a The position of reinforcement in pile is not disturbed from its original position.

b These piles can be driven under water. Concrete in the cast-in-site piles may not be set under water.

c It is possible to have a proper control over the composition and design of these piles as they are manufactured in a workshop.

d Any defect of casting such as hollows etc can be found out and repaired before driving the pile.

e Any number of piles can be manufactured at a convenient place and this may prove to be economical.

f These piles process high resistance to biological and chemical action of the ground.

g These piles, when driven are ready to take up the load. There is no wastage of time.

Disadvantages of pre-cast concrete piles

a These piles are heavy in weight and it is therefore difficult to transport, to handle and to drive them.

b Extra reinforcement is provided to resist the stresses during handling and driving operation. This fact makes the pile costly.

c If sufficient care is not taken, piles may break during transport or driving.

d The size and length of pile will depend on the available transport facilities.

ii **Cast-in-situ concrete pile :** In this type of concrete piles a bore hole is dug into the ground by inserting a casing. This bore is then filled with concrete after placing reinforcement, if any. The casing may be kept in position or it may be withdrawn. The former piles are known as cased-cast-in-situ concrete piles and the latter is known as uncased-cast-in-situ concrete piles.

Advantages of cast-in-situ concrete piles

a Light weight shells are used in cast-in-situ concrete piles and these shells are easy to handle and to drive in the ground.

b No extra reinforcement is necessary to resist stresses developing during handling or driving operation only.

c There is no wastage of materials as the piles of required length is constructed.

d The pile are sound in construction as they are not driven into the ground by a hammer.

Disadvantages

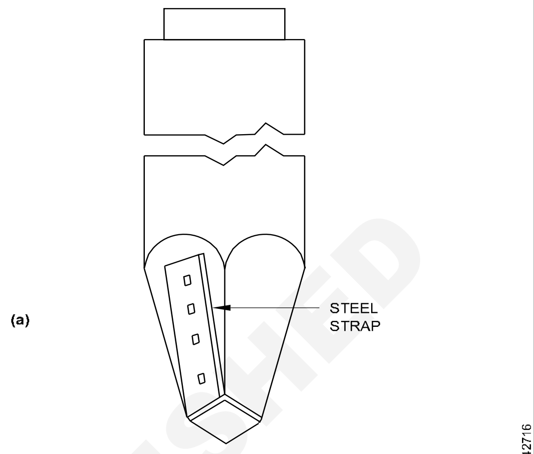
a It is difficult to maintain the reinforcement in correct position during construction of piles.

b These pile cannot be constructed under water.

c The dry ground may absorb, moisture from the wet concrete. The piles are then weakened.

2 **Timber piles (Fig 6) :** The timber pile may be rectangular, circular, square. The size of timber varies from 30cm-5-cm. The length of the timber pile does not exceed 20times its top width otherwise it may fail by buckling. At the bottom a cast-iron shoe is provided and at the top, a steel plate is fixed. The timber pile should be properly treated so as to make them durable.

Fig 6



TIMBER PILES

A timber pile is made of trunk of a tree. The wood to be used for timber pile should be free from knots. flaws and shakes and other defects. The common Indian timber which are used are babool, chir, jarul, poon,. Sal, teak.

Advantages of timber piles

a Where timber is available easily these piles prove to be economical in cost.

b These piles can be handled easily with little risk or danger of break.

c The length of the timber pile can be adjusted either by cutting or lengthening without must extra cost.

d Skilled supervision is not required in the construction of timber life.

e These piles can be removed easily if necessary.

f These pile donot required heavy equipment for driving them into the ground.

Disadvantages

a These piles cannot be take heavy loads and are unsuitable for used as end bearing piles.

b A joint in the lengthened timber pile is a source of weakness.

c It becomes very difficult to drive these piles in the hard formation.

d Timber piles are generally used for temporary work.

3 **Steel piles :** Steel piles are used as load bearing piles in the different form.

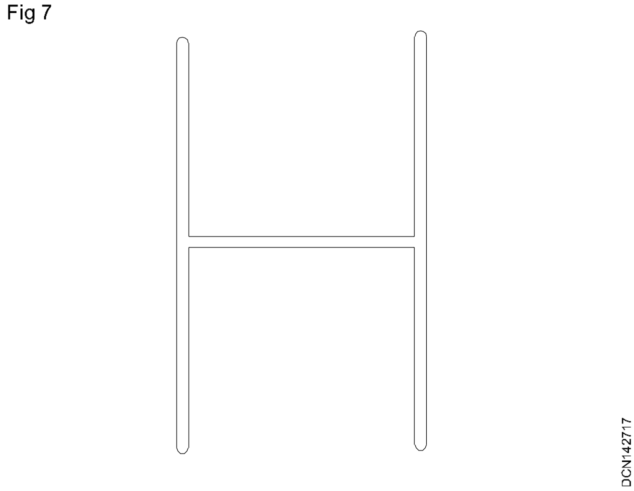
i **H-beam piles**

ii **Box-piles**

iii **Tube-piles**

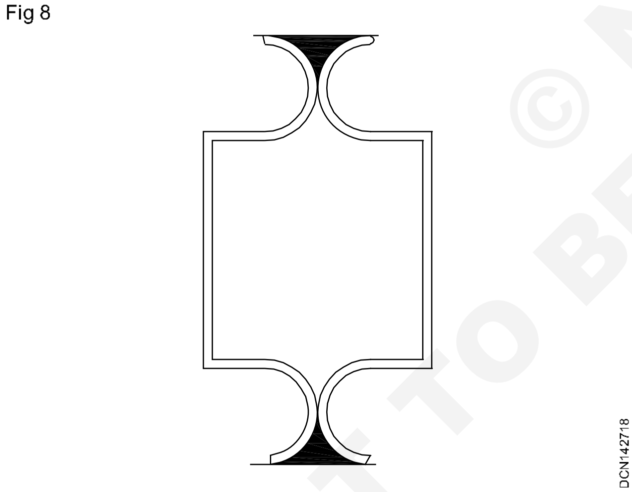
i **H-beam piles :** Fig 7 shows the plan of an H-beam steel piles. These piles are usually of wide flange section and they are most common variety of steel piles in general use. They are found very much suitable especially for trested type structure in which the pile extent above ground level and work also as column for the structure. The driving of H-piles is very simple and energy from a piles hammer is effectively transmitted to the lower portion of the pile.

Fig 7



ii Box pile : Fig 8 shows the plan of box pile. Various type of patended box piles are available, the figure shows "Larssen-Box pile". A box is driven either with closed bottom or with open bottom. These piles are used when it is not possible to drive H-beam piles upto the hard strata.

Fig 8



iii Tube piles : Fig 9 shows the plan of tube pile. In this type of steel piles, tubes or pipes of steel are driven into the ground. The pile may be driven either with open end or with closed end. Concrete is filled in side the tube piles. Because of circular cross section these piles are easily to handle and easy to drive.

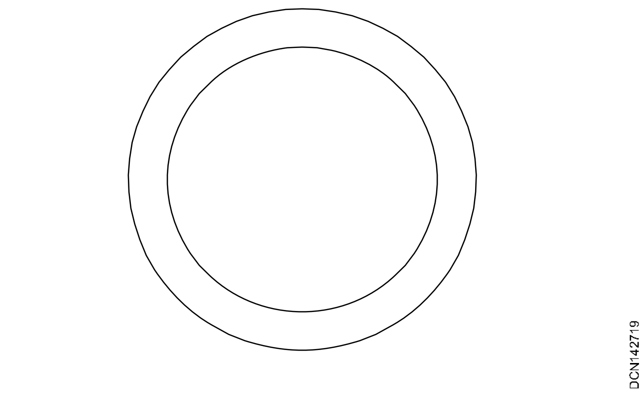
Advantages of steel piles

a These piles withstand easily the stresses due to driving.

b These piles can be easily to lengthened by welding without any delay in driving operation.

c The extra length of these piles can be cut off easily.

Fig 9



d The bearing capacity of these pile is comparatively high. The allowable compressive stress on steel is taken as about 6-8 kg/mm^2

e These piles can be handled roughly without any serious damage.

Disadvantages

a Corrosion is the only drawback of steel pile.

4 Composite piles : Composite piles are those which are made of two portion of two different materials driven one above the other. Two common type of composite piles are :

a Timber and concrete pile : In the timber and concrete composite pile, timber portion is use below the permanent or lowest water level, while concrete piles, usually cast-in-situ is formed above it. Due to this combination the advantages of both types are combined. Also the total cost of the pile is reduced.

b Steel and concrete composite pile : This type of composite pile is used where the required length of pile is greater than that available for the cast-in-situ type pile. The pile consist of steel pile attached to the lower end of concrete pile. This type of composite pile is used where satisfactory penetration of the pile into the rock is required for heavy loads.

Foundation for black cotton soil : Black cotton soil is a loose type of soil, and it considerably swells and shrinks by variation in moisture content. The variation in the volume of the soil is to the extent to the extend of 20%-30% of the original volume. During rainy season moisture penetrates into the soil the particles separate out, resulting in increase in the volume.

This increase in volume is known as swelling. During summer season, moisture moves out of the soil and consequently the soil shrinks, shrinkage cracks are formed on the ground surface. These shrinkage cracks are formed on the ground surface. These shrinkage cracks sometimes also known as tension cracks may 10-15cm wide,1/2-2m deep. Hence extreme care should be taken when foundation are to rest on this soil.

Following are the precautions to be taken in designing footings on black cotton soil:-

a For important structure the raft foundation should be adopted.

b The black cotton soil should be completely removed if possible and convenient.

c The black cotton soil should not be allowed to come in direct contact with the foundation masonry.

d The construction work should be carried out in dry season.

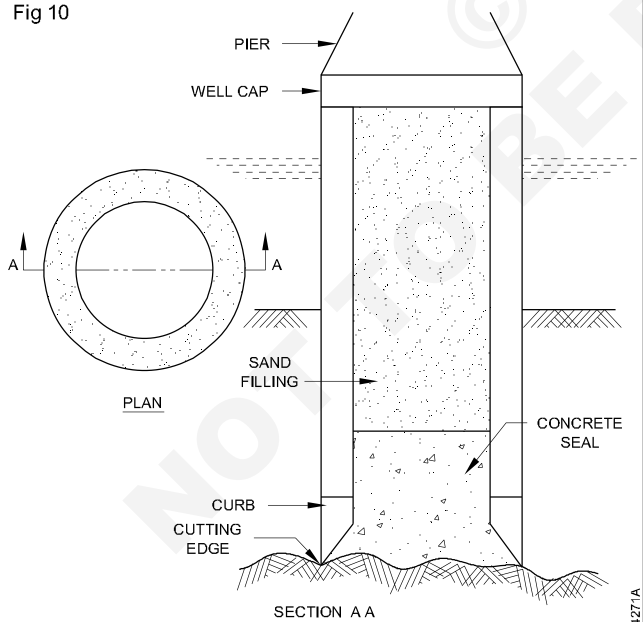
e The depth of foundation should extend beyond the depth of crack in black cotton soil.

Pile cap and pile shoe : When the column or any other load carrying structural component is supported on more than one pile, the pile should be connected through a rigid pile cap, to distribute the load to individual pile, pile cap maintain the proper alignment of the pile. It is advisable to ensure that a pile projects atleast by about 10cm in the pile cap.

Pile shoes are provided at the tips to facilitate the process of driving through hard strata. Pile shoes are made from cast iron, steel or wrought iron. In case of steel piles it is necessary.

B Well foundation (caissons) (Fig 10) : Well foundation is the convenient of securing a trust worthy foundation in deep sand or soft soil. It is also useful in moderate depth of water when foundation is to be taken in soft sandy soil, well are generally made of concrete or masonry. In masonry well vertical holding down bolt and iron plate or loop iron are provided to secure good bond.

Fig 10



CYLINDRICAL OPEN CAISSON (WELL FOUNDATION)

In order to prevent cracks during sinking operation. At the bottom of the well curb made of concrete, a steel or cast iron, cutting edge is attached. The position of well to be sank is first correctly marked on the ground and the curb is placed upon it. On the curb masonry ring is built to a height of about 1.2m and allowed to drying.

Type of foundation in black cotton soil : Foundation in black cotton soil may be of the following types.

1 Strip or pad foundation

2 Pier foundation

3 Under-reamed pile foundation

1 Strip or pad foundation : For medium loads strip foundation (for walls) and pad foundation (columns) may be provided. These are two method of strip or pad foundation.

1st method : This method of constructing foundation on black cotton soil is adopted when the depth of black cotton soil is more and there are not chances for surface water to penetrate through the soil for more than 1m-1.5m.

The procedure is as follows

a The foundations trenches are excavated to a depth given by the equation.

d = maximum depth of crack+30cm

b The width of the trenches is kept such that the allowable bearing capacity of the soil does not exceed 15 tone/m^2.

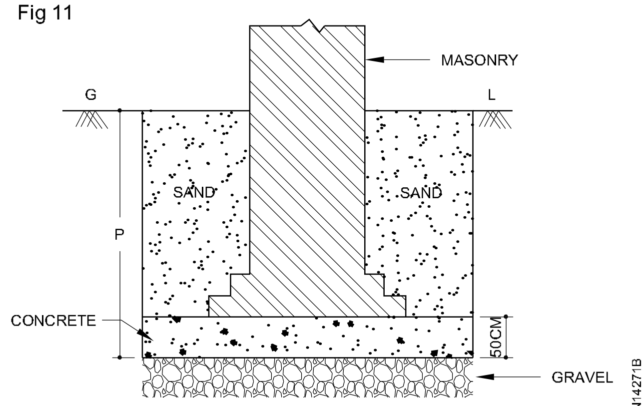
c Gravel is spread for the face width of the trench and well rammed.

d A layer of concrete of 50cm depth is laid on the gravel.

e The masonry work is started on the top of the foundation soil and it is carried out upto the plinth level.

f The side of the trenches are filled with sand as shown in fig 11.

Fig 11



II method

This method of constructing foundation on black cotton soil is adopted at places where there is heavy rain-fall and there are chances for surface water to reach a greater depth in the soil.

The procedure as follows

a The foundation trenches are excavated to a depth of 2m.

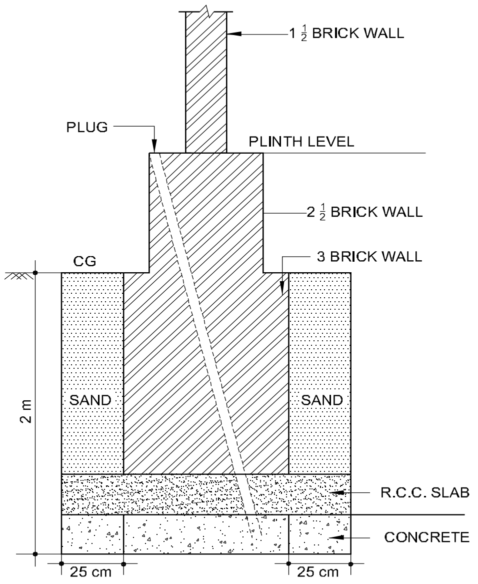
b The side portion of the trenches are filled with concrete having a section of 25cmx25xm as shown in fig 12 and the hollow space equal to 1st layer of masonry is filled with sand.

c 12cm-15cm thick R.C.C slab covering the face width of the trench is laid.

d The masonry work is started on the top of R.C.C slab and it is carried upto the plinth level.

e 80mm diameter pipes spread at 1.5cm centre to centre are placed through the masonry and R.C.C slab, as shown in figure. The pipes are brought upto plinth level and filled with sand. A plug is provided at the plinth level. These piles are inspected periodically if required.

Fig 12



2 **Pier foundation (Fig 13) :** When a heavy loaded building is situated in a sandy soil, black cotton soil or soft soil, over lying hard bed at reasonable depth pier foundation are sometimes used to transfer the load the building to the hard bed below. This method consist in sinking vertical shaft upto hard bed and filling them with concrete.

The diameter of the shaft and the centre to centre spacing depend upon the loading condition, the nature of soil and depth at which hard bed is situated. The diameter or horizontal dimension should be less than 1/12th its height. To prevent the side earth from falling in the side, the shaft is sometimes lined with timber. The timber lining is removed during the filling upthe shaft with concrete. The shaft are connected to each other by an arch or reinforced cement concrete or steel grillage cap.

3 **Under reamed pile foundation :** These piles are developed for serving as foundation for black cotton soil. An under reamed pile is a bored concrete pile having one or more bulbs in its lower portion. The bulbs or under-reams are formed by under reaming tools. The foundation will be anchored to the ground, and it would not move with the movement of the soil. The diameter of a under-reamed pile is about 3m-8m. The spacing of pile may vary from 2m-4m. The safe load for an under reamed pile varies from 20 to 40 tone (Fig 14).

Fig 13

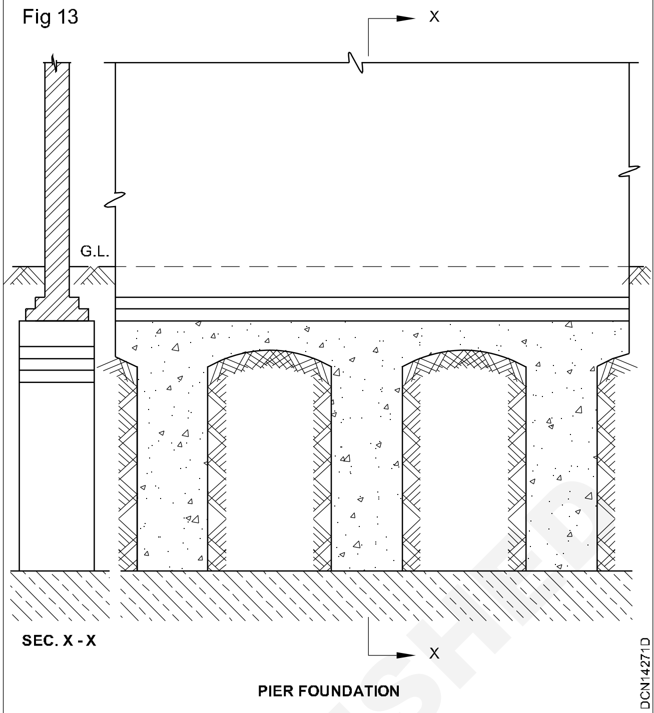
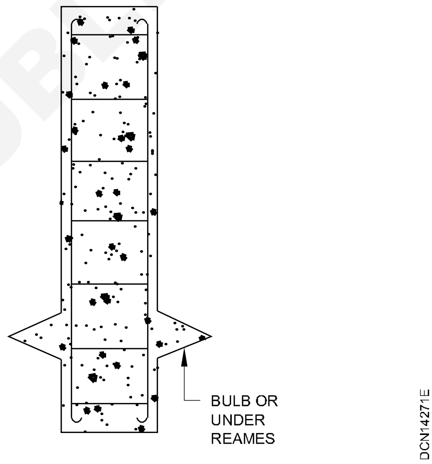


Fig 14



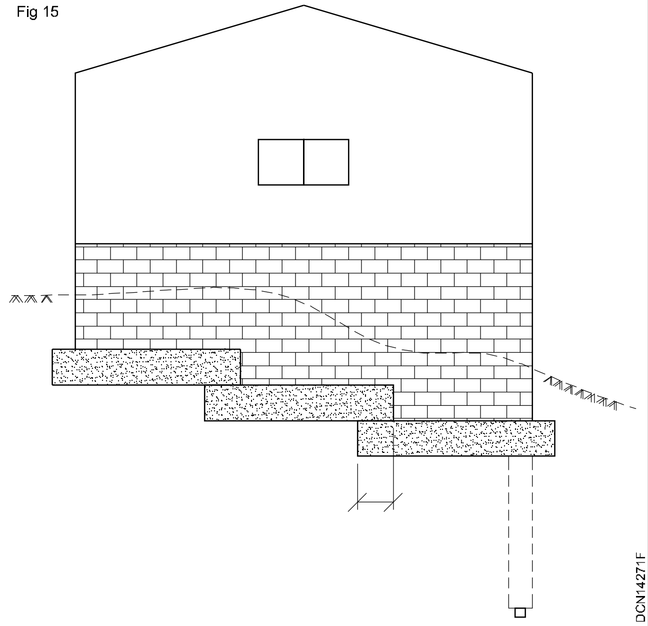
The load carrying capacity of under reamed pile can be increased by adopting pile of large diameter or by extending the length of pile, or by making more bulb at the base. A single under-reamed pile has only one bulb at the bottom. When the no.of bulbs at the base (2 or more) it is known as multi under-reamed piles. The vertical distance of bulbs varies from 1.25 to 1.50 times the diameter of the bulb. The under-reamed pile is selected by the consideration of pile length, stem diameter, bulb diameter, a no of bulbs. In black cotton soil the bulb of under-reamed piles, not only increase the load bearing capacity, but also provide anchorage against uplifts.

Stepped foundation on slopping ground (Fig 15)

1 When the ground is sloping it becomes an-economical to provides foundation at same level along the length of the wall, in such cases stepped or benching foundation may be provided. The foundation trunch is excavated in the form of steps, if possible all the steps should be of equal depth and length. Overlap between two layer of foundation concrete should be atleast equal to the depth of foundation concrete. A minimum

depth of 1m for soil and 60cm for rock should be provided between sloping surface and the lower edge of the footing.

Fig 15



Coffer dam and Caisson

Coffer dam

Is defined as a temporary structure which is constructed so as to remove water and soil from an area and make it possible to carry out the construction work under reasonably dry condition.

Following are the uses of coffer dam

1 To facilitate the pile driving operation

2 To place grillage and raft foundation.

3 To construct foundation for pier and abutment of bridge, dams etc.

4 To provide working platform for the foundation of buildings when water is met with.

5 To provide space for carrying out the foundation work without disturbing or damaging the adjoining structure such as building, pipe line etc.

Caisson

It is defined as a structure which is sunk through ground or water to exclude the water and semifluid material during the process of excavation of foundation and which subsequently becomes an integral part of the sub-structure.

Following are the use of the caisson

1 To reach the hard bearing stratum for transferring the load coming on supports for bridge pier

2 To serve as an impervious core wall of earth dams. when place adjacent to it.

3 To provide on acces to a deep shaft or tunnel.

4 To provide an encloser below water level for installing machinery, pump etc.

The main difference between coffer dam and caisson is that the coffer dam is a temporary structure, while caisson forms the part of the permanent work.

Method of settingout of foundation trench

Setting out or ground tracing is the process of laying down the excavation lines and centre lines etc on the ground.

The process for setting out of foundation trenches as follows :-

1 From the site plan of the building one line which can be easily established on the ground is selected.

For example as per fig16 the point 'A' can be easily located on the ground and its co-ordinates are completely defined. With the help of point 'A' line 'AB' can be demarcated on the ground.

Thus line 'AB' will be the base line and from this base line the entired building can be traced out on the ground. It should be noted that the point 'A' and 'B' are on the centre line of the wall and hence it is essential to prepare the centre line plan of the building before starting this work.

2 Centre line wooden pegs are driven on the ground and they project about 25mm above the ground level. Nails are provided on the top of the pegs as shown in figure.

3 Two other pegs are driven at equal distance on either side of the centre line peg such that the distance between them becomes equal to the width of the foundation tranch as shown in figure 16.

4 With the help of these pegs the foundation plan can be completely traced on the ground. For this purpose strings are tied to respective pegs and lines are marked along these strings with the help of pick-axe or wing powder.

5 Along the centre line pegs brick pillars of size 20cm x 20cm are constructed about 2m away from centre. In some level upto plinth level height. The top surface of the piller is plastered and grooves showing centre lines are provided as shown in figure.

6 The masonry pillar should be preserved till the foundation work is completed.

7 The depth of excavation can be started.

8 The depth of excavation is check by fixing a strings along the grooves on the opposite pillars and holding boning rod. The length of the boning rod should be equal to the depth of foundation trenches.

Simple- Machine foundation

Objectives: At the end of this lesson you shall be able to
- **state the functions of a foundation bolt**
- **name the type of foundation bolts**
- **explain the specific application of the bolts.**

Machines are generally subjected to the vibration of forces. Due to this cause the machines are like to shift or move or dislocate from their positions. To over come this defaults the machines are fixed to the ground with the help of specific devices which are called as foundation bolts.

These bolts do not have a specific shape of head similar to hexagonal or square bolts. The length of the shank is according to the thickness of nut and the thickness of machine base. The odd shaped part of the bolt hold the machine firmly to the ground and preventing the machine, shift or move or dislocation from its positions.

Types (Fig 1 & 2)

Fig 1

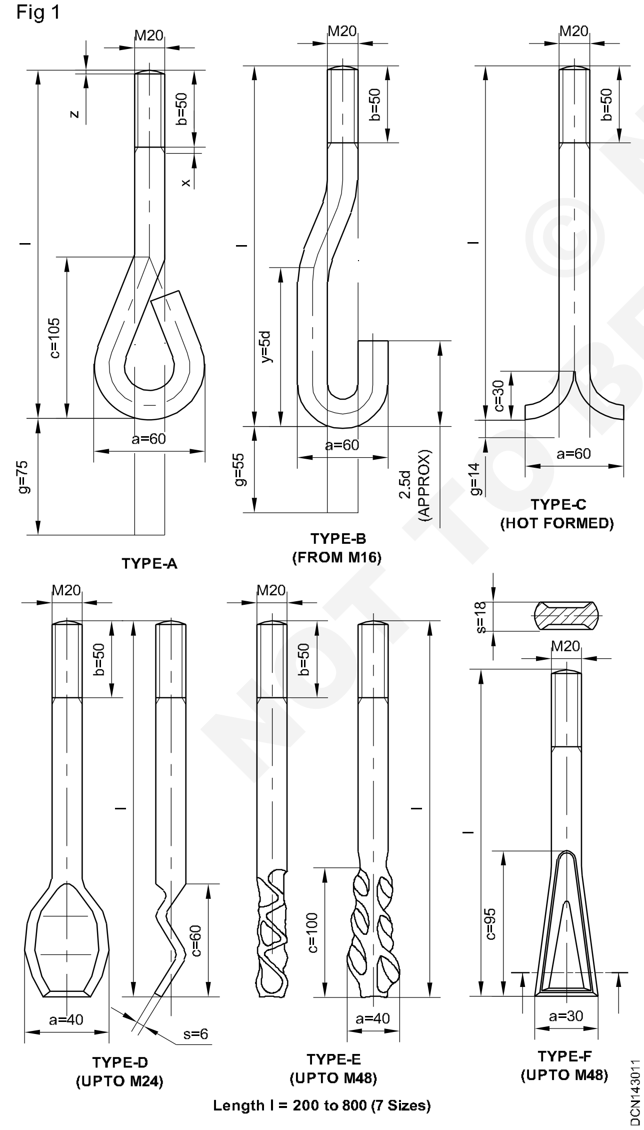
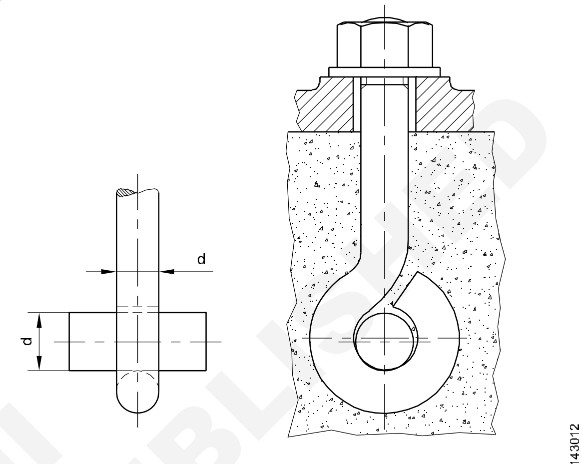


Fig 2



EYE FOUNDATION BOLT

As per IS : 5624-1971 there core six types designated as type A, B, C, D, E & F figure 1 shows the same. These bolts are available in 13 dia sizes from M8 to M75, length 80mm to 320mm. These botls are designated by the shanks dia and length without nut . The ends tare formed by forging .

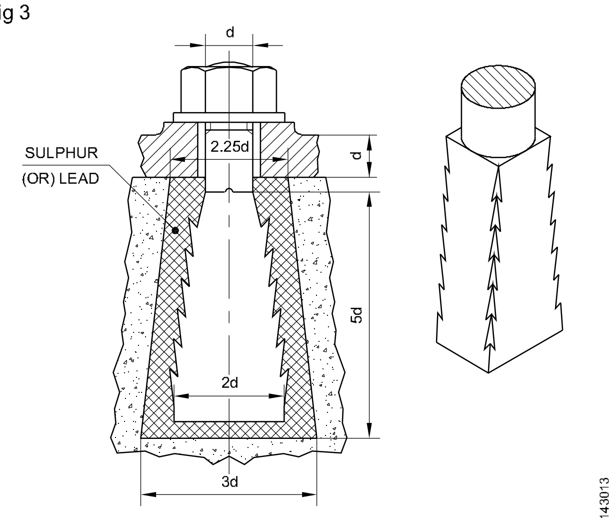
There are other non standard forms which are generally used are

- Eye foundation bolt
- Rag foundation bolt
- Lewis foundation bolt
- Cotter foundation bolt

Eye foundation bolt : The position of the holes of machine base /feet marked on the ground. Pits are formed and foundation bolts are placed in position, with cross bars placed in bolt eyes. The position of eye bolt is checked and aligned. The thread and of the bolt protrude above the ground level. Cement eye foundation bolt (Fig 2) and rubble are mixed with water and pounced around the bolt. When it sets, the bolts are hold in aligned. After this, the machine is placed in position and nut are toughened on the bolts holding the machine firmly.

Rag bolt (Fig 3) : This is in the shape of a rectangular pyramid with round shanks are formed with rags or grooved, forming small projections. These are bolts are placed in the foundation cavity in position as done in previous case and then molten lead of sulphur is pound around with. When the molten lead or sulphur /lead solidified the bolts are held firmly. The machines are placed in position and nuts are fixed. By melting the lead or during the sulphur the bolt can be removed.

Fig 3

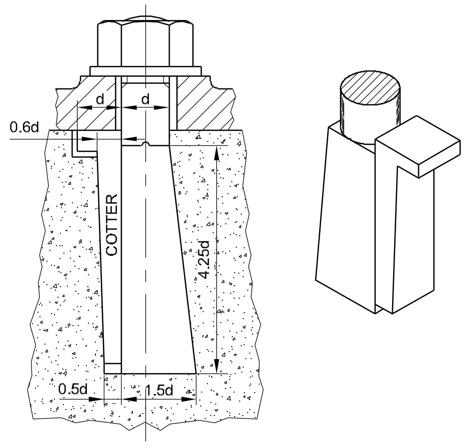


RAG FOUNDATION BOLT

Lewis foundation bolt (Fig 4) : This is a rectangular shanks bolt with one side taper. AGIB headed key is placed on the other side of the taper and concrete is panned around it if is aligned. The foundation bolt can easily be with drawn by removing the gib headed key first and then the bolt.

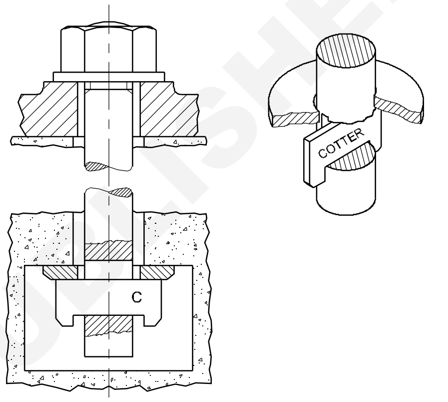
Cotter foundation bolt (Fig 5) : This type of bolt has a rectangular slot through which a double headed cotter is placed. A cast iron washer is rests above the cotter. Through the hand hole, connecting the cavity in the concrete and the bolt is pulled down and lifting the cotter. Now the cotter is placed in position.

Fig 4



LEWIS FOUNDATION BOLT

Fig 5



COTTER FOUNDATION BOLT

Shoring

Objectives : At the end of this lesson you shall be able to,
- **define shoring**
- **sketches and explain types of shores**
- **describe raking shore with its parts and functions**
- **follow important points while supervising the shoring work.**

Introduction

Structures which have become unsafe due to unequal settlement of foundations or due to removal of the adjacent building or due to any other reason. For safe structures, the shoring is required to prevent movements when certain additions and alterations are being carried out.

Circumstances

The shoring is required under following circumstances,

1 Adjacent structure is to be dismantled.

2 Cracks developed due to unequal settlement of foundation in a wall are to be required.

3 Defective walls of a building are to be dismantled and rebuilt and support is necessary to the floors or roofs connected to that wall.

4 Large openings are required to be made in the main walls of an existing building.

5 Walls of a building showing signs of bulging out or leaning outwards due to bad workmanship.

Materials: timber or steel tubes or in a combination of both.

Duration: no limit for the duration of shoring.

Requirements: loads coming on shoring are required to study separately and designed accordingly.

Approval: The shoring should be carried out as per prevailing rules and regulations of the authority and necessary approval should be obtained.

Types of shoring: Shores are classified, depending upon their supporting characteristics:.

1 Raking or Inclined shores.

2 Flying or Horizontal shores.

3 Dead or Vertical shores.

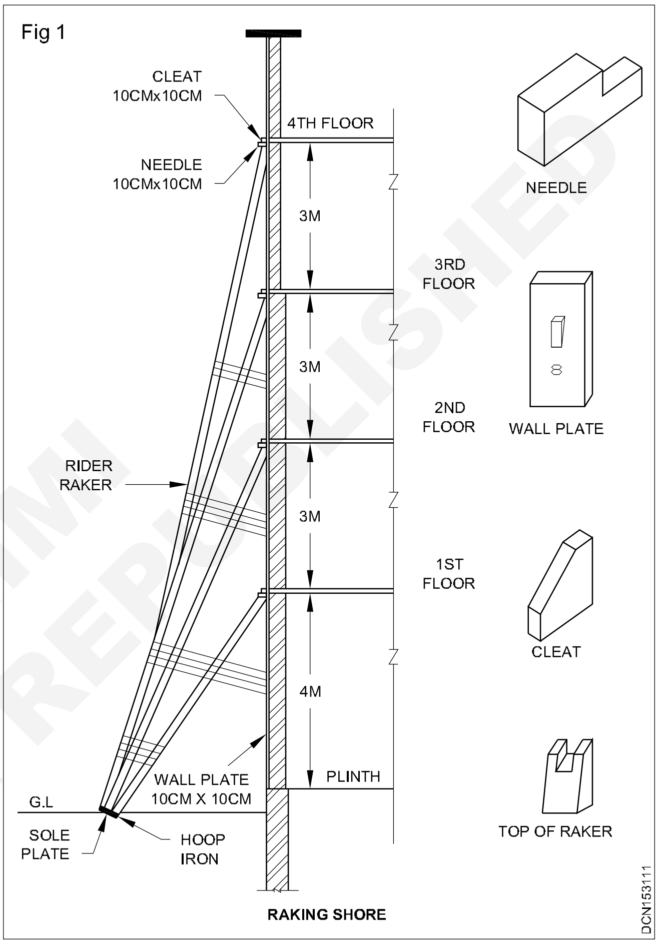
1 Raking or inclined shores: (see fig 1)

This is an inclined support provided to an unsafe existing structure externally is called Raking or Inclined Shores.

Component parts of a Raking

1 Wall Plate: - A wall plate is secured against the wall by means of square needles which penetrate in to the wall for a distance of about 15cm.

2 Needle: in turn, secured by cleats which are nailed to the wall plate?



3 Rakers: are interconnected by struts or braces or lacings. The feet of rakers are stiffened by similar braces or hoop iron and they are connected with the sole plate by means of iron dogs.

4 Braces :(Struts or lacings) these members are fixed diagonally on the standards.

5 Cleats: These are small blocks of wood, angle iron, or steel, to fixed raker and needle.

6 Sole Plate:-The bottom of the raker rest on sole plate

7 Hoop Iron:-The bottoms of rakers fixed hoop iron Dog, to avoid slip of rakers.

8 Straining Sill:-This horizontal tie beam between two inclined strut

Flying or Horizontal Shore (see figure): In this arrangement, the horizontal supports are given to the parallel walls, which have become unsafe due to the removal or collapse of the intermediate building

Shores are two Flying or Horizontal types,

1 Single flying shore

2 Double flying shore

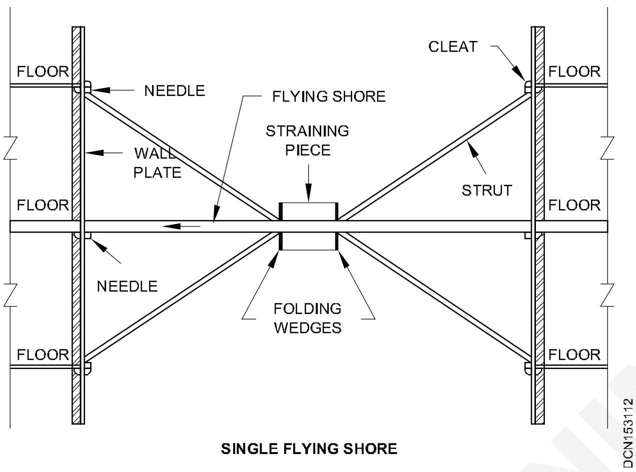
1 Single flying shore (see fig 2)

1 A single flying shore consists of wall plate, needles, cleats, struts, straining pieces, and folding wedges.

2 The flying shores should have a depth not less than one-third of the clear spans and width not less than one- fifth of its length.

3 This is suitable for a maximum distance of about 9m between the adjacent parallel walls.

Fig 2

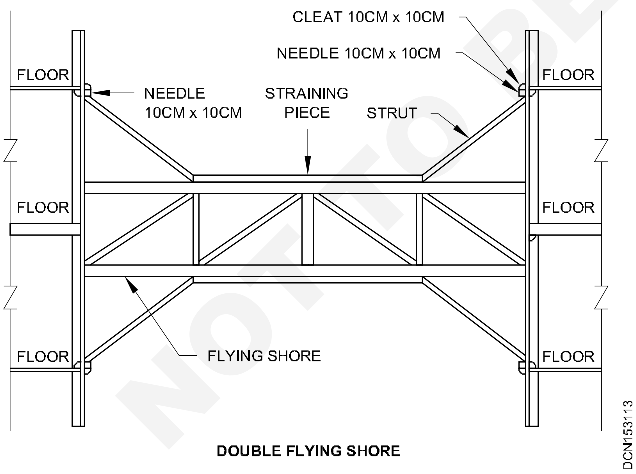


SINGLE FLYING SHORE

2 Double flying shore (see fig 3)

When the distance is between 9 m to 12 m, a compound or double flying shore is provided.

Fig 3

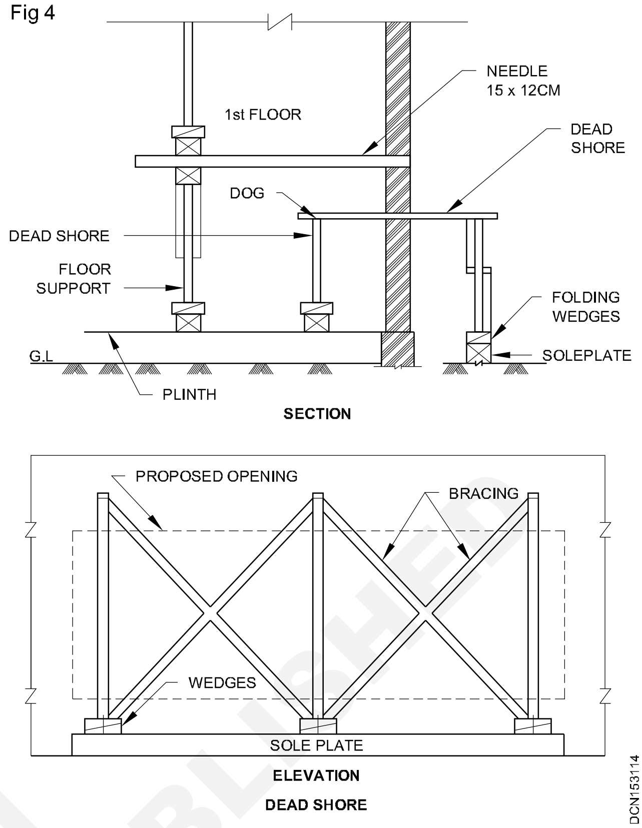


DOUBLE FLYING SHORE

3 Dead or vertical shores (see fig 4)

In this arrangement, the horizontal members, known as the needles are supported by vertical members known as the dead shores. The needles are driven at right angles to the wall through the holes made in the wall.

Fig 4



A dead shore is used under the following circumstances.

1 The lower part of the wall has become defective.

2 The foundations are to be deepened.

3 The lower part of the wall is to be rebuilt or reconstructed.

4 The large openings are to be made in the existing wall.

Important points for supervision the work of shore

1 Various It is possible to calculate the stresses in the members of a dead shore.

2 The needles are placed at a distance of about 1.50 m to 2 m and they are suitably braced. The folding wedges, sole plate, dogs and braces are used as shown figure.

3 The floors are suitably supported inside.

4 The openings above and near a dead shore are suitably strutted.

5 A raking shore may be provided as an additional safety especially in case of weak walls.

6 The shores should be removed at least after 7 days of construction of new work .This period is necessary for the new work to obtain the required strength.

7 The sequence of removal should be needles, strutting from openings, the floor strutting inside and raking shores. If any it is desirable to allow an interval of two days between each of these operations.

Scaffolding

Objectives : At the end of this lesson, you shall be able to,
- **define scaffolding**
- **identify required materials**
- **explain the purpose/uses of scaffolding**
- **state component parts of a scaffolding**
- **describe the types of scaffolding**
- **follow important points while supervision the scaffolding work.**

Introduction

In the normal activities of the building construction, it becomes necessary to have some type of temporary structure or support, so as to proceed with the work.These temporary arrangements take up the form of scaffolding , shoring, underpinning and formwork .

Definition

When the height above floor level exceeds about 1.50 m a temporary structure, usually of timber, is erected close to the work to provide a safe working platform for the workers and to provide a limited space for the storage of plant and building materials. This temporary framework is known as scaffolding.

Materials

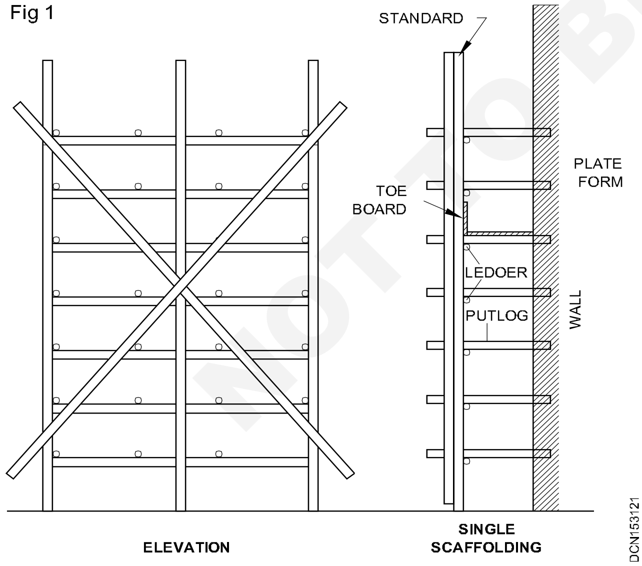
The scaffolding can be carried out either in Timber, bamboo, teak or steel tubes, G.I. pipe, Steel Square, or composite materials. The timber surfaces should be coated with a preservative so as to give protection against wet rot.

Purpose/uses

It is useful in construction, demolition, maintenance or repair works, etc.

Component parts of scaffolding (Fig 1)

Fig 1



The Technical Term associated with the design and construction of scaffolding is defined below:

Standards: These are the vertical members of the framework and they are either supported on the ground or drums or embedded into the ground.

Ledgers: These are the horizontal members parallel to the wall.

Putlogs: These are the transverse pieces which are placed on the legders and which are supported on the wall at one end. They are at right angles to the wall.

Transoms: These are putlogs, but the both ends are supported on the ledgers.

Bridle: This is a piece which is used to bridge an opening in a wall and it supports one end of the putlogs at the opening.

Braces: These are the diagonal or cross pieces fixed on the standards.

Guard rail: This is a rail provided like a ledger at the working level.

Toe board: This is a board placed parallel to the ledgers and supported between the putlogs. It is provided to work as a protective measure on the working platform.

Raker: This is an inclined support.

The various members of a scaffold are secured by means of devices such as nails, bolts, rope, etc.

Types of scaffolding:

1 Single scaffolding or bricklayer's scaffolding.

2 Double scaffolding or mason's scaffolding.

3 Cantilever or needle scaffolding.

4 Suspended scaffolding.

5 Trestle scaffolding.

6 Steel scaffolding.

7 Patented scaffolding.

Single (putlog) scaffolding or bricklayer's scaffolding (Fig 1)

1 This is the most common type of scaffolding and is widely used in the construction of brickwork.

2 It consists of a single row of standards placed at a distance of about 1.2 m from the wall .

3 The distance between the successive standards is about 2 m to 2.50 m.

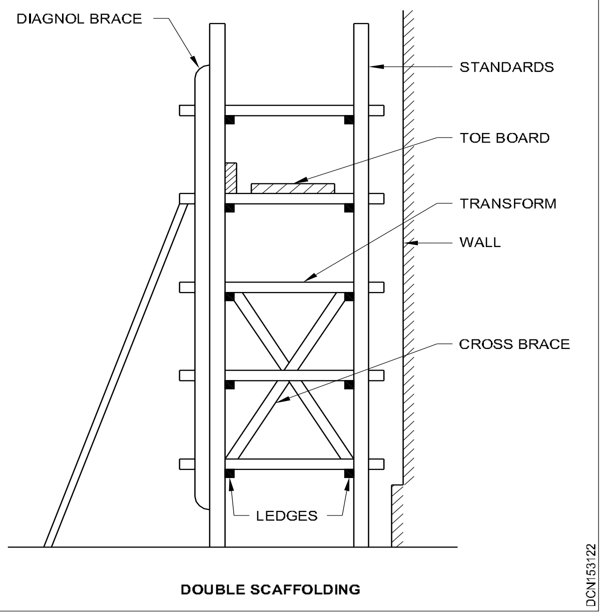
4 The ledgers are then fixed to the standards at a vertical distance of about 1.20 m to 1.80 m.

5 The putlogs, with one end on the ledger and the other end on the wall, are then placed at a horizontal distance of about 1.20 m to 1.80 m.

6 The braces, guard rail and toe board are fixed.

Double (Independent) scaffolding or mason's scaffolding (Fig 2)

Fig 2



DOUBLE SCAFFOLDING

1 This scaffolding is stronger than single scaffolding and it is used in the construction of stonework.

2 The framework is similar to the single scaffolding except that two rows of standards are provided.

3 The distance between the face of the wall and the first row of standard is about 200mm to 300 mm and the distance between the two rows is about one meter.

4 The rakers and cross braces may be provided to make the scaffolding more strong as shown in figure.

5 This type is also sometimes known as Independent Scaffolding.

Cantilever/Needles scaffolding

The general framework, in this type of scaffolding, may be of single scaffolding type or of double scaffolding type. But the standards are supported by a series of needles or ties which are taken out at floor levels or through openings or through holes kept in the masonry.

It is useful under the following circumstances,

1 The proper hard ground is not available for the standards to rest.

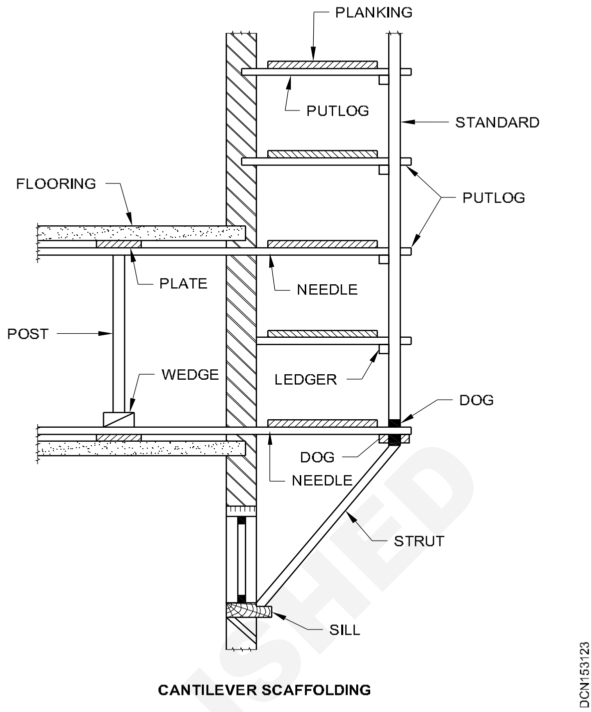
2 It is desired to keep the road or pavement near the face of wall, clear of obstruction caused by the scaffolding.

3 The construction work is to be carried out for upper parts of a multi-storied building.

1 A Cantilever Scaffolding of Single Scaffolding Type (Fig 3)

- The needles are supported at the floor levels and struted through projections such as sills, cornices, string courses, etc.

Fig 3

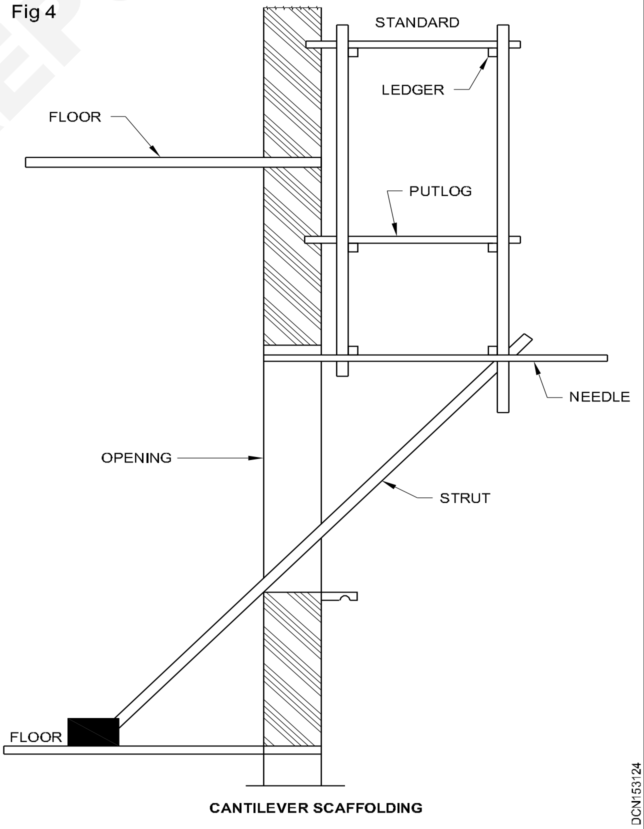


CANTILEVER SCAFFOLDING

- The inner end of the needle projects sufficiently in side and is well strutted between the floors as shown in figure.

2 A Cantilever Scaffolding of Independent Type (Fig 4)

Fig 4



CANTILEVER SCAFFOLDING

- The needles are passing through the openings and are strutted on the floors through the openings as shown figure.
- The suitable timber blocks should be interposed at the ends of struts on the floor levels.

Independent Type (Fig 1)

Suspended scaffolding

1 This is a very light type of scaffolding and can be used only for the maintenance works such as painting, pointing, whitewashing, distempering, etc.

2 The working platform is suspended from the roofs by means of ropes, wires or chains and arrange ments are made such that the platform can be raised or lowered

3 This type of scaffolding does not create any obstruction on the ground and

4 It is the most effective as it always provides the optimum level for working.

Trestle scaffolding

In this type scaffolding,

1 The working platform is supported on movable contrivances such as ladders, tripods, etc., mounted on wheels.

2 It is useful for minor repairs or painting work inside the rooms and

3 The maximum height up to which this type of scaffolding can be adopted is about 5 m from the supporting surface.

Steel scaffolding

1 In place of timber, the steel tubes can be effectively used for the scaffolding work.

2 The diameter of the tubes is about 40 mm to 50 mm and the thickness is about 5 mm.

3 The tubes are available in standard lengths with special couplings and set-screws.

4 The advantages of steel scaffolding are manifold.

5 The scaffolding can be used up to any height;

6 It is strong and more durable;

7 It can be easily erected and dismantled;

8 It possesses high scrap value and it is resistant to fire.

9 The disadvantages are that the initial cost is high,

10 It requires skilled labour and

11 Also requires periodical painting.

Patented scaffolding

1 Now a days, the various patented scaffoldings made of steel, with special types of couplings and frames,

2 Usually the working platform is supported on a bracket which can be adjusted to any suitable height.

Important points for supervising the work of scaffolding

Following important points should be carefully attended to the scaffolding work;

1 Bedding of standards

If standards are not resting on the firm ground, the base-plates of suitable size should be provided at their bottom ends. Further, if required a timber sole plate may be provided on which all the base-plates rest.

2 Loading

The scaffolding should never be loaded heavily mainly because it is a temporary structure and in case of single scaffolding, one of the ends of putlogs rests on the green surface of the masonry.

3 Tying-In scaffold

It is necessary to tie back the scaffolding with the building at suitable levels. This can be achieved in different ways:

A vertical or horizontal tube, wedged by means of a reveal pin, may be provided in an opening and one of the ends of the putlogs may be coupled with this tube.

A tube may be provided across the opening inside the wall and one of the ends of the putlogs may be coupled with this tube.

4 The Rakers: Strutting from the ground level, may be provided.

5 Raising

As the work proceeds, the standards are suitably lengthened and fresh ledgers and putlogs are inserted. The working platforms are then shifted to new levels.

6 Finishing

After the scaffolding is removed, the holes of putlogs in the wall should be immediately filled up.

7 Spacing of standards

The loading on the scaffolding decides the spacing of standards. It is less for heavy loading and more for light loading .The maximum spacing is about 3 m.

8 Miscellaneous structure

The scaffolding of special types should be built for miscellaneous structure such as chimney's lowers domes etc.

Under pinning

Objectives : At the end of this lesson you shall be able to
- **define under pinning**
- **describe the situations demanding underpinning**
- **state the purposes**
- **follow the guide lines for supervise underpinning**
- **explain the methods of underpinning.**

Introduction

The placing of new foundation below an existing foundation or the process of strengthening the existing foundation is known as the underpinning of foundation.

Situations demanding underpinning

1 A building with deep foundations is to be constructed adjoining to an existing building.

2 The settlement of existing foundation has taken place.

3 The basement is to be provided to an existing building.

4 The existing foundations are to be depended so as to rest them on soil of higher bearing power.

Materials: used timber or steel etc.

Purpose/Uses: mainly to strengthening of existing foundation.

Important points to consider before underpinning

1 Shoring and strutting

The necessary shoring and strutting should be provided to the structure to make it safe for carrying out the process of underpinning.

2 Examination of structure

The structure should be carefully examined before underpinning is commenced and poor masonry work should be suitably rectified.

3 Repairs

It is necessary to carry out urgent repairs such as grouting of cracks, insertion of tie rods between walls, etc. before commencing underpinning.

4 Checking arrangement

The levels may be marked on the structure and the movement of structure during underpinning should be checked and recorded.

5 Expensive operation

The process of underpinning is an art rather than a science. Due to advance made in the science of soil mechanics, much guess-work in underpinning is eliminated. But still it remains an expensive operation.

6 Bearing plate

When R.S. joist is used as needle, the bearing plate is provided to avoid the crushing of masonry

Methods of underpinning

Following are the methods of underpinning:

i- Pit method, ii- Pile method, iii- Miscellaneous methods.

Pit method (Fig 1)

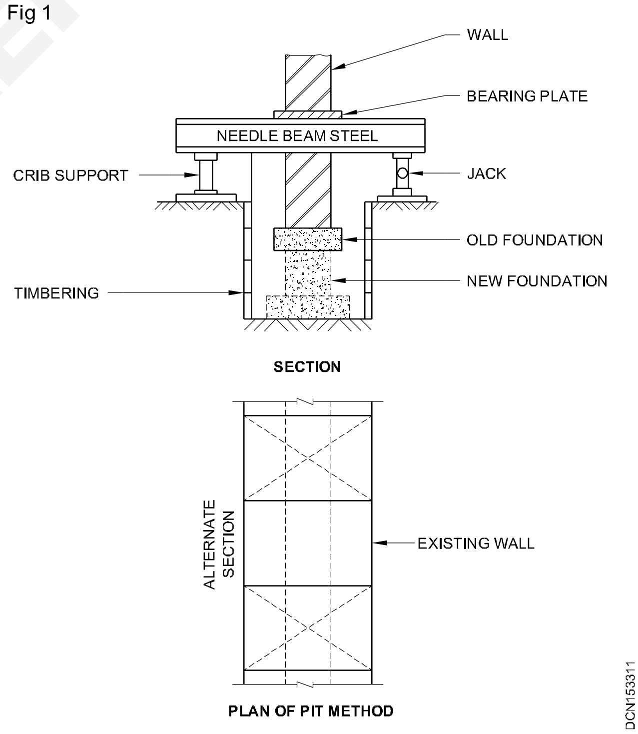
1 In this method the existing wall is divided into suitable sections of width about 1:20 m to 1:50 m.

2 The holes are then made in the existing wall.

3 The needles with bearing-plates are then inserted through these holes and supported on jacks.

4 The pit is excavated and the existing foundation is taken up to the required level.

Fig 1



Following precautions are necessary

1 One section should be excavated at a time.

2 The alternate sections should be taken in succession.

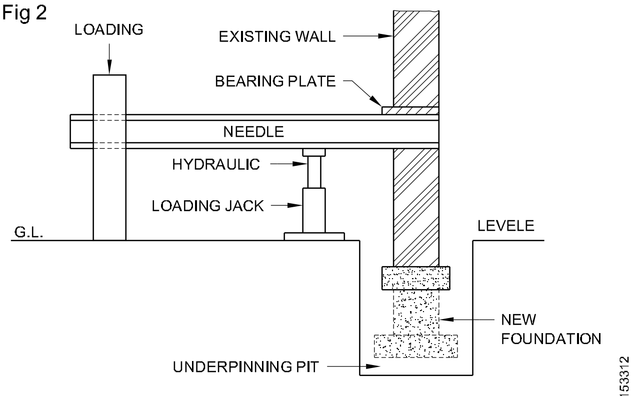
3 If the length of wall is more, the underpinning is started from the middle and it is then extended in both the directions.

4 The proper timbering should be provided for the trench.

5 It is desirable to carry out the new foundation work in concrete.

6 If space to support needles on outside is not available, the cantilever needles, projecting inside and provided with fulcrums and loadings, may be adopted as shown in (Fig 2). A hydraulic jack is placed between the needles and fulcrum.

Fig 2



SUPORT BY CANTILEVER NEEDLES

Pile method

1 In this method, the piles are driven along both the sides of the existing wall and

2 Then needles in the form of pile caps are provided through the existing wall as shown in fig.

3 Thus the existing wall is relieved of the loads coming on it.

4 This method is useful in clayey soils and for water-logged areas and for walls carrying heavy loads.

5 For structure and then brackets or cantilever needles are provided to carry the structure.

Miscellaneous methods

Following are some of the specialized underpinning methods which may sometimes be successfully adopted:

1 Cement grouting,

2 Chemical consolidation

3 Freezing ,

4 Vibroflotation.

1 Cement grouting

This method is used to restore slab or pavement which has settled. The operation is simple. The holes are drilled in the slab and the cement grout is forced under pressure through these holes. The pressure is maintained until the cement grout has set.

2 Chemical consolidation

In this method, the soil under the existing footing is consolidated by using chemicals.

The procedure for chemical consolidation is as follows

1 The perforated pipes are driven in an inclined direction.The inclination slopes are so adjusted that the entire area under the existing footing comes under the command of the inclined pipes.

2 When the pipes are being driven, the solution of sodium silicate in water is injected through the pipes.

3 The pipes are then withdrawn and during the withdrawal of pipes, the calcium or magnesium chloride is injected through the pipes.

4 The chemical reaction takes place between these two chemicals and the soil is consolidated.

5 This method is useful when the soil consists of sand or granular materials and the cost of consolidation depends on nature of soil, depth of consolidation, site of work, etc.

3 Freezing

1 In this method, the freezing pipes are driven below the existing footing and the soil is frozen.

2 This method is rarely adopted, mainly because of two reasons: (i) it is expensive and (ii) more time is required for the installation of freezing pipes.

4 Vibroflotation

1 In this method, the underpinning is carried out by vibrating the sand and

2 Thereby increasing its density which ultimately results in the increase of bearing capacity of soil.

3 This method is useful for granular or sandy soil and before the process of underpinning starts, the building or any of its structural components is shored carefully.

4 The vibrating equipment or soil to be compacted is to be isolated from the building and its shoring.

Formwork or shuttering

Objectives : At the end of this lesson you shall be able to,
- **definition of formwork.**
- **state requirements of formwork**
- **explain removable of formwork**
- **describe centering for various building components.**

Introduction

Temporary boarding or shuttering or sheeting created to hold concrete work for some days to allow the hardening and strengthening, of concrete is known as formwork (casing or shuttering).

Moulds: The term moulds is sometimes used to indicate formwork of relatively small units such as lintels, cornices.

Centering: For circular work such as arch, dome, etc. the term centering is generally used.

Materials: Materials used for formwork such as wooden, plywood, steel, combined wooden-steel etc.

Requirement of formwork:

1 It should be sufficiently strong to take the dead and live loads during construction.

2 It should be as water tight as possible.

3 It should be easily removable without damage to it.

4 Formwork gives a smooth level surface concreting.

Removal of formwork: (Stripping)

The operation of removing the formwork is commonly known as stripping.

Stripping time:

Formworks may be struck after expiry of following periods:

1 Walls, columns and vertical sides of beams- 24 to 48 hours as may be decided by the engineer-in-charge.

2 Slab soffits (props left under)- 3 days.

3 Beam soffits (props left under)- 7 days.

4 Removal of props to slabs:

i) Spanning up to 4.5 m- 7 days.

ii) Spanning over 4.5 m - 14 days.

5 Removal of props to beams and arches:

i) Spanning up to 6 m- 14 days

ii) Spanning over 6 m - 21 days.

Centering for square and circular columns

Shuttering for a column is probably the simplest.

It consists of the following main components:

1 Sheeting all round the column periphery,

2 Side yokes and end yokes,

3 Wedges and

4 Bolts with washers.

5 The side yokes and end yokes consist of two numbers each, and are suitably spaced along the height of the column.

6 The two-side yokes are comparatively of heavier section, and are connected together by two long bolts of 16 mm dia. Four wedges, one at each corner, are inserted between the bolts and the end yokes.

7 The sheathing is nailed to the yokes shuttering for octagonal and round columns.

Centring for beam and slab

1 The formwork for beam and slab floor.

2 The slab is continuous over a number of beams.

3 The slab is supported of 2.5 cm thick sheathing laid parallel to the main beams.

4 The sheathing is supported on wooden battens which are laid between may be propped at middle of the span through joints.

5 The side forms of the beam consist of 3 cm thick sheathing.

6 The bottom sheathing of the beam form may be 5 to 7 cm thick.

7 The ends of the battens are supported on the ledger which is fixed to the cleats throughout the length.

8 Cleats 10 cm X 2 cm to 3 cm are fixed to the side forms at the same spacing as that of battens, so that battens may be fixed to them.

9 The beam form is supported on a head tree.

10 The shore or post is connected to head tree through cleats.

11 At the bottom of share, two wedges of hard wood are provided over a sole piece.

Centering for concrete wall

1 Fix form for walls.

2 The boarding may be 4 to 5 cm thick for walls up to 3 to 4 m high.

3. The boards are fixed to 5 cm x 10 cm posts, spaced at about 0.8 m apart, known as studs or soldiers,

4. Horizontal waling of size 7.5 cm x 10 cm are fixed to the posts at suitable interval.

5. The whole assembly is then strutted using 7.5 cm x 10 cm struts.

6. The two shutters are kept apart equal to the thickness of the wall, by providing a 5 cm high concrete kicker at the bottom and by 2.5 cm x 5 cm spacers nailed to the posts.

Centering for arches: Refer Exercise No. 1.738

1 A temporary structure (centering) is required to support brick, stone or concrete arches during their construction.

2 The upper surface of the centering corresponds to the shape of intrados of the arch.

3 The centering for arches consists of two parallel boards having their upper edges shaped to the required curvature.

4 The boards are connected through their curved length by mans of narrow wooden strip which are known as the laggings. These laggings are used to support the bricks or stones.

5 The centering is supported by props at each end.

6 The boards are prepared from two ribs whose thickness varies from 25 mm to 40 mm and whose width varies from 200 mm to 300 mm.

7 The struts and braces are provided to strengthen the ribs to prevent them from spreading.

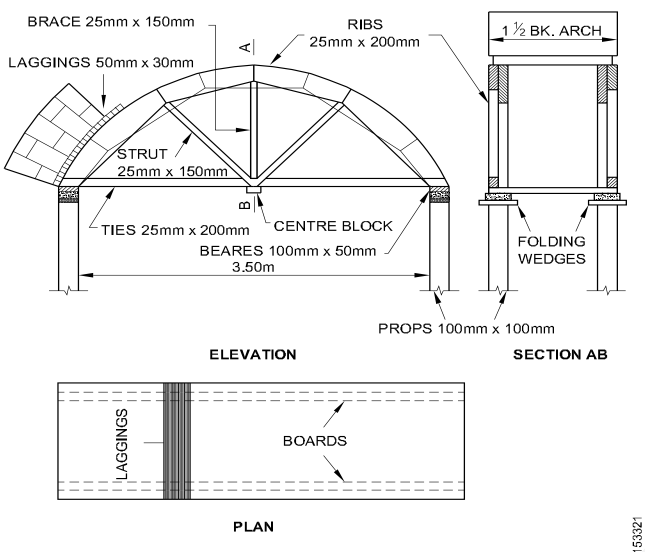
8 The ties are generally 25 mm to 50 mm thick and 200 mm to 250 mm wide.

9 The bearers support the ribs and a pair of folding wedges is provided at the top each drop to tighten or to loosen the centering.

Figure shows an arch centering for a span of 3.50 m and of width equal to 1½ brick thickness.Fig 1.

Following points should be noted in connection with the arch centering.

Fig 1



CENTERING FOR ARCHES

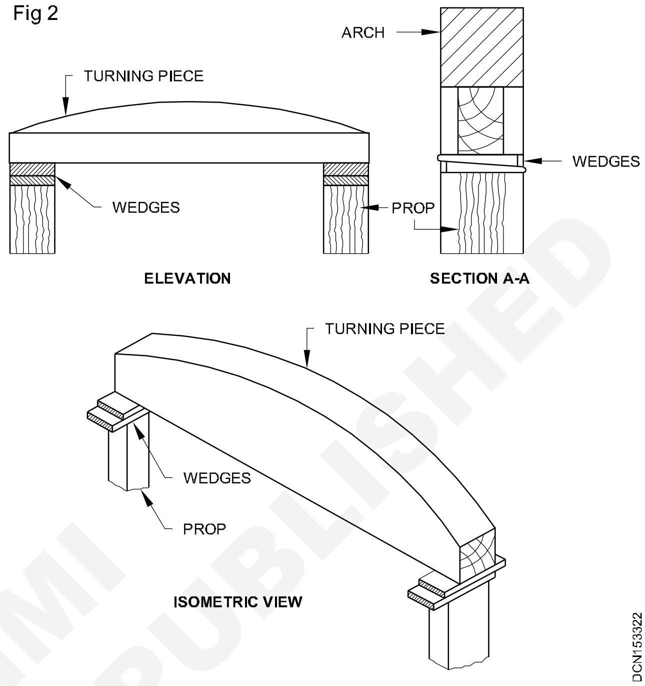
1 The length of laggings and the distance between the boards depend on the width of an arch. For rough and axed arches, the laggings are provided 20mm apart. But for gauged work, they are closely spaced.

2 The laggings should be kept 10 mm to 12 mm back from the face of arch work so that they will not form an obstruction to the line and plumb rule observed by the masons during construction.

3 A thick wooden plank can be used as centering for arch of thickness one-half brick. The plank is shaped to the curvature of the arch and it is supported on the props. Fig 2 shows the elevation, section and isometric view of centering with turning piece. The thick wooden plank with horizontal bottom and the upper surface shaped to the underside of the soffit is known as the center of turning piece. Its width is normally 100 mm and it is supported on vertical timber posts known as the props. The wooden wedges are provided to tighten or loosen the centering.

4 For small spans, the single ribs may be provided on side and laggings, bearers and folding wedges may be provided as usual.

Fig 2



5 The centering for arch should be removed after the arch has developed sufficient strength. For small spans, the removal of centering is done by slightly loosening the folding wedges. But when the span exceeds 7 m or so, a method known as the sand box method, is adopted to avoid shocks. A box is filled with sand and a hole is provided at the bottom of box. The hole is plugged to retain sand. The bottom of prop rests on a plate which is provided at the top surface of sand when it is desired to lower the centering, the plug is taken out and the sand is allowed to come out of the box. The prop is thus lowered gradually.

6 The construction of centering for an arch depends on the span of arch, rise or arch, form of arch curve and the materials of which arch is constructed .

Timbering of trenches

Objectives : At the end of this lesson you shall be able to
- **definition of timbering of trenches.**
- **technical terms used for timbering**
- **method of timbering.**

Timbering of trenches

When the depth of trench is large, or when the sub-soil is loose, the sides of the trench may cave in. The problem can be solved by adopting a suitable method of timbering. Timbering of trenches, sometimes also known as shoring consists of providing timber planks or boards and struts to give temporary support to the sides of the trench.

Technical terms used for timbering

Following terms are used to denote the various members of the timbering

1 **Sheeting:** This is defined as the main plank which remains in contact with the sides of trench. The term sheathing is used to indicate vertical members of timbering which directly resist pressure from the side of a trench.

2 **Ranger or wale:** This is the name given to the piece of timber which transfers the load from the sheeting to the strut.

3 **Strut:** The piece of timber which maintains a fixed distance between the sheeting or between the walls is known as the strut.

4 **Bracing:** The diagonal piece of timber used to give rigidity to the framework is known as the bracing.

Methods of timbering

Following are the five methods of timbering:

1 Stay bracing

2 Box sheeting

3 Vertical sheeting

4 Runners

5 Sheet piling.

1 Stay bracing

1 This arrangement of preventing the slip of earth in foundation trenches is used when excavation is to be carried out in moderately firm ground and when the depth of excavation does not exceed 2 meter.

2 The vertical sheets or poling boards are placed opposite each other against the walls of the trench and they are held in position by one or two rows of struts.

3 The sheets are placed at an interval of 3 to 4 meter and generally, they extend to the full depth of the excavation.

4 The width of poling boards may be equal to 200 mm with thickness of about 40 mm to 50mm.

5 The struts may have size of 100 mm x 100 mm for trench up to 2 m width and 200 mm x 200 mm for trench exceeding 2 m in width.

2 Box sheeting

This arrangement of preventing the slip of earth in foundation trenches is used when excavation is to be carried out in loose soil and when the depth of excavation does not exceed 4 meters.

A box like structure is formed by providing sheeting, Wales, struts and bracings.

The arrangement is adopted for loose soil. In this arrangement, the vertical sheets are placed nearer or sometimes, touching each other as shown. The sheets are kept in position by longitudinal rows of Wales, usually two in number and then, the struts are provided across the Wales as shown.

The arrangement is adopted for very loose soil. In this arrangement, the sheets or planks are placed horizontally in plan and they are supported by Wales and struts as shown.

3 Vertical sheeting

For deep trenches up to about 10 meters in soft ground, the vertical sheeting is adopted.

The method is similar to box sheeting except that the work is carried out in stages and at each stage, an offset is provided. For each stage, vertical sheets, horizontal Wales, struts and braces are provided as usual. The offset is provided at a depth of 3 to 4 meters and its value varies from 300 m to 600 mm per stage.

Suitable movable working platform may be provided across the struts. This arrangement is very much suitable for laying sewers or water pipes at considerable depths.

4 Runners

In case of extremely loose and soft ground which requires immediate support as the excavation progresses, the arrangement, is adopted.

The runners which are long thick wooden sheets or planks are used in this arrangement. One end of a runner is made of iron shoe. The runners are driven by hammering about 300 mm in advance of the progress of the work. The Wales and struts are provided as usual.

5 Sheet piling

This arrangement of preventing the slip of earth in foundation trenches is adopted when-

a Large area is to be excavated for a depth greater than 10 meters or so;

b Soil to be excavated is soft or loose;

c Width of trench is also large; and

d Sub-soil water is present.

It should be noted that the sheet piles are designed to resist earth pressure only. The timber sheet piles can be used up to a depth of about 10 meters, depending upon the joints between them. The steel sheet piles are available in various sizes and patterns and can be used up to a depth of 30 meters.

The process consists of driving the sheet piles along the boundary of the area to be excavated. The sheet piles are driven slightly more than the depth of excavation. The work of excavation is then started and as soon as the excavation reaches a certain suitable depth, the vertical sheeting and struts are provided us usual, if required.

Damp proofing

Objectives : At the end of this lesson you shall be able to
- **define damp proofing**
- **state the causes and effects of dampness**
- **describe the requirements of ideal damp proofing material**
- **state the materials used for damp proofing**
- **explain the methods of damp proofing**
- **explain the water proofing treatments for roofs.**

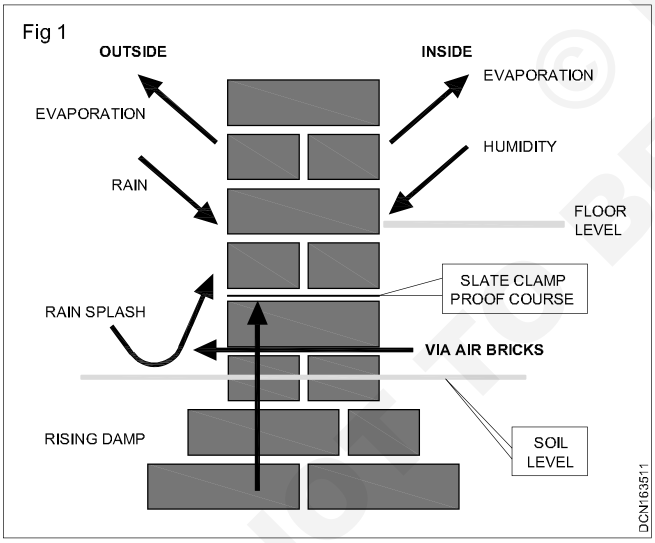
Introduction

Dampness, is the unwanted and unauthorized accumulation of water in the building components. Continued presence of dampness in the building, deteriorates building components, spoils, the interior decoration and external appearance and affects the health and comfort of the occupants. Hence, in order to prevent the entry of damp into a building, the application of courses known as damp proofing courses, which are provided at various levels, at entry of damp into a building.

Definition

Treatments given to various places of building structure to keep walls, floors and basement dry, is called damp proofing.

Causes of dampness (Fig 1)



1 Rising moisture from ground
2 Condensation
3 Defective junctions between roof slab and parapet wall.
4 Defective roof covering of pitched roof
5 Faulty eaves and valley gutter.
6 Improper rain water pipe connections
7 Inadequate roof slope
8 Splashing of rain water
9 Unprotected tops of wall, parapet walls etc.

Effects of dampness

1 Metals used in the building corroded.
2 Unsighty patches formed
3 Decay of timber
4 Electrical deteriorated leakage of electricity and short circuiting.
5 Floor covering materials get damaged
6 Promotes the growth of termites.
7 Softening and crumbling of plaster
8 Gives rise to breading of mosquitoes, germs of dangerous diseases etc.
9 Wall decoration materials are damaged
10 Floorings get loosened
11 Cause efflorescence.

Requirements of an ideal damp proofing material

1 Durable
2 Remains steady and do not allow any movement it self.
3 Perfectly impervious
4 Capable of resisting the loads coming over it safely.
5 Flexible
6 Dimensionally stable
7 Reasonably cheap
8 Possible to carryout leak proof jointing work
9 Free from deliquescent salts like sulphates, chlorides and nitrates.

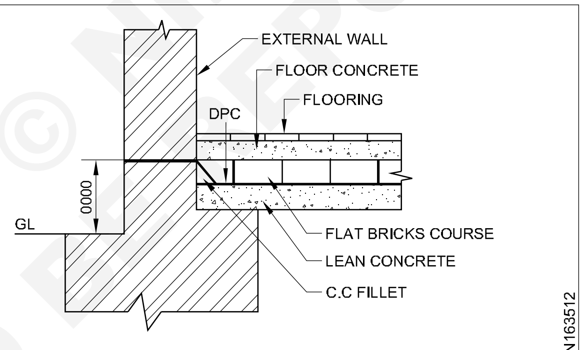
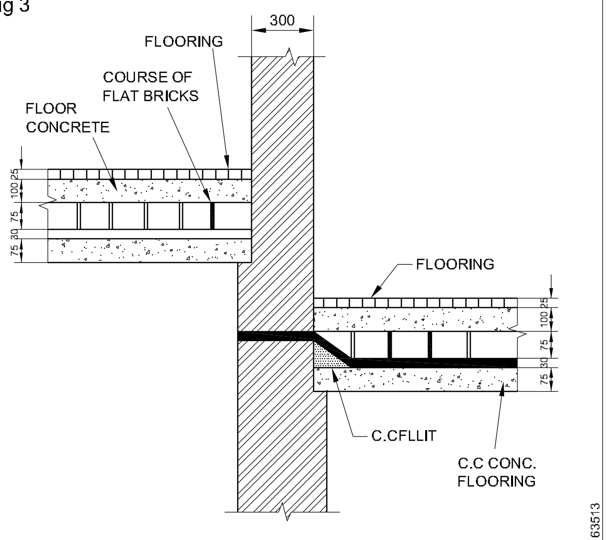
Materials for damp proofing

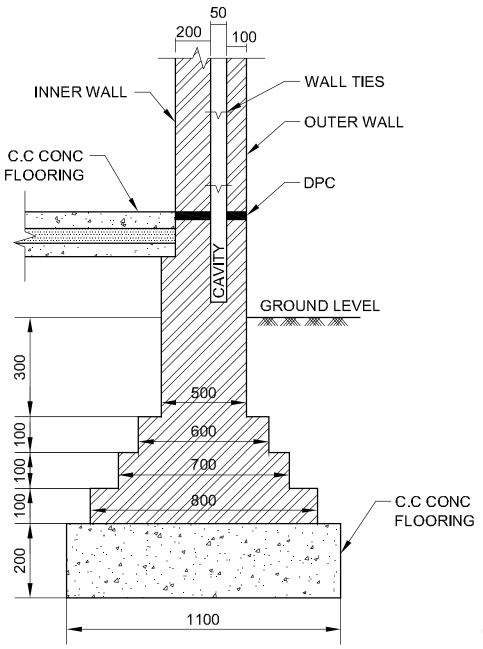
1 Bitumen
2 Mastic asphalt
3 Bituminous felt
4 Metal sheets (Lead, Copper, Aluminium)
5 Combination of sheets and felts
6 Stones
7 Bricks

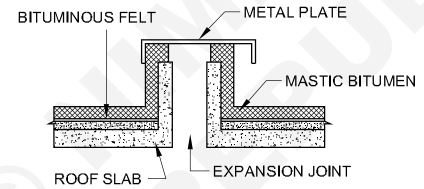
8 Mortar

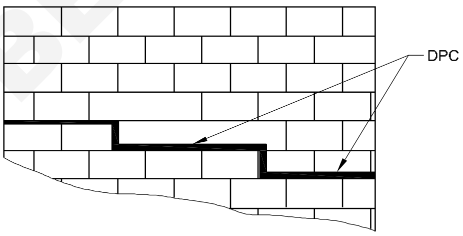
9 Cement concrete

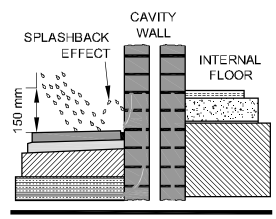
10 Plastic sheet.

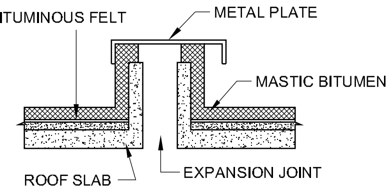
Methods of damp proofing		
S.No	**Method**	**Description / Figure**
1	Integral treatment	Water proofing compounds or materials are added during the process of mixing the materials. Chalk, tale or filler's earth is used to fill the pores in concrete or mortar. Water proofing compounds such as Pudlo, Impermo etc. are used after diluting with water. Concrete is made water repellent by the use of soap solution, calcium and petroleum oil etc.
2	Surface treatment	Joints in brickwork or stone work are pointed or the surface is plastered. Paints, oils, waxes and soap solution are used for surface treatment. The cement paints act as vertical DPC.
3	Membrane damp proofing	This is done by providing a layer of water repellent materials between the source of dampness and part of the structure adjacent to it.
a (i)	Treatment to external walls	Fig 2  DAMP PROOFING OF AN EXTERNAL WALL
(ii)	Treatment to internal walls	Fig 3  DPC FOR INTERNAL WALL

<table>
<tr><th>S.No</th><th>Method</th><th>Description</th><th>Figure</th></tr>
<tr><td>b</td><td>Treatment to foundations against gravitational water</td><td colspan="2">Fig 4


CAVITY WALL</td></tr>
<tr><td>c</td><td>Treatment to basements</td><td colspan="2">Fig 5


EXPANSION JOINT IN FLAT ROOF</td></tr>
<tr><td>d</td><td>Treatment to sloping ground</td><td colspan="2">Fig 6

</td></tr>
<tr><td>e</td><td>Treatment In pitched</td><td colspan="2">1 In pitched roofs , the rain water gutters may be constructed in cement concrete and standard rain water fittings may be used.

2 The gutters lined with bituminous materials.</td></tr>
<tr><td>4</td><td>Cavitywall construction</td><td>Cavity in between two walls prevents the moisture from reaching the inner wall Cavity wall prevent the entry of dampness</td><td>Fig 7

</td></tr>
</table>

S.No	Method	Description	Figure
5	Treatment to expansion and construction joints	The expansion joints and construction joints should be properly sealed by water proofing materials to obstruct the leakage of water.	Fig 8  EXPANSION JOINT IN FLAT ROOF
6	Guniting	Cement mortar consists of 1:3 is shot on the cleaned surface with the help of a cement gun, under a pressure of 2 to 3 kg/m2. Can be used over pipes, cisterns etc. for resisting water pressure	
7	Pressure grouting	Forcing cement grout, under pressure into cracks,voids,fissures etc. present in the structural components of the building or in the ground	

Water proofing treatment to flat roof

Flat roof must have to be provided with proper water proofing courses. Leakage of water through roof occur mainly due to stagnation of water at low area. To avoid this roof must have proper slope towards the outlets.

Following are the commonly adopted methods of water proofing treatments.

A Cement mortar plastering

1 The entire area of roof is cleaned with wire brush and all dirt is removed.

2 A neat cement wash is given to the surface and

3 20mm thick layer of cement mortar mixed with standard water proofing compound is laid and finished smooth.

B Tar felting

Hot bitumen is applied over the roof surface and tar felt is laid over it.

C Lime concrete terracing

1 It is most common in southern region of India.

2 They offer good resistance to solar radiation.

3 Lime concrete is made by mixing over burnt brick aggregate of size 25mm with lime mortar of 1:2mix.

4 First 10 cm thick lime concrete is laid, spread and rammed with wooden rammers.

5 Slope if required should be given in this layer.

6 Then entire surface is consolidated by beating.

D Lime concrete terracing with tiles

1 As explained above, proportion, method of laying, consolidation etc. is same.

2 At first a hot bitumen wash is given to the entire roof surface.

3 Then a layer of fine sand is spread immediately, when the bitumen is still hot.

4 Over this 10 cm thick lime concrete is spread and rammed with light rollers to get even thickness or the required slope.

5 Ramming is continued till 10 cm laid thickness will come down to 8 cm.

6 When lime concrete layer is still green, two courses of flat brick tiles are laid in cement mortar 1:3.

E Mud pushka terracing with tile paving

1 At first a layer of hot bitumen is spread over the entire roof surface.

2 The prepared mud pakka earth is spread to a thickness of 10 cm. and compacted to till the thickness reaches to 8cm.

3 Over this 25mm thick layer of mud mortar is laid and allowed to dry.

4 After drying up, a coat of gobi leaping is given.

5 Over this a layer of flat brick tiles is laid in mud mortar, and allowed to dry.

6 Joints are pointed with cement mortar 1:3.

7 Entire roof surface is covered with wet gunny bags.

8 After 12 hours brick terracing is cured by sprinkling of water.

Water proofing treatment for pitched roof

Usually the pitched roof has self draining property. The over laps should be as specified and size of gutters should be designed taking into consideration the average rainfall. The common methods adopted for water proofing are:

a Covering the entire roof surface with tar felt

b Covering the entire roof surface by lime mortar of proportion 1:1:2 (lime putty: surkhi: coarse sand)

Termite proofing

Objectives: At the end of this lesson you shall be able to
- **define the term termite proofing**
- **state the types of termites**
- **explain the methods of anti termite treatment.**

Introduction

The removal of termites from a building is not an easy task. The termites live in a colony and they are very fast in eating wood and other cellulosic materials as food. They damage materials of organic origin with cellulosic base, damage house hold articles like furniture, furnishings, clothing and stationary. Therefore it is necessary to adopt anti termite treatment in building.

Definition

The treatment which is given to a building to prevent or control the growth of termites is called termite proofing.

Types of termites

Termites
- Dry wood termites (Non sub terranean termites/wood nesting termites)
- Subterranean termites / Ground nesting termites

Methods of Anti-termite treatment

1 Preconstruction treatment

Here three operations involved.

a Site preparation :- Remove stumps, roots, logs, waste wood etc. Detect termite mounds and destruct these by using insecticide solution. Chemicals for preparing solution are DDT, BHC, Aldrin, Heptachlor, Chlordane.

Chemical	Concentration by weight
DDT	5%
BHC	0.5%
Aldrin	0.25%
Heptachlor	0.25%
Chlordane	0.5%

Four litres of the above emulsion in water is required per cubic metre of volume of mound.

b Soil treatment

The best method to protect the building to protect against termites is to apply a chemical treatment to the soil at the time of construction of the building. A complete chemical barrier is created.An insecticide solution consist of any one of the following chemicals in water solution.

Chemical	Concentration by weight
Aldrin	0.5%
Heptachlor	0.5%
Chlordane	1%

The emulsion should be applied evenly at the following stages.

Stage1-In foundation pits, to treat the bottom and sides upto a height of 30 cm.

Stage 2-Refill earth on both sides of the wall, for a width of 30cm and depth of 45cm approximately.

Stage 3-Before laying the floor ,entire levelled surface is to be treated at the rate of 5 litres of emulsion per square metre.

c Structural Barriers:- These are concrete layer of 5cm-7.5cm thick or Metal sheets (Copper or G.I Sheets 0.8mm thick)

Post construction treatment

It is a maintenance treatment. Open earth around building and treat it with chemicals. In wood work or masonry work, bore holes and inject chemicals.

Fire protection

Objectives : At the end of this lesson you shall be able to
- **define the term fire protection**
- **state the important considerations in fire protection**
- **explain the fire resistant construction.**

Introduction : Every building contains some materials which can either easily catch fire or which are impossible to fire..However, the architects and engineers should plan, design and construct the building in such a way that safety of the occupants may be ensured to the maximum possible extent.

Definition : It is defined as the protection of the occupants of the building, contents and structure of the building and adjacent buildings from the risks of fire and spread of fire.

Important considerations in fire protection

1 It should be the objective of every engineer and arch tect while planning and designing the building that the structure offer sufficient resistance against fire so as to afford protection to the occupants, use of fire-resisting materials and construction techniques and providing quick and safe means of escape in the building.

2 All the structural elements such as floors, walls, columns, beams etc should be made of fire resisting materials

3 The construction of structural elements such as walls, floors, columns, lintels, arches etc

should be made in such a way that they should continue to function atleast for the time, which may be sufficient for occupants to escape safely in times of fire.

4 The building should be so planned or oriented that the elements of construction or building components can with stand fire for a given time depending upon the size and use of building, to isolate various compartments so as to minimize the spread of fire suitable separation is necessary to prevent fire, gases, and smoke from spreading rapidly through corridors, staircases ,shafts etc.

5 Adequate means of escape are provided for occupants to leave the building quickly and safely in terms of out break of fire.

6 In multi-storeyed office buildings suitable equipment for detecting, extinguishing and warning of fire should be installed in the niches.

Fire-resistant construction : National building code classifies the construction into four classes, namely type 1, type 2, type 3 and type 4 on the basis of fire-resistance offered by building components for 4-hours, 3- hours, 2- hours and 1-hour respectively. To achieve the objective of fire-resistance, due considerations should be made in design and construction of the structural members and use of combustible material should be avoided as far as possible in the construction

a Walls and columns

b Floor and roofs

c Wall openings

d Building fire escape elements (i.e.,) stair, staircase, corridors, entrances etc.

A Walls and columns

1 The load-bearing non-load bearing walls should be plastered with fire resistive mortar.

2 Normally 20cm thick common wall is sufficient from fire resistance point of view.

3 Bricks should be preferred to stones if the construction is solid bearing wall.

4 For framed structures R.C.C. frames are preferred to those of steel frame.

5 Partition walls, should also be fire resistant materials.

6 Wooden partitions should be covered with metal lath and plaster.

7 Sufficient cover to R.C.C. members like beams or columns should be provided.

8 It has been recommended that a cover of atleast 5cm inside the main reinforcement of structural members, like columns, girders, trusses etc, 38mm for ordinary beam, long span slabs, arches etc, 25mm for partition walls, short spans should be provided.

9 Fire proofing treatments, which can possibly to concrete and steel column construction.

B Floors and roofs

1 The floors and roofs should be made of fire-resisting material as they act as horizontal barriers to spread of heat and fire in vertical direction.

2 The floor such as concrete jack arch floor with steel joists embedded in concrete or hollow tiled ribbed floor, R.C.C. floor etc should be used as shown in figure.

C Wall openings

1 The openings in the walls should be restricted to a minimum and they should be protected by suitable arrangements in case of fire.

2 Wireglass panels are preferred for windows.

3 Steel rolling shutters are becoming popular for door ways and window openings in garages, godowns, shops etc due to their ability in preventing the spread of fire

D Building fire escape element

1 Staircases, corridors, Lobbies, entrances etc are the fire escape elements should be constructed out of fire-resistant materials and be well separated from the rest of the building.

2 Doors to the staircase, corridors and lifts should be made of fireproofing materials.

3 Staircase should be created next to the outerwalls and should be accessible from any floor in the direction of flow towards the exits from the building.

General measures of fire safety in building

In important buildings, in addition to the fire-resisting materials and adopting fire resistant construction, the following general measures of fire-safety have been recommended

i Alarm system

ii Fire extinguishing arrangements

iii Escape routes for public buildings

Arches

Objectives : At the end of this lesson you shall be able to
- **define arch**
- **state the technical terms regarding the arch**
- **identify the components of arch**
- **classify the arches.**

Introduction

It is a geometrical shaped structure placed over an opening to transfer the load coming over it. It generally consist of small wedge shaped units which are joined together with mortar.

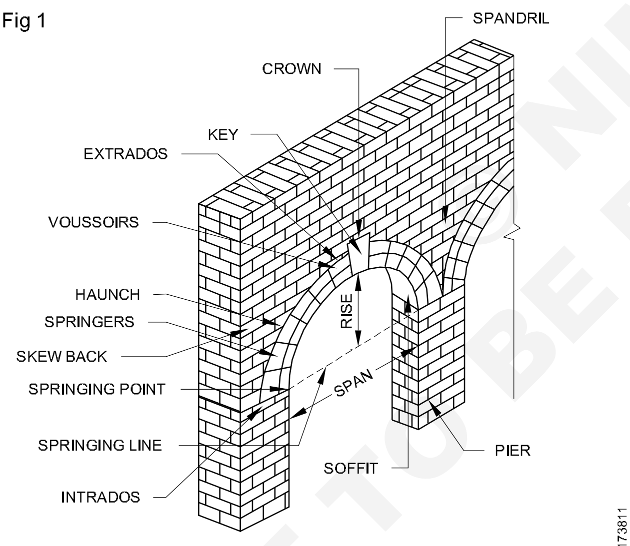
Arches made of steel and R.C.C is built in single units without the use of wedge shaped units and they are used for bridge construction.

Definition

An arch is a structure which is constructed to span across an opening.

Components of arch

Fig 1



COMPONENTS OF ARCH

Intrados : Inner curve of an arch.

Soffit : Inner surface of an arch.

Extrados : Outer curve of an arch

Voussoirs : Wedge shaped units of masonry

Crown : Highest part of extrados

Key : Wedge shaped unit fixed at the highest point of arch.

Spandril : Curved triangular space formed between extrados and the horizontal line through the crown.

Skew back : Inclined splayed surface on the abutment which is Prepared to receive the arch.

Springing point : Points from which the curve of the arch springs.

Springing line : It is an imaginary line joining the springing points.

Springers : The lowest voussoir immediately adjacent to the skewback.

Abutment : End support of an arch

Pier : An intermediate support of an arch

Arcade : Row of arches.

Haunch : Lower half of the arch.

Span : Clear horizontal distance between supports

Rise : Clear vertical distance between highest point on the intrados and the springing line.

Depth : Perpendicular distance between the intrados and extrados.

Thickness : Horizontal distance measured perpendicular to the front and back faces.

Classification of arches

Arches

According to shape	According to number of centers	According to materials used	According to workmanship
1. Flat arch	1. One centered arch	1. Brick arch	1. Rough arch
2. Segmental arch	2. Two centered arch	2. Stone arch	2. Rough cut
3. Semi-circular arch	3. Three centered arch	3. Concrete arch	3. Gauged arch
4. Bull's eye arch	4. Four centered arch	4. Purpose made	
5. Semi elliptical arch	5. Five centered arches		
6. Inverted arch			
7. Pointed arch			
8. Relieving arch			
9. Horse-shoe arch			
10.Stilted arch			
11.Venetian arch			
12.Florentine arch			
13.Ogee arch			
14.Tudor arch			
15.Drop arch.			

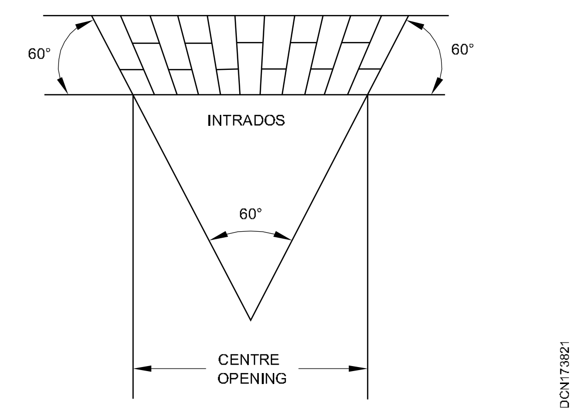
Arches according to shape

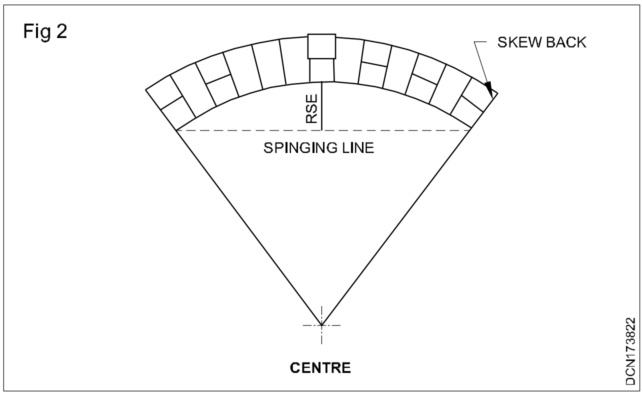
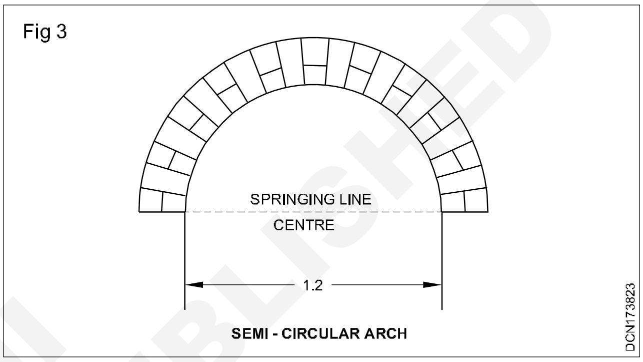
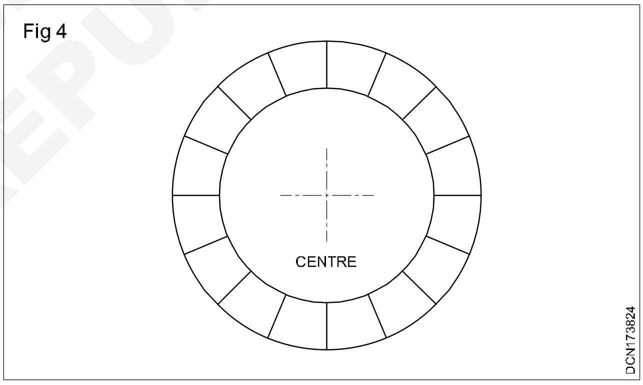
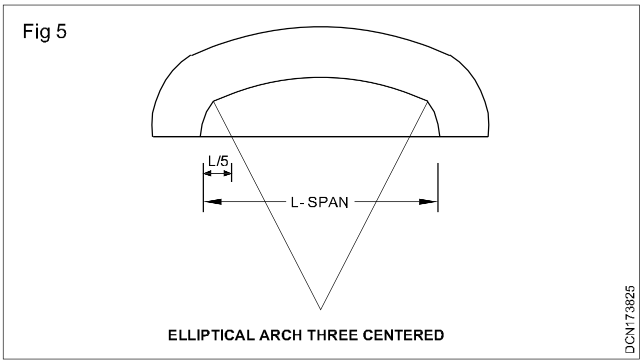
Objectives : At the end of this lesson you shall be able to
- **classify arches according to shape**
- **state the technical terms regarding the arch**
- **classify the arches.**

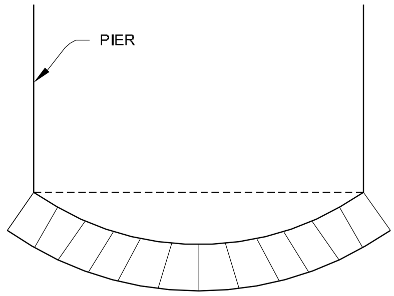
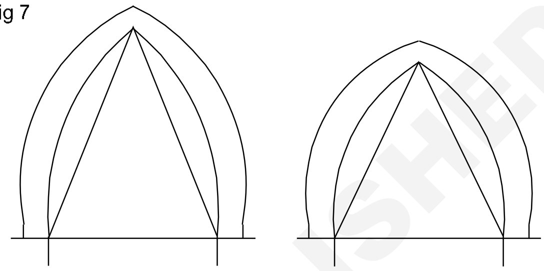
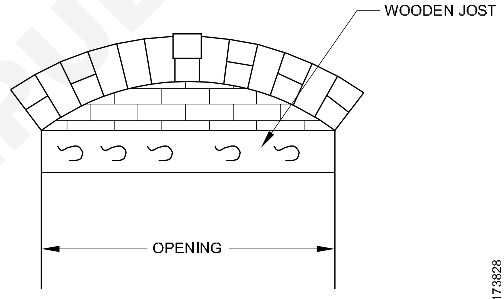
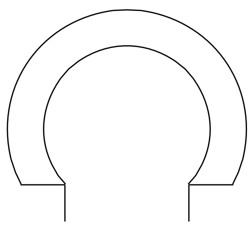
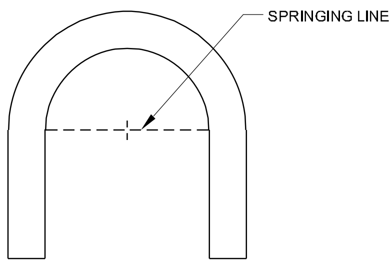
According to shape ,the arches are classified as follows.

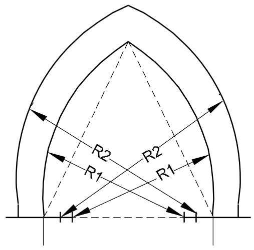
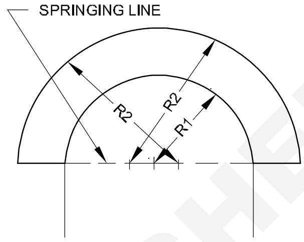
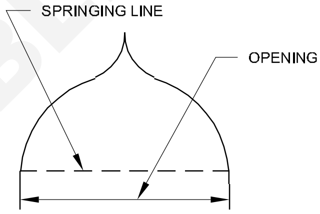
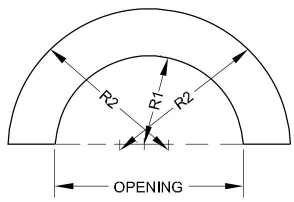
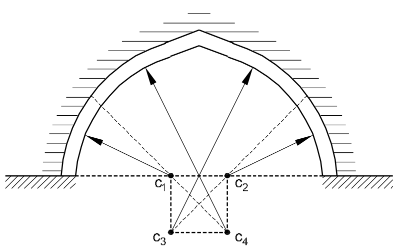
Classification of arches according to shapes

Classification of arches according to shapes

Name of arch	Features	Figure
1 Flat arch	• Shape flat and skewback forms 60 degree with horizontal. • Depth equal to course of masonry. • Slight rise of about 10mm to 15mm per metre length of masonry opening. • Max.span upto 1.5m • Used for light loading.	Fig 1 

Name of arch	Features	Figure
2 Segmental arch	• Centre of arch is below spring line. • Thrust transferred to the abutment in an inclined direction	
3 Semi-circular	• Centre of arch lies on the springing line • Skewback is horizontal. • Thrust transferred to the abutment in vertical direction.	
4 Bull's eye arch	• One centre only. • Used for circular windows	
5 Semi -elliptical	• More than one centre arch (Three or five)	

Name of arch	Features	Figure
6 Inverted arch	• Constructed between piers to increase the bearing power of soil. • Rise is 1/5 to 1/10 of span. • Built in ½ brick rings.	Fig 6  INVERTED ARCH
7 Pointed arch	• Two curves meeting at the apex of a triangle. Two types are • Equilateral arch and • Lancet or isosceles arch.	Fig 7  LANCET OR ISOSCELES ARCH EQUILATERAL ARCH
8 Relieving arch	• Constructed over a wooden joist or flat arch. • It relieves the joist or flat arch from carrying load.	Fig 8  RELIEVING ARCH
9 Horse shoe arch	• Adopted from architectural considerations. • Shape include more than a semicircle.	Fig 9  HORSE - SHOE ARCH
10.Stilted arch	• Semi circular portion attached at the top of two vertical por=tions. • Springing line passes through the top of vertical portions.	Fig 10  STILLED ARCH

Name of arch	Features	Figure
11 Venetian arch	• Depth at crown is more than that at the springing line. • Have four centres.	Fig 11  VENETIAN ARCH
12 Florentine arch	• Similar to venetian arch except that the intrados has a Semi circular shape.	Fig 12  FLORENTINE ARCH
13 Ogee arch	• Consist of three centres and with reverse (Ogee) curve.	Fig 13  OGEE ARCH
14 Drop arch	• Consist of two centres	Fig 14 
15 Tudor arch	• Consist of four centres. • This is a pointed arch of four centres.	Fig 15 

Arches according to number of centres

Objectives : At the end of this lesson you shall be able to
- **classify arches according to number of centers**
- **sketch the various arches with number of centers**
- **state the features of arches according to the number of centers.**

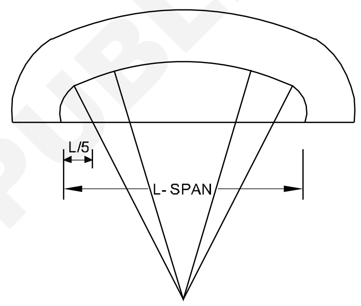
According to number of centers ,the arches are classified as follows

Classification of arches according to number of centres

Name of arch	Description	Example
1 one- centered arch	This type of arches have only one centre	Flat, Segmental, Circular, Horse shoe, Stilted, Etc.
2 Two- centered arch	This type of arches have two centers	Pointed arches ie, Equilateral pointed and isosceles pointed arch (Lancet and Drop).
3 Three-centered arch	This type of arches has three centers	Three centered semi-elliptical arch, Florentine arch, Ogee arch.
4 Four-centered arch	This type of arches has four centers	Venetian, Tudor.
5 Five-centered	This type of arches has five centers	Five centered semi elliptical arch.

We can make more types of arches with more number of centers.

Fig 1



FIVE CENTERED SEMI ELLIPTICAL ARCH

DCN173831

Arches according to material of construction & workmanship

Objectives : At the end of this lesson you shall be able to
- **classify arches according to material of construction & workmanship**
- **state the features of arches according to material of construction**
- **state the features of arches according to workmanship.**

ARCHES

- Stone arches
  1.Rubble arches
  2.Ashlar arches
- Brick arches
  1.Rough brick arches
  2.Axed or rough cut brick arch.
  3.Gauged brick arches and
  4.purpose made brick arches
- Concrete arches
  1.concrete block arches
  2. Monolithic arches

Classification of arches according to materials of construction

NAME	TYPE OF MATERIALS	DESCRIPTION
Stone arch	1 In ashlar masonry	• Constructed from wedge shaped units.
	2 In rubble masonry	• Stones should be laid with their natural bedding plane.
		• Weak and used for inferior work.
		• Span limited to 1m or so
Brick arch	1 With ordinary bricks	• Joints are made wedge shaped.
	2 With purpose made brick	• Not suitable for exposed brick work.
	3 With soft brick	• Good quality arch work.
		• Soft bricks are cut,sawn and rubbed to desired shape.
Concrete arch	1 With precast concrete blocks	• Similar to stone arches in ashlar masonry.
	2 Monolithic concrete	• Constructed from cast in -situ concrete and are suitable for long spans.

Classification of arch according to workmanship

Name	Description
1 Rough arch	• Using ordinary uncut bricks
	• Bricks are rectangular shape and mortar joints are wider at extrados than at the intrados.
	• Rough arch is used where appearance is secondary importance, the arch surface is plastered.
2 Axed or rough cut arch	• The bricks used are wedge shaped by means of an axe
	• The thickness of mortar joints varies 3 mm to 6 mm.
3 Gauged arch	• The bricks used are wedge shaped by means of a wire saw, the bricks are cut finely.
	• The mortar joints are 1.5mm to .75mm

Lintels with chajja

Objectives : At the end of this lesson you shall be able to
- **define lintel**
- **explain bearing of lintel**
- **list out the materials used lintel**
- **classify the lintel according to material of construction.**

Introduction

A lintel can be a load bearing building component placed over an opening. The function of lintel is just the same as that of an arch or a beam. However the lintels are easy and simple in construction. Lintels are made from various materials. The lintels of RCC are widely used to span the openings for doors, windows etc. in a structure.

Definition

A Lintel is a structural horizontal member which is placed across an opening to support the portion of the structure above it.

Bearing of lintel

Bearing of lintel means the distance up to which it is inserted in the supporting wall. Bearing should be the minimum of the following three considerations.

1 150 mm or

2 The height of lintel or

3 1/10th to 1/12th span.

Materials for lintels

The common materials used in the construction of the lintel are as follows.

1 Wood or timber

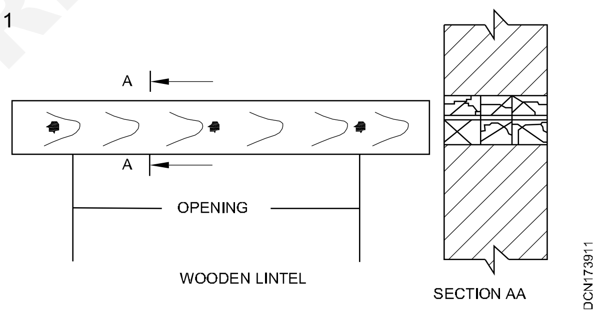
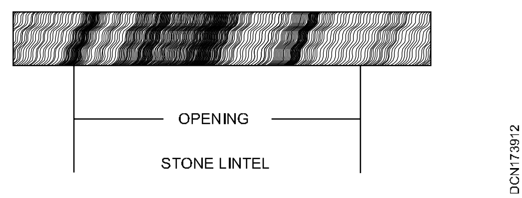
2 Stone

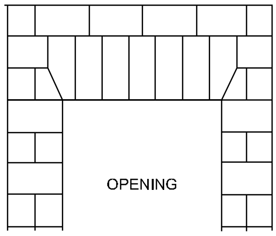
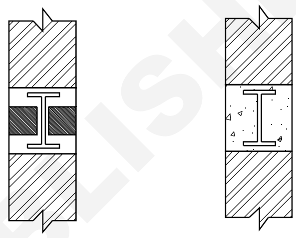
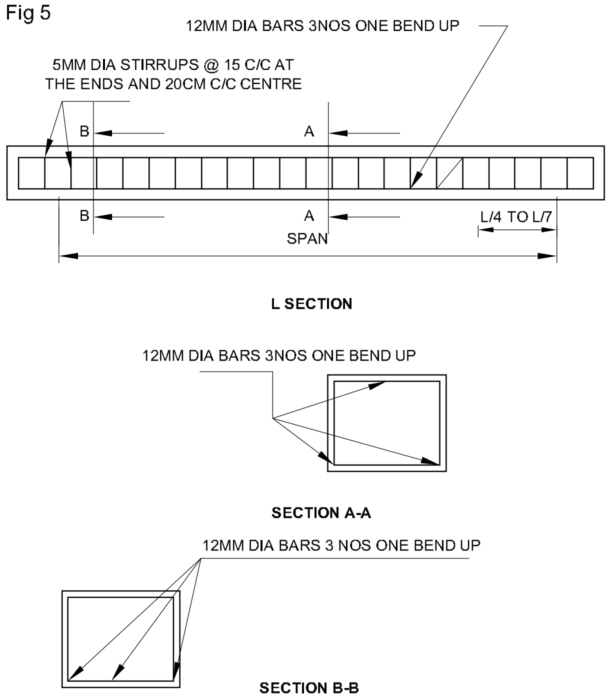
3 Brick

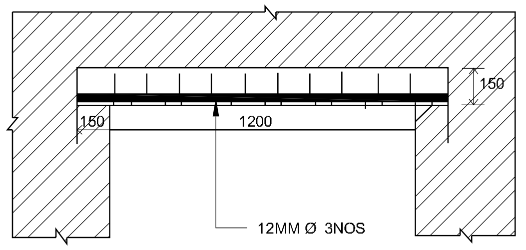
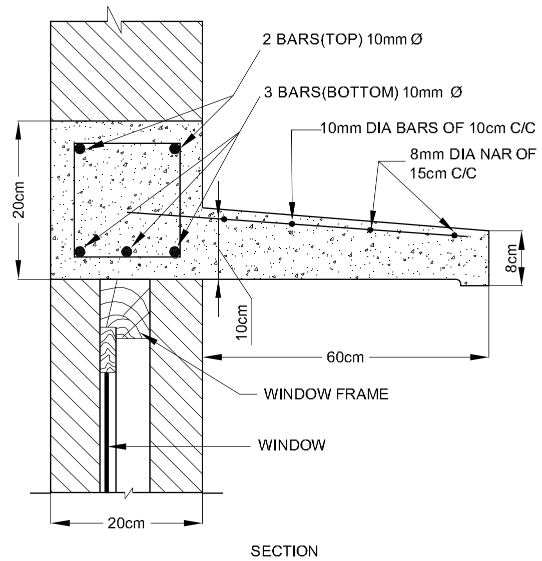
4 Steel

5 Reinforced cement concrete

Classification of lintels according to the material used

Name	Features	Figure
1 Wood or timber lintel.	A single piece of timber or built up sections of wood can be used as a lintel. • A bearing of about 15 cm to 20 cm should be provided. • The width of lintel should be equal to the opening • The depth of lintel should be about 1/12 to 1/8 of the span with a minimum value of 80 mm.	Fig 1 
2 Stone lintel	These lintels consists of slabs of stones which it placed across the openings. **Disadvantages of stone lintels** • Stone posses low tensile resistance. • It is difficult to obtain a good stone of required depth.	Fig 2 

Name	Features	Figure
3 Brick lintels	Brick lintels consist of bricks which are generally placed on edge. • bricks should be well burnt, copper coloured • free from cracks and with sharp and square edges. • this lintel have a depth equal to some multiple of brick courses. • Suitable up to a span of one metre and for greater spans reinforcement or steel angle may be provided.	Fig 3 
4 Steel lintels	• steel lintels consist of steel angles or rolled steel joists. Steel angles are used for small spans and light loading. • Rolled steel joists are used for large spans and heavy loading. • Tube separator-may be provided to keep the joists in position. • R.S.J - The joists are embedded in concrete to protect steel from corrosion and fire.	Fig 4 
5 Reinforced cement concrete	These lintels consists of reinforced cement concrete. The usual mix for concrete R.C.C lintel is 1:2:4 lintels lintels Properties of R.C.C lintels. • fire proof • durable • strong • economical • easy to construct • no relieving arches are necessary. The reinforcement provided depends on 1 span of lintel 2 width of opening 3 total load to be supported	Fig 5 
a Precast RCC	• Economical, Increase speed of construction • Allow sufficient time for curing before fixing.	

Name	Features	Figure
b Cast in situ RCC Lintel	• Centering is prepared reinforcement is placed and concreting is done.	
6 Reinforced Brick lintel	Brick lintel strengthened by the provision of mild steel. In this use first class bricks with high compressive strength. Dense cement mortar is used to embed the reinforcement. It is adopted or used in the following circumstances. • Brickwork has to bear tensile and shear stress • To increase the longitudinal bond • Brickwork supported on large settlement soil. • Brickwork is supported to act as a beam or lintel over opening • When brickwork is to resist lateral loads as in retaining walls • To carry heavy compressive load • In seismic areas	Fig 6  REINFORCED BRICK LINTEL DCN173916
7 R.C.C. lintel with chajja or canopy	• The number of main bars depends upon the load to be carried from the wall above and span of opening. • The diameter of the bar varies with the span and is adopted as follow • 6 mm ϕ bar span upto 1 m • 8 mm ϕ bar span 1 to 1.5m • 10 mm ϕ bar span 1.5 to 2 m • 12 mm ϕ bar span 2 to 3 m • The details of chajja projection or canopy is shown in Fig 7	Fig 7  R.C.C LINTEL WITH CHAJJCH (OR) SUNSHADE DCN173917

Introduction - History and principles of chain survey and instrument & employed

Objectives : At the end of this lesson you shall be able to
- **define surveying**
- **explain the classification of surveying**
- **narrate different methods of measurements**
- **express the instruments used for chain surveying.**

Introduction

Planning and design of all Civil Engineering project such as alignment of road, canal, railway, water supplies, sanitation etc. of any magnitude is constructed along the lines and points established by surveying. Surveying is a basic requirement for all Civil Engineering projects.

Surveying details are used in transportations, communications, nation security, policy making environmental regulations, mapping, and the definition of legal boundaries for land ownership.

Definition

Surveying is the art of making linear or angular measurements in horizontal plane or vertical plane to determine the relative positions of points on the surface of the earth or beneath the surface of the earth.

Ancient Surveying

Evidence shows that basic surveying techniques used in 1400 BC in ancient Egypt. There is a representation of land measurement on the wall of a tomb at Thebes (1400 BC) men measuring a grain field. They used marked rope and wooden rods for measuring distance. The Romans recognized land survey as a profession. They used some standard tools for basic measurement.

Modern Surveying

Modern surveying starts with the introduction of more refined standard tools including instrument for measuring direction. Triangulation and resection method were introduced. The Great Trigonometric Survey of India began in 1801. The Indian survey had an enormous scientific impact. It was responsible for one of the first accurate measurements of a section of an arc of longitude. It named and mapped Mount Everest. Surveyors laid out canals, road and rail playing a pivotal role in Industrial Revolution.

Theodolite total station and GPS survey are the commonly used surveying instrument in 21st century. Aerial surveying techniques, remote sensing and satellite survey improved and become cheaper. New technologies like three-dimensional (3D) scanning and Lidar are gathering momentum in land surveying.

Some specific use of surveying

- Survey output is used for determining area, volume.
- Survey involves surveying existing conditions of the work site.
- Stake out building corners and grids.
- Stake limit of work.
- Stake out reference points.
- Marking floor levels.
- Verify the location of structures during construction.
- Verify that the work authorized was completed to the specifications set on plans
- Provide horizontal control on multiple floor

Other principal works in which surveying is primarily utilized are

- To fix the national and state boundaries.
- To chart coastlines, navigable streams and lakes.
- To establish control points and
- To prepare topographic map of land surface of the earth.

Surveyor: A person performing operation to obtain the requirement measurements, distance, directions, etc. to prepare plan or map is known as surveyor.

Duty of a Surveyor

A surveyor plays a pivotal role in any engineering project. A surveyor should possess all leadership quality, should be punctual and responsible, know time and resource management techniques

A surveyor should also have engineering thinking capabilities and decision making capabilities.

A surveyor's duty can be mainly classified into three

1 Care and adjustment of instrument

2 Field work

3 Office work

Surveying

Levelling: Levelling is the branch of surveying which deals with the measurements of relative height or depth of different point on the surface of the earth is known as levelling.

Object of surveying: The main object of surveying is the preparation of plan or map of an area. In olden days the surveyors were performed only for the purpose of reaching the boundaries of plot. But due to the advancement in technology the science of surveying has also attaining its due importance. The layout of alignment of road, railway, canal, tunnel, transmission power lines, microwave or television, relaying towers and water supplies or sanitary scheme etc. are requirement a very accurate map i.e. the success of these engineering project is based upon the accurate and complete survey work. Therefore, an engineer must be thoroughly familiar with the principle and different method of surveying and mapping.

Plan: A plan is a graphical representation of features on the earth surface or below the earth surface on horizontal plane in a largest scale compared to map (i.e. a smaller area surveyed)

Map: A map is a graphical representation of features on the earth surface or below the earth surface as projected on a horizontal plane in a smaller scale compare to plan (i.e. larger area surveyed)

Classification of surveying

Classification based on the accuracy surveying

The Surveying may be divided into two

1 Plane surveying

2 Geodetic surveying

1 Plane surveying

The surveying in which the earth surface is assumed as plane and the corrective of the earth is original is known as plane surveying. As the plane surveying extends only small area the lines connecting any two points on the surface of the earth are treated as straight line and the angles between these lines are taken as plane angles. Survey is covering area 200 sq.km may be treated as plane surveying. This is because of difference in length between the arc and its subtended chord on the surface of the earth for a distance of 18.2 sq.km only 10cm.

2 Geodetic surveying

The survey which the corrective of the earth surface is taken into account and a higher degree of precision is exercised in linear and angular measurements is termed as geodetic surveying. Such survey extended over the longer area. A line connecting two points is regarded as an arc and the angles between the intersecting line are spherical angles.

Classification based upon the nature of the field of surveying

1 Land surveying

2 Marine or navigation or hydrographical surveying

3 Astronomical surveying

1 Land surveying

It consists of re-running old land line to measure to determine the length and direction. Sub-dividing land into pre-determined shape and size and calculating the areas and survey stories and locating position. Land survey can be sub-divided into following:

a **Topographical survey:** It is for the determined by the natural as well as artificial features of a country such as hills, valleys, rivers, lakes, woods, railways, canals, building, town, village etc.

b **Cadastral survey:** The survey in which area generally plotted to a larger scale than the topographic survey and are carried out for fixing the property land preparation of revenue maps of states are called cadastral survey. These are also sometimes used for fixing boundaries of municipality corporation or candonment.

c **City survey:** The survey which are carried out for the construction of road, water supplying system, sewer for any developing townships are called city survey.

d **Engineering survey:** For determining quantities and for collecting datas for design of engineering work such as road, railway, reservoir or works in connection with water supplies, sewage etc. engineering survey may be further divided into three.

I **Reconnaissance survey:** For determine the feasibility and rough cost of the scheme.

II **Preliminary survey:** For collecting more precious datas and choose the best location of the work and to estimate the quantities and cost.

III **Location survey:** For setting out the work on the ground.

2 Marine or navigation or hydrographic survey

The Survey which deals with the mapping of large water body for the purpose of navigation construction of harbour work, prediction of tide and determination of sea level are called marine or navigation or hydrographical survey.

3 Astronomical survey

The survey which carried out for determining absolute location of different places on the earth surface and directions of any lines by making observation to heavenly bodies, i.e. star and sun are called astronomical survey.

Classification based upon the object surface of survey

1 **Archeological survey:** For determining unearthing relics of antiquities

2 **Geological survey**: For determining different stratus of earth crust.

3 **Mine survey:** For exploring mineral wealth such as gold, coal, copper etc.

4 **Military survey:** For determining points of strategic importance of both offensive and defensive.

Classification of based upon the method employed in the survey

1 Triangulation survey

2 Traverse survey

Classification of based upon the instrument used

1 Chain survey

2 Compass survey

3 Plane table survey

4 Theodolite survey

5 Tacheometric survey

6 Photographic survey

7 Aerial survey

Principles of survey

The two fundamental principles upon the various survey methods based are

Units of measurements

Metric	British
10mm = 1cm	12 inches = 1 foot
10 cm = 1dm	3 feet = 1 yard
10dm = 1m	51/2 yard = 1 rod, pole, perch
1000m = 1km	4 pole = 1 chain
10m = 1 decum	10 chain = 1 furlong
1 million = 1 mega metric	8 furlung = 1 mile, 100 links = 1 chain
1852m = 1 nautical	6 feet = 1 fathoms
1 hectometre = 1000 cm^2	120 fathoms = 1 cable length
	6080feet = 1 nautical mile
	1 engineer chain = 100 feet

Basic unit of area

Metric	British
100 sq.mm. = $1cm^2$	144 $inch^2$ = 1 $foot^2$
$100cm^2$ = $1dm^2$	9sq.feet = 1sq. yard
$100dm^2$ = $1m^2$	30 1/4 sq.yard = 1sq. rod, 1 sq. pole.
$100m^2$ = 1 acre	40sq.rod = 1sq.rod
100 acre = 1 hectare	$144inch^2$ 4 rods = 1 acre
100 hectares = $1km^2$	640 acre = 1sq. miles
1 cent = $40.47m^2$	484 sq. yard = 1sq. chain
100 cent = 1 acre	100sq.chain = 1acre

1 To work from whole to part

The main principle of survey plain or geodetic survey is work from the whole to part.sufficient number of primary control point are established with higher precision and then around the area to be surveyed. Minor control points in between the primary control points are then established with less precise method, i.e. in general practice the area is divided into a number of large triangles and the position of their various of surveyed with greater accuracy by using sophisticated instrument.

These triangles are further divided into smaller triangles and their vertices are surveyed with lesser accuracy by using these smaller triangles. The more interior details are collected.

The main idea of working from whole to the part is prevented accumulation of errors and to localize minor error within the frame works of control points on the other hand smaller error are magnified.

2 To fix the position of new station by at least two independent points.

The new station is fixed from points already fixed by

a Linear measurement

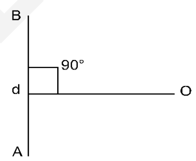
b Angular measurement

c Both linear and angular measurement

According to the convenient methods locating convenient points.

Rectangular Co-ordinate (Fig 1) : By perpendicular distance dD and distance Ad or by the distance Bd.

Fig 1

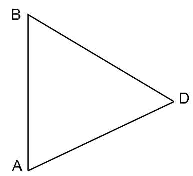


RECTANGULAR CO-ORDINATE

DCN214111

Trilateration (Fig 2) : By two distance AD, BD. This method is chain surveying

Fig 2

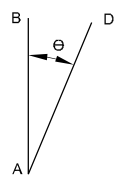


TRILATERATION

DCN214112

Polar co-ordinates (Fig 3 & 4) : By the angle ∠ BAD measured at distance AD by the according to the condition.

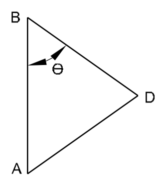
Fig 3



POLAR COORDINATES

DCN214113

Fig 4



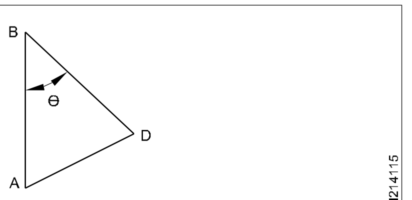
POLAR COORDINATES

DCN214114

By the ∠ BAD measured at B and distance AD or by the DAB measured at A and distance BD. This method is used when it is not possible to measure the distance to the point from the point of reference at which the angle is measured.

Triangulation (Fig 5) : By two angle BAD and ABD measured at A and B. This method is used in traverse survey

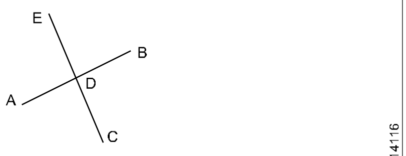
Fig 5



TRIANGULATION

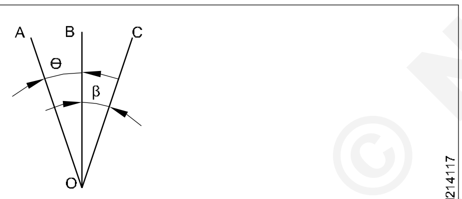
Intersection (Fig 6 & 7) : By the intersection of two straight line (AB and CE) between four known points A,B,C and E

Fig 6



INTERSECTION

Fig 7



INTERSECTION

By the two angles ADB and BDC measured at the point "D" to be located with respect to three known points reference and AB and CE

Linear measurement: Horizontal and vertical distance.

Angular measurement: Horizontal and vertical angles.

Measurements of distances: There are two main methods of determine measurements of distances.

1 Direct Method

The distance is measured on the ground by means of chain or tape or any other instrument.

2 Computation Method

There the distances are obtained by calculation tachometry, or triangulations.

Direct measurements

Several methods are available for measuring distance according to the degree of accuracy and speed of the work.

1 **Pacing:** Where approximate results are required distance may be determined by pacing. The method consisting working over a line and counting the number of paces knowing the average length pace (which may be taken as 80 cm) the required distance may be obtained multiplying the no. of pace by the average length of pace.

2 **Passo meters:** The monotony and strain of accounting paces may be obtained by the use of an instrument called paso meter. It is a pocket instrument resembling a watch in size and appearance and automatically records the number of paces taking pacing in a given distance and calculate the distance as in pacing method.

3 **Pedo meter:** It is a similar instrument and is used for measuring distance. It registers the distance traversed by the person carrying in it instead of number of pacing. We can adjust the length of one pace is according to the site condition and person carry it.

4 **Odo Meter:** The distance may be approximately by means of a simple device is called as odometer.It can be attached to the wheel of any vehicle such as carriers of bicycle, etc and register the no. of revolution of wheel knowing the circumference of wheel.

5 **Speedo Meter**: The Speedo meter is an automobile may be used to measure distance approximately. It gives better result than pacing provided the rout is smooth.

6 **Perambulator**: Another method of rapid determination of distance is by an instrument is called perambulator. It resembles simple bicycle wheel provided with a fork and hand it is wheeled along the line whose length is decided. The distance traverse automatically registered by the dial.

7 **Judging distance**: It is a very rough method of obtaining distance. It is used in estimating distance of details in reconnaissance survey.

8 **Time measurement:** The distance is roughly determined by line intervals of trend knowing the average time per km by a person at the walk or horse. The distance travel may be readily obtained.

9 **Chaining:** Of the various method of measuring distance the most accurate and common method is the measuring distance with chain or tape is called chaining.

Instrument used for Chaining

1 **Chain:** Chain is composed of piece of galvanised mild steel wire 4mm diameter (8 swg) called links. The end of each links are bent into a loop and connected together by means of 3 oval rings, which offers flexibility to the chain. The end of the chain is provided with brass handles for dragging and stretching chain on the ground. Each with swivel joints so that the chain can be turned around without twisting. The length of a link is the distance between the centres of the two connective needle rings. The end link includes the handles, indicators (Talley) or distinctive pattern are fixed at distinctive point on the chain to facilitate quick

readings of fractions of chain is in surveying measurement.

Chain composed of links	Steel band or band chain
1 It can with stand rough treatment.	If carelessly used it gets broken.
2 It can be easily reparied with the hammer in the field.	It can be repaired only by soldering or riveting
3 It can be read easily.	It cannot be read so easily.
4 It is heavier and sags considerably when suspended.	It is lighter and doesn't sags to extent to which chain sags.
5 It is liable to easily increase or decrease in length due to continuous use and bending of links respectively.	It maintain length very much better than the chain.
6 It is heavier and takes more time to spread.	For the same length it is lighter than chains and easier to open.

The following chains are used in different countries according to the unit of linear measurement. It is classified into two namely.

I Metric and

II Non- Metric chain

i **Metric chain:** These chain is made in length of 20 m and 30 m. The length of one link is 20 cm.

ii **Non-metric chain**

a **Gunder's chain:** A gunter's chains is 66 feet long and is divided into 100 links each 0.66 feet long. It is very convenient for measuring in distances in miles and furlongs and area in acres.

b **Revenue chain:** The revenue chin is commonly used for measuring fields in cadastral survey. It is 33 ft. long and divided in to 16 links each 2 1/16 feet long.

c **Engineers chain:**The engineers chain is 100ft. long and is divided into 100 links each one foot in length.

2 **Steel band**

It is also called the band chain consist of a ribbon of steel with brass swivel handles at each end. It is 20 or 30m long. The graduation is marked in two ways.

1 The band is divided by studs at every 20cm and numbered at every one metre. The first steel and last link sub - divided into cm and mm.

2 The graduation is etched as metre, decimetre, centimetre on one side and point 2 metre links all the other. Brass tallies are fixed at every 5m length. It is used for accurate survey work.

The following are the point on comparison between the chain composed of link and band chain.

Tape

It is an instrument used for marking linear measurements where the length is to be measured accurately. It is also used for marking offsets distance different object from the chain line. The tapes are generally classified according to the material from which they are manufactured.

1 **Linen or cloth tape:** It is made out of linen or cloth with brass handles at zero end and whose length is included in the tape length. This tapes are availble in different lengths such as 10, 20 and 30m. This tapes are light and handy and cannot with stand much wear and tear. Its length gets elongated when stretched and shortens by sagging in a windy weather. This tape cannot be used for accurate work.

2 **Metallic tape:** The linen tape when reinforced with fine brass or copper wires to prevent stretching or switching of fibres is known as metallic tape. These wires are interwoven into the varnished strips and are not visible to the naked eye. This tapes are available in different length such as 2m, 5m, 10,15,20, 30m. Each metre length is divided into 10 equal parts (decimetres) and each part divided into 10 parts (centimetre) and it is commonly used for taking offset chain surveying.

3 **Metric steel tape**: The denomination of the tapes measures is 1,2,10,30 and 50m. The tape is of steel or stainless steel. The outer end of the tape is provided with a long ring. The length of the tape included the metal ring provided. The tapes are marked legibly on one side only with a line every 50 mm and at every cm. dm and m. The first decimetre having the marked. Every decimeter and metre shall be marked with Hindu, Arabic, numerals with bold type. In metre division in addition bears the designation 'm'. Every centimeter in the first decimeter shall be marked with Hindu Arabic numerals. The end of tape measure of denomination 10,30 and 50 m is marked with the words metre.

4 **Invar Tape:** For work of the highest precision the invar type is generally used as in measurement of base line to triangulation and in the city work. It is made up of an alloy of steel and nickel (36%) and the co-efficient of thermal expansion is 0.000000122 for PC. It is six mm wide and may be obtained in the length 30, 50 and 100 m. It is very expensive and extremely delicate and must be handled with greatest care to avoid bending and kinking. It cannot be used for ordinary work.

Instrument used for marking station

1 **Pegs :** Wooden pegs are used to mark the position of station. They are made up of hard timber and are tapered at one end. They are usually 25 cm square and 15 cm long. But in soft ground pages 40 to 60 cm long and 4-5 cm square are suitable. They should firmly driven in the ground with steel hammer with about 4 cm projecting above the surface of the ground, instead of wooden pegs 10mm diameter steel rods are used.

2 **Ranging Rod :** The ranging rods are used to marking the position for station for ranging the lines. They are made up of well –seasoned straight grained timber of teak. Blue pine or deodar. They are circular or octagonal in cross sectional on 3cm, nominal diameter and show cross shoe 15 cm long the lower end. They are made up of two sizes namely one of 2 cm and the other of 3 cm and are divided into equal pairs, each 0.2 m long. In order to make them visible at a distance they are painted alternatively black or white and red and white or red, white and black successively. When they are at a considerable distance red and white or white and yellow flag about 25 cm square should be fastened at the top.

3 **Ranging poles :** The ranging poles are similar to the ranging rods. But are of heavier section. They vary in length from 4-10 cm or more and are used in the case of very long line.

Chain Surveying

Land Surveying: Land surveys are made for one or more of the following purposes:

I To secure data for exact description of the boundaries of a piece of land (or tract).

II To determine its area.

III To secure the necessary data for making a plan.

IV To re-establish the boundaries of a piece of a land which has been previously surveyed, and

V To divide a piece of land into a number of units.

There are two general methods of land surveying

1 Triangulation and

2 Traversing

1 Triangulation Survey: Triangulation is the basis of trigonometrical or geodetical surveys. The term triangulation when used without qualification, denotes a system of surveying in which the sides of the various triangles are computed from

i a single line measured directly, called the base line, and

ii the three angles of each triangle measured accurately with a theodolite.

Chain triangulation or chain surveying: It is the system of surveying in which the sides of the various triangles are measured directly in the field and no angular measurements are taken. The simplest kind of surveying is the chain surveying. It is most suitable when.

I The ground is fairly level and open with simple details.

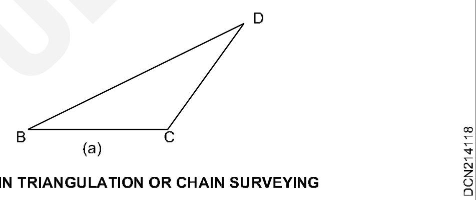
II Plans are required on a large scale such as those of estates, fields, etc.

III The area is a small in extent.

It is unsuitable for large areas, and areas crowded with many details or difficult or wooded country. The principle of a chain survey is triangulation. It consists of the arrangement of framework of triangles since a triangle is the only simple plane figure, which can be plotted from the lengths of its sides alone. The exact arrangement of triangles to be adopted depends upon the shape and configuration of the ground, and the natural obstacles met with. If a point is located by the intersection of two arcs, its displacement due to errors in the radii is a minimum if the arcs intersect at 90°.The three sides of a triangle being equally liable to error, each of the three angles of a triangle should be nearly 60°. i.e. the triangle should be equilateral. An equilateral triangle can therefore, be more accurately plotted than an obtuse-angled triangle. Hence the best shaped triangle is equilateral and it is desirable to approximate to this form in order that distortion due to errors in measurement and plotting should be minimum.

The framework should, therefore, consist of triangles which are as nearly equilateral as possible, such triangles being known as well conditioned, or well-shaped. A triangle is said to be well conditioned or well-proportioned when it contains no angle smaller than 30° and no angle greater than 120°. Ill - conditioned triangles (Fig 8) having angles less than 30° or greater than 120° should always be avoided. If however, they are unavoidable, great care must be taken in changing and plotting.

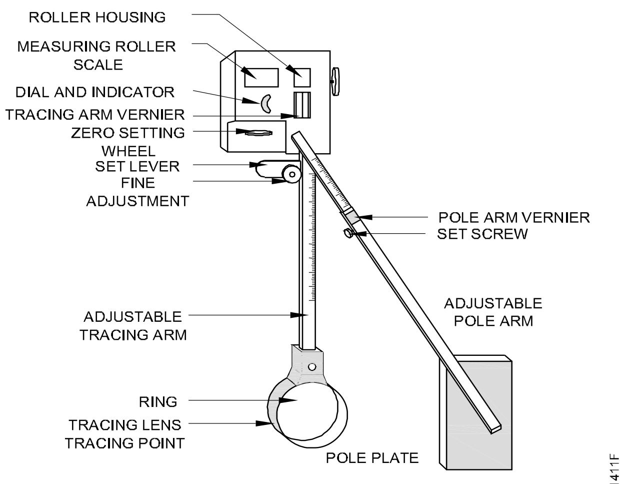
Fig 8



CHAIN TRIANGULATION OR CHAIN SURVEYING

Planimeter (Fig 9)

Fig 9



PLANIMETER

The planimeter is simple instrument for the precise measurement of areas of plane figures of any shape. To measure an area, it is only necessary to trace the outline of the figure in a clockwise direction with the centre point (with in the ring) of the tracing lens and to read off the result on the scales.

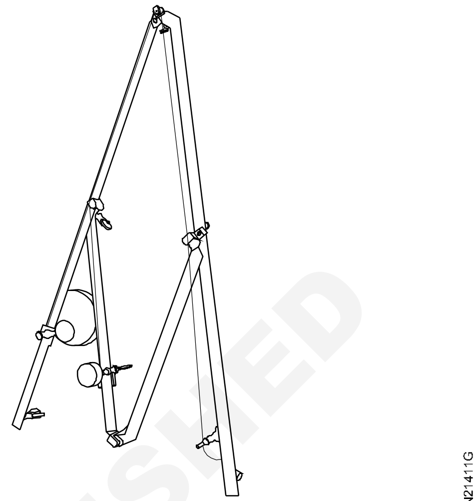
The Planimeter consists of 3 separate parts; the tracing arm to which is attached the roller housing the pole arm and the pole plate. The three parts are packed separately in the case. The pole arm is a simple beam. On each end is fixed a ball, one for fitting into the roller housing, the other into the pole plate. The roller housing rests on three supports; the tracing lens, the measuring roller and a supporting ball.

Pantagraph (Fig 10)

The pantagraph, an apparatus for making enlarged or reduced drawings, first appeared in the early seventeenth century, its invention credited to the Jesuit mathematician and astronomer Christoph Scheiner (1575 -1650). The CCA (Canadian Centre for Architecture) version, shown here, was manufactured in England in the early nineteenth century. It is part of a collection of some 40 individual and sets of drawing instruments and aids of the CCA.

The lacquered brass instrument is engraved with the maker's name and with standard ratios and scales to assist in its functioning. The pantagraph includes a brass disc fitted with sharp points on its underside to hold the tool firmly to the drafting table, a stylus with which to trace an existing drawing, and a pencil holder that also accommodates a cup to hold a lead weight. Ivory wheels permit the instrument to move smoothly. A fitted mahogany case, lined with felt, protected the instrument within the office and during transport.

Fig 10



PENTAGRAPH

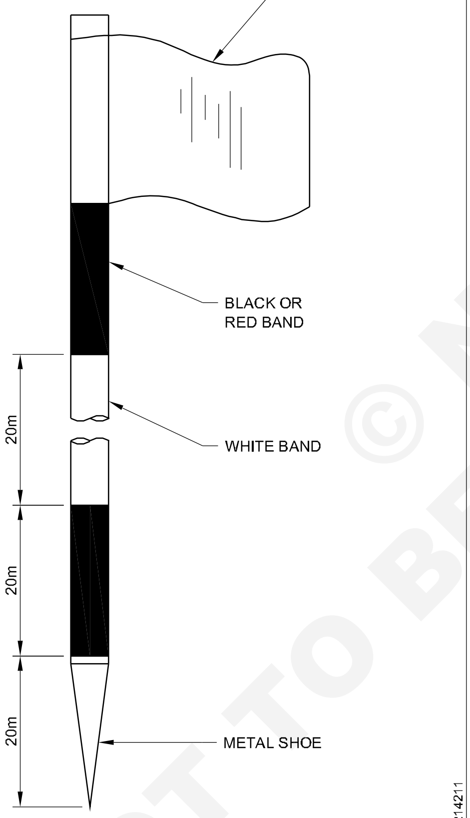
Introduction about chain survey instruments

Objectives : At the end of this lesson you shall be able to
- **state the construction and uses of the following chain survey instruments.**

- Ranging Rod
- Offset Rod
- Arrows
- Wooden Peg
- Plumb bob
- Measuring Tapes

Ranging Rod (Fig 1)

Fig 1

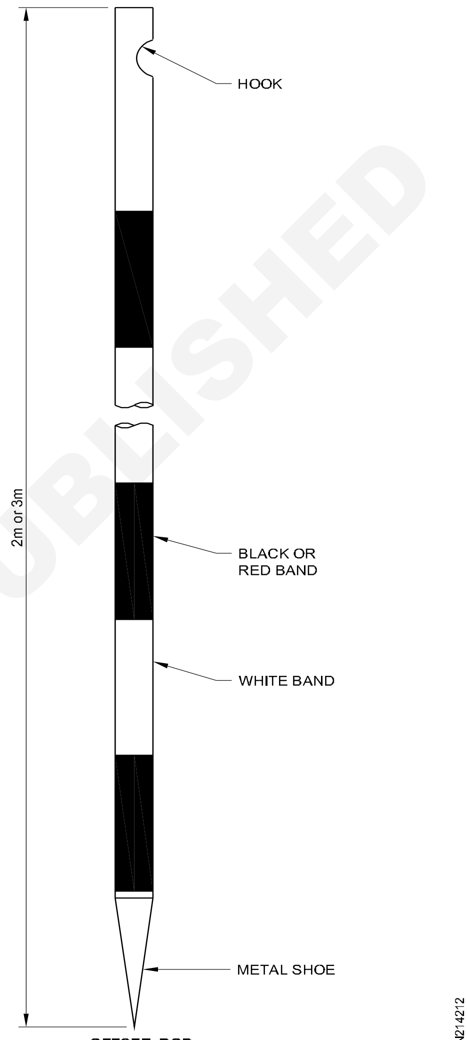


RANGING ROD

- It is wooden/steel pipe of 2m or 3 m in length with 3 cm in diameter.
- It is painted in red and white or black and white in 20 cm band width.
- Bottom of rod is fixed with a sharp metal shoe for fixing on ground
- Flag is fixed on the top for visibility when it is more than 200m in distance.
- It is used for making the position of station in chaining.
- If is also used for fixing intermediate points in ranging.

Offset rod (Fig 2)

Fig 2



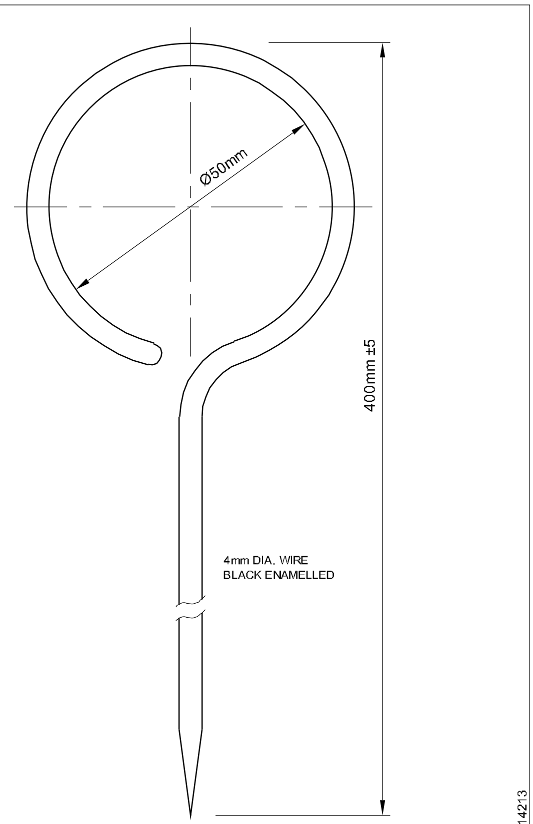
OFFSET ROD

- It is similar to the ranging rod with a hook at the top.
- It is used for pulling or pushing the chain through hedges and other obstruction.
- It is also used for aligning offset line and measuring short offset.

Arrows

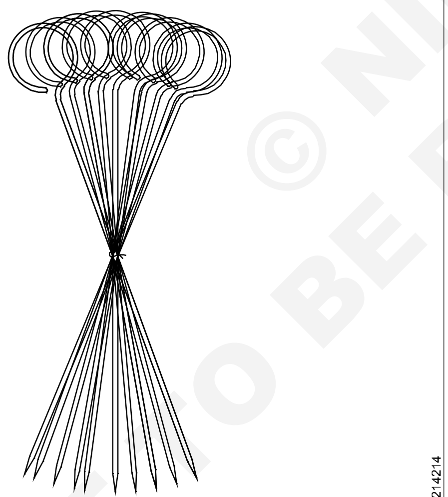
- It is made up of 4mm steel wire and 40cm long as shown in Fig 3. It is pointed at one end for inserting into the ground. Another end bent into a ring for easy handling. Each metric chain shall accompanied with 10 arrows as shown in Fig 4.
- It is used to make the ends of each chain during the process of chaining.

Fig 3



ARROW

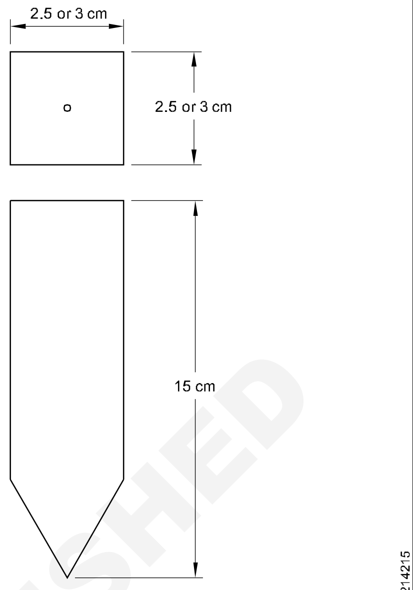
Fig 4



ARROWS

Wooden peg (Fig 5) : These are 15cm in length and tapered at one end. It is used to drive on the ground to mark the position of stations.

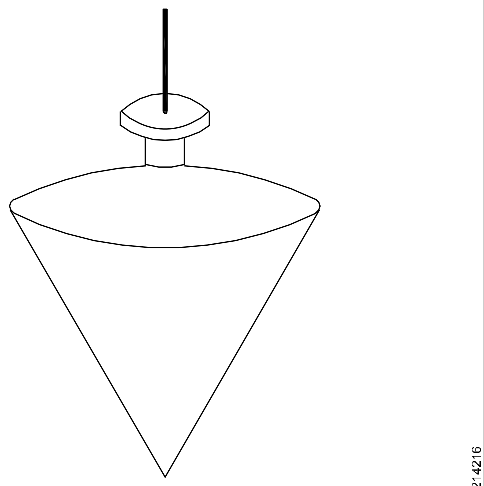
Fig 5



WOODEN PEG

Plumb bob (Fig 6) : While chaining along a sloping ground, it is used to transfer the points on the ground. It is also used as a centering aid in Theodolite, compass and plane table.

Fig 6



PLUMB BOB

Testing of metric chain (20m/30m)

Objectives : At the end of this lesson you shall be able to
- **state the necessity of checking the chain**
- **state the methods of testing**
- **list out the errors in the chain**
- **state the limits of error in chain**
- **explain the adjust the chain**
- **state Indian optical square.**

Necessity of checking the chain : The length of chain changes due to wear and tear, mud sticking and change in temperature.

The length of chain increases due to

– Stretching of links and joints.

– Opening out of the rings.

– Wear of wearing surfaces.

– Rough handling in pulling it through hedges and fences.

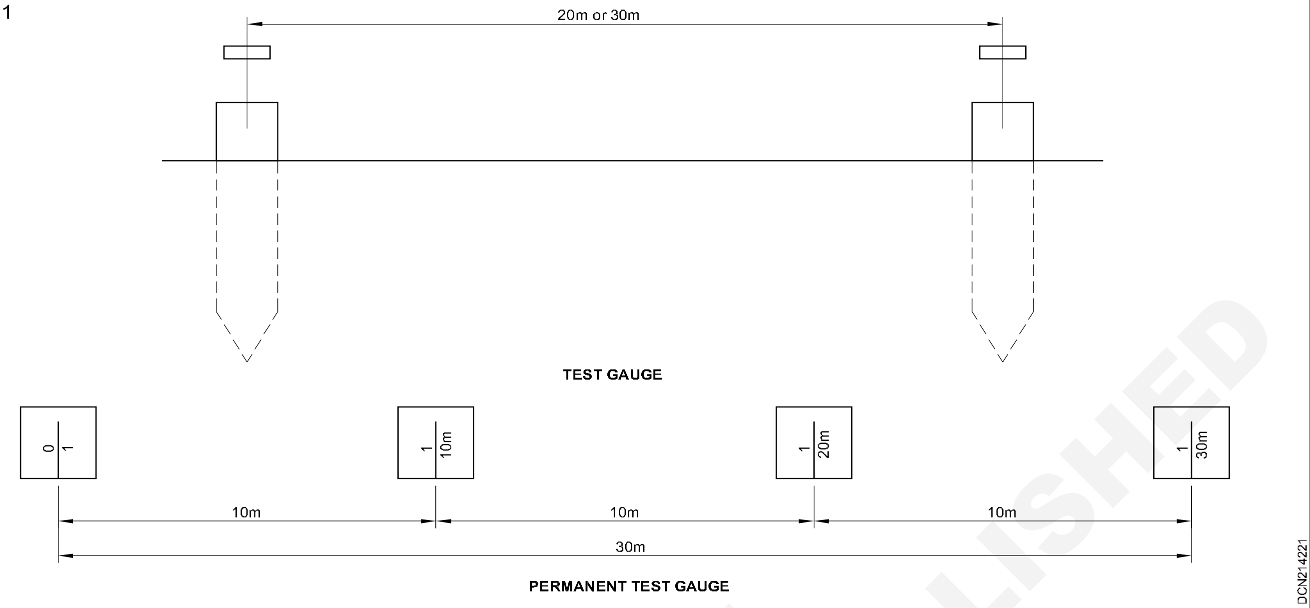
The length of chain decrease due to bending of the links and mud-sticking.

Therefore, it becomes necessary to check the chain before commencing the survey work. Before testing the chain, the bentup links should be straightened and mud should be removed from the joints.

Method of testing chain

– Following are the method of testing a chain (Fig 1)

Fig 1



– By comparing it with a chain standard or with a test gauge.

– By comparing the chain with the levelling staff laid down successively.

– By comparing the chain with the steel tape reserved specially for this purpose

Errors in Chain

Errors in Chain are:

1 **Instrumental Error**: They occur due to faulty adjustment of devices such as chain may be too long or too short etc.

2 **Natural Errors:** They arise due to variation of temperature.

3 **Personal Errors:** They are due to chain not being straight.

Mistakes in Chaining

Mistakes are generally done by in experienced chainman. These can be avoided by careful working. Following are the common mistakes made in the field.

I **Miscounting the chain length:** This is the most serious mistake and occurs due to wrong counting or due to loss of arrow.

II **Displacement of Arrows:** If an arrow is displaced, it may not be replaced correctly. To avoid this mistake, the end of the chain length should be marked both by scratching a cross on the ground and fixing an arrow.

III **Misreading:** It happens due to reading from the wrong end of the chain. It can be avoided by carefully noticing the position of the central tag.

Limits of Error in Chain : As per Indian standard specifications every meter length of chain should be accurate to within ± 2mm when measured with tension of 8 kg and checked against a certified steel tape which has been standardized at 20°C.

The overall length of chain should be within the following limits.

20m chain: ± 5 mm

30m Chain: ± 8mm

Adjusting the Chain

I If the chain is found to increase in length than the standard length, it may be adjusted.

- i by closing up the joints of the opened out rings.
- ii by Hammering back to the shape, of the flattened out rings.
- iii by replacing some of the larger rings by smaller rings.
- iv by removing some of the rings.
- v by adjusting links at the handle.

II If the chain is found to decrease in length than the standard length, it may be corrected.

- i by straightening the bent up links.
- ii by replacing some of the smaller rings by larger ones.
- iii by inserting the new rings as required
- iv by adjusting the links at the handle.

Measurement of distance by chain

Objectives : At the end of this lesson you shall be able to
- **state chaining and chaining a line**
- **state unfolding the chain**
- **describe the reading the chain**
- **state folding the chain**
- **calculate the errors in chaining.**

Chaining

Definition: The operation of measuring a distance between two points with the help of a chain or tape is called chaining.

For ordinary works chain is used for measuring the distances but where great accuracy is required, a steel tape is invariably used.

Identification and Construction of metric Chain

_ It is a measuring instrument consists of
  - i 100 links in 20m chain and (Fig 1)
  - ii 150 links in 30m chain (Fig 2)
- – It is composed of 4mm dia. Mild steel wire.
- – Each link having 20 cm in length and connected together by means of three circular rings to give flexibility to the chain.
- – Length of link is the distance between the centres of two consecutive middle rings.
- – Brass handles are provided at the ends of the chain with swivel joints so that the chain can be turned round without twisting.
- – The outside of the handle is the zero point or the end point of the chain.
- – The length of the chain is the distance from outside of one handle to the outside of the other handle.
- – End links also includes the length of the handle.
- – Chain has brass rings at every one metre length.
- – Brass tallies are provided at every 5m length as shown in (Fig 1 & 2)

Fig 1

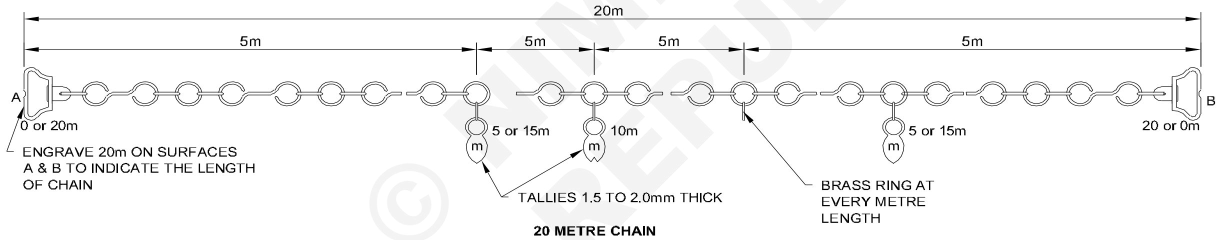
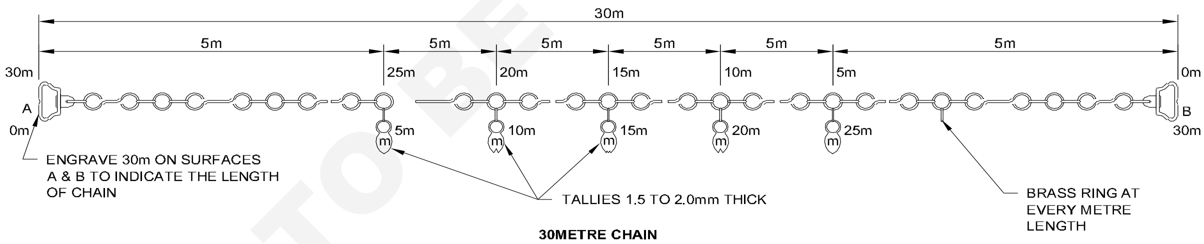
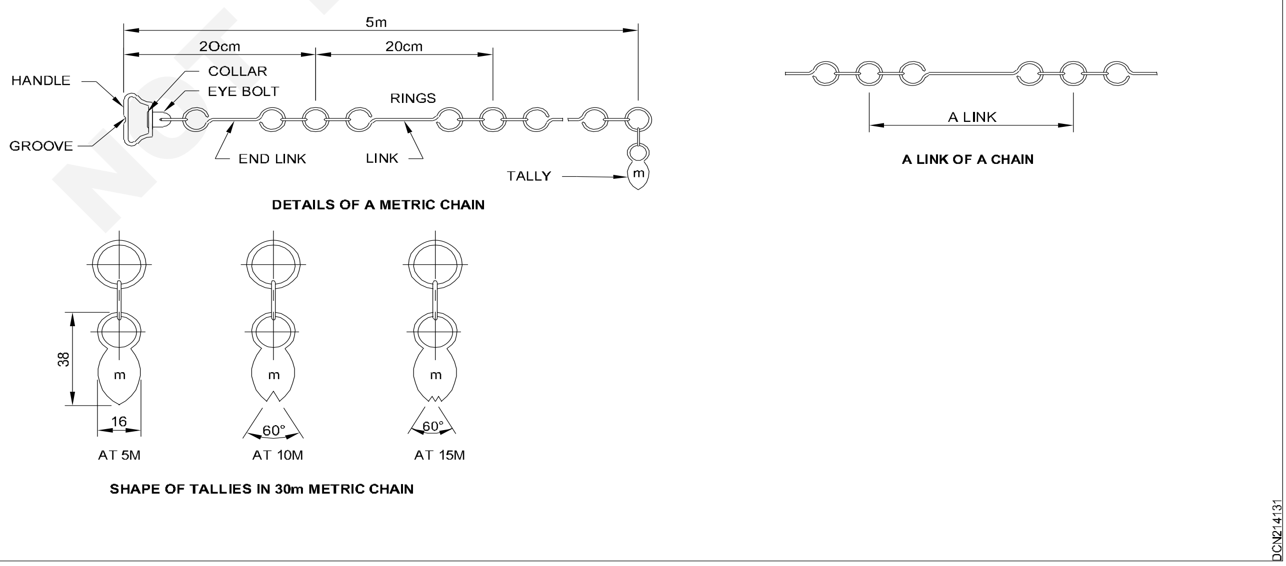


Fig 2





Chaining a Line

For a chaining operation two chain men are required.

– The chain man at the forward end of the chain is called leader and other chain man at the rear end is called a follower.
– The duties of leader and follower are tabulated under:

Leader	Follower
To drag the chain forward.	To direct the leader to be in line with the ranging rod at the end stations.
To insert an arrow at the end of every chain.	To carry the rear end of the chain ensurig that it is dragged above the ground.
To obey the instructions of the follower	To pick up the arrows inserted by the leader.

Unfolding the chain : Before commencing the chain, the surveying or follower keeping both handles of the chain in his left hand, spread the chain with the forward direction with the right hand. The leader taking handle of the chain in his hand and moves towards till the chain is fully extended.

Reading the chain

- The chain is marked by tallies at every 5m length and small brass rings at every 1m length without having difficulty in reading the chain.
- In taking measurements, observe the tag immediately before the end point, which is being measured to and count the number of brass rings and links from it in the forward direction to the end point.
- In reading near the centre of the chain care must be taken to see the position of the central tag.
- To get the total distance add the above fractional part of the chain with number of full chain, it distances exceeds more than one chain length.

Folding the Chain : After the field work the chain should be folded into a bundle. The chain is folded by taking central two lines in the left hand until the handle of links is formed and lied up with a strip of leather.

Error in length due to in correct chain

Correct or True distance =

Incorrect or measured distance x

$$\frac{\text{Incorrect length of chain (or) tape}}{\text{Correct length chain (or) tape}}$$

(or)

$$\text{True distance} = \text{Measured distance} \times \frac{L'}{L}$$

where L = True length of chain or tape

L' =Incorrect length of chain or tape

Error in area due to incorrect chain

$$\text{True area} = \text{Measured area} \times \left(\frac{L'}{L}\right)^2$$

Error in volume due to incorrect chain

$$\text{True volume} = \text{Measured Volume} = \times \left(\frac{L'}{L}\right)^3$$

Example

Problem 1

The distance between two points measured by 20m chain was recorded as 720m. It was afterwards found that the chain used was 4cm too long. What was the true distance between the points?

Solution

$$\text{True distance} = \text{Measure distance} \times \left(\frac{L'}{L}\right)^3$$

Measured distance = 720 m

Chain = 20m

Error = (+) 4 cm

$$\therefore L' = \; = 20 + \frac{4}{100} = 20.04\text{m}, L=20\text{m}$$

$$\text{True distance} = 720 \times \frac{20.04}{20} = 721.44\text{m}$$

Problem 2

A field was surveyed by a chain and the area was found to be 127.34 hectares. If the chain used in the measurement was 0.8% too long. What is the correct area of the field?

Solution

Chain used = 100 units

$$\text{True area} = \text{Measured area} \times \left(\frac{L'}{L}\right)^2$$

L = 100 + 0.8 = 100.8 units, L = 100 units

$$\text{True area} = 127.34 \times \left(\frac{100.8}{100}\right)^2$$

= 129.386 hectares

Exercise

1 The length of a line, measured with a 30m chain was found to be 4920m. If the chain was 0.3 link too short, find the true length of the line.

2 A road actually 2660m long was found to be 2652m when measured with a defective 30m chain. How much correction does the chain need?

Knowledge of mouza map

Objective : At the end of this lesson you shall be able to
• describe above mouza.

Mouza

In Bangladesh, Pakistan and parts of India a mouza (or mauza) is a type of administrative district, corresponding to a specific land area within which there may be one or more settlements. Before the 20th century, the term referred to a revenue collection unit in a pargana or revenue district. As populations increased and villages became more common and developed, the concept of the mouza declined in importance. Today it has become mostly synonymous with the gram or village. Most censuses and voter lists for example, now use the name of village rather than mouzas.

The term has a similar meaning in the Assam region of India, where a mouza is a locality in a district or within a large Assamese city. This terms should not be confused with the terms Gaon (meaning village in Assamese, Hindi and Urdu) In Assam, several villages typically form a single mouza. The head of the mouza is known as a mouzadar or mazumdar.

Study the mouza map

Kolkatta mouza map (Fig 1)

Koch bihar river map (Fig 2)

Fig 1

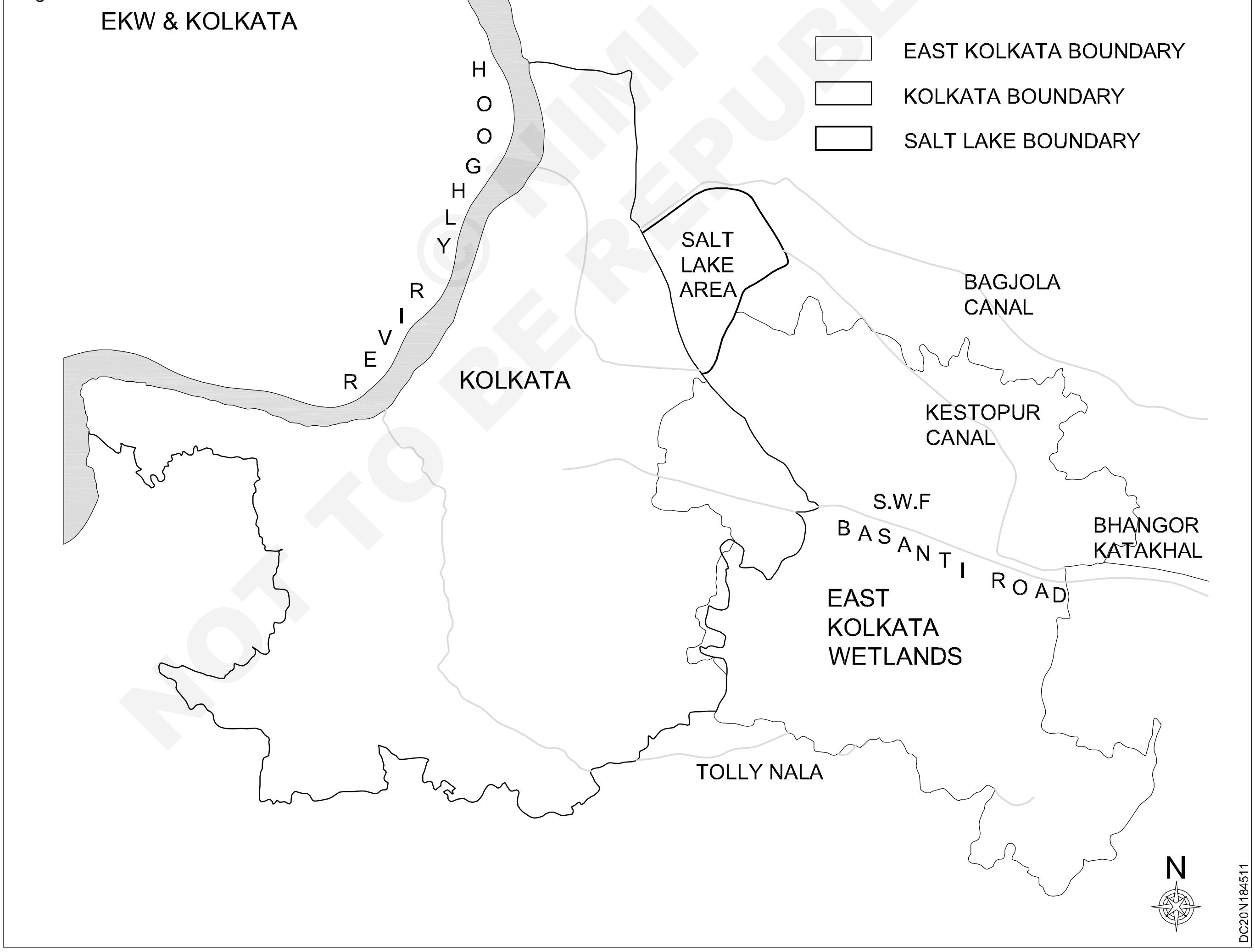
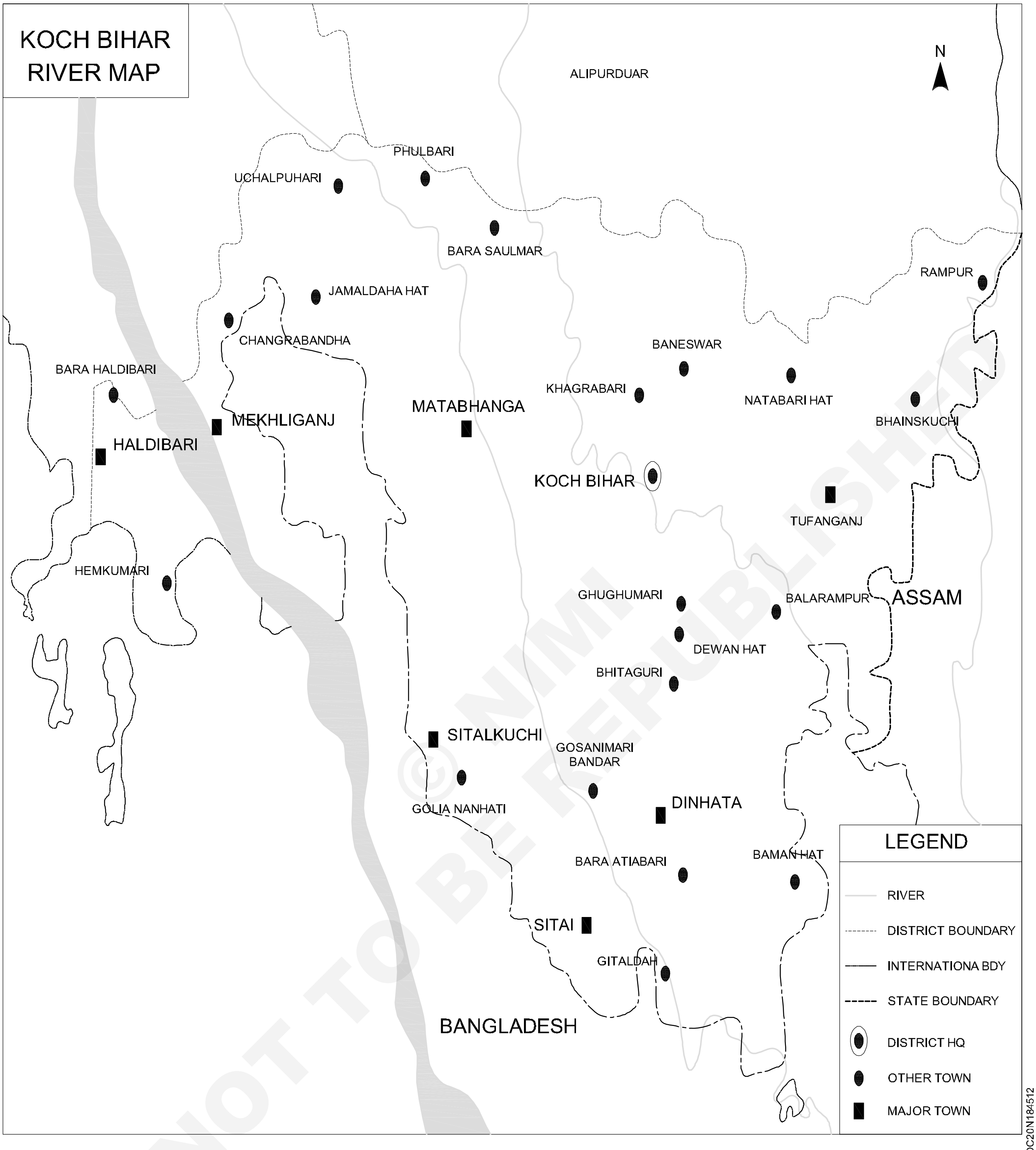


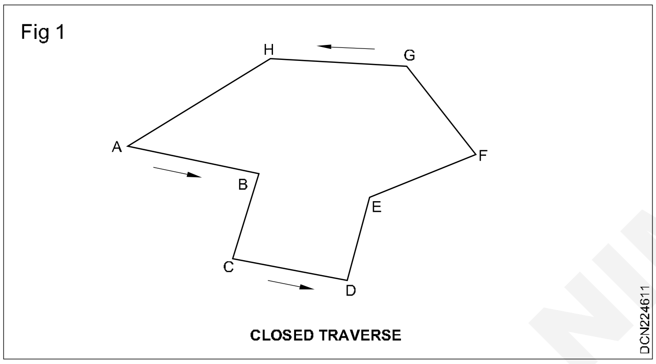
Fig 2


KOCH BIHAR
RIVER MAP
N
ALIPURDUAR
PHULBARI
UCHALPUHARI
BARA SAULMAR
RAMPUR
JAMALDAHA HAT
CHANGRABANDHA
BANESWAR
BARA HALDIBARI
KHAGRABARI
NATABARI HAT
MATABHANGA
BHAINSKUCHI
MEKHLIGANJ
HALDIBARI
KOCH BIHAR
TUFANGANJ
HEMKUMARI
GHUGHUMARI
BALARAMPUR
ASSAM
DEWAN HAT
BHITAGURI
SITALKUCHI
GOSANIMARI
BANDAR
DINHATA
GOLIA NANHATI
BARA ATIABARI
BAMAN HAT
SITAI
GITALDAH
BANGLADESH
LEGEND
RIVER
DISTRICT BOUNDARY
INTERNATIONA BDY
STATE BOUNDARY
DISTRICT HQ
OTHER TOWN
MAJOR TOWN
DC20N184512

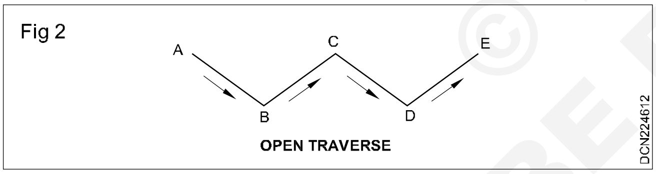
Identification and parts of instruments in compass survey

Objectives : At the end of this lesson you shall be able to
- **state about traversing**
- **state types of compass**
- **name the prismatic compass and construction**
- **construction of survey's compass.**

Traversing : Traversing is that type of survey in which a number of connected survey lines from the frame work and the directions and lengths of the survey line are measured with the help of an angle measuring instrument and a tape respectively. When the lines form a circuit which ends at the starting point is called closed traverse. Fig 1. If the circuit end else where it is said to be an open transverse. (Fig 2)



CLOSED TRAVERSE



OPEN TRAVERSE

Compass: A compass is a small instrument which consists essentially of a magnetic needle, a graduated circle and a line of sight. When the line of sight is directed towards line, the magnetic needle points towards magnetic meridian and the angle which the line makes with the magnetic meridian is read at the graduated circle.

The compass cannot measure the angle directly. If it is desired to find out the angle between the two lines, firstly their angles with the magnetic meridian are determined separately and the difference of the two valves is found which is equal to the angle between the lines.

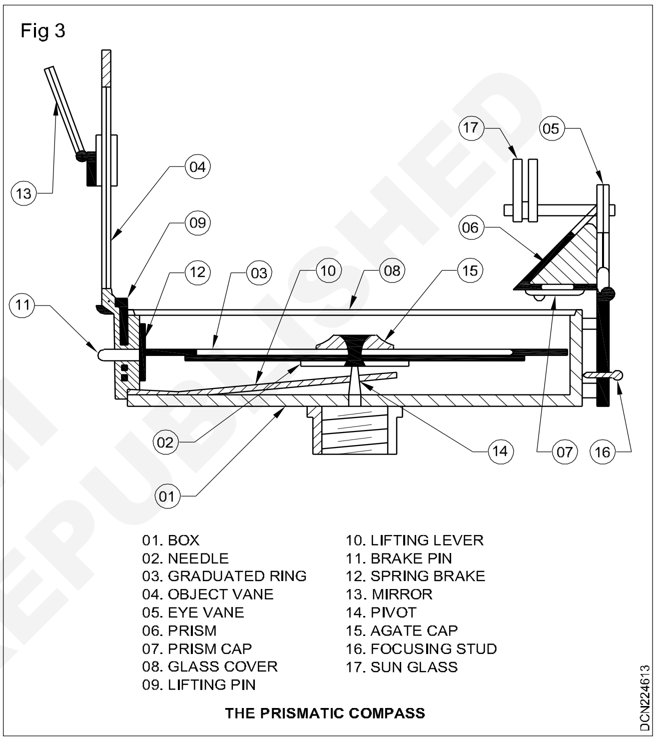
Types of Compass: The two forms of the compass commonly used are:

1 The prismatic compass

2 The surveyors compass

The prismatic compass: It is the most convenient portable magnetic compass, which can either be used as a hand instrument or can be fitted on a tripod. The main parts of prismatic compass are shown in Fig 3.

Construction (Fig 3)



THE PRISMATIC COMPASS

- The prismatic compass consists of cylindrical metal box (1) of 8cm to 12 cm diameter in the centre of which is a pivot (2) carrying a magnetic needle. (3) which is already attached to the graduated aluminium ring (4) with the help of an agate cap (5)
- The ring is graduated to half a degree and is ready by a reflecting prism (6) which is protected from dust, moisture etc. by the prism cap (7)
- Diametrically opposite to the prism is the object vane (8) hinged to the box side and carrying a horse hair (9) with which an object is bisected.
- The eye is applied at the eye hole below the sighting slit (10)
- The graduations on the ring can be observed directly by the eye after they are reflected from the diagonal of the prism.
- The graduations can be made clearly visible by adjusting the prism to the eye sight by the focusing screw (11)
- Both the horizontal and vertical side faces of the prism are made convex to give magnified readings.

- To prevent undue wear of the pivot ,point the object vane is brought down on the face of the glass cover (12) which presses against a lifting pin (13)
- The needle is then automatically lifted off the pivot by the lifting lever (14)
- To damp the oscillations of the needle, before taking a reading and bring it to rest quickly the light spring break (15) attached to the inside of the box is brought in contact with the edge of the ring by gently pressing inward the brake pin (16)
- If the bearings of very high (or) very low objects are taken the reflecting mirror (17) which slides on the object vane is tilted and image is bisected by the horse hair.
- A pair of sun glasses (18) shall have to be inter proposed between the slit and colored vane when the sun or luminous of objects is to be bisected.
- A metal cover fits over the glass cover as well as the object vane when the compass is not in use.
- In the prismatic compass (Fig 4a) graduations are marked on the ring in a clockwise direction with 0 or 360 at south end of the needle.
- So that 90 is marked at the west 180 at the North and 270 at the east.
- The figures are written upside down as in Fig (4b)

Fig 4a

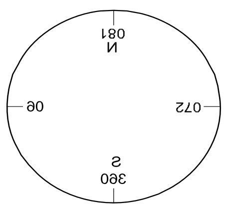
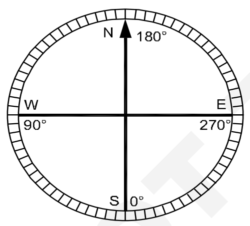


Fig 4b



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SYSTEM OF GRADUATION IN PRISMATIC COMPASS

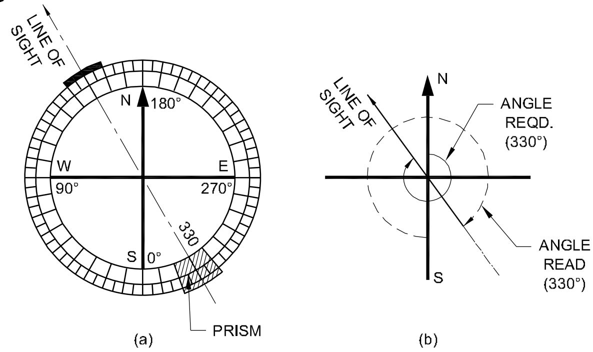
- The greatest advantages of prismatic compass is that both sighting the object as well as reading circle can be done simultaneously without changing the position of the eyes.

The bearing shows 330° at the observer's end under the prism (ie at the south end) (Fig 5)

Surveyors Compass: It is similar to prismatic compass except with a following few modification (Fig 6)

– The graduated ring is directly attached to the circular box and not with the magnetic needle.

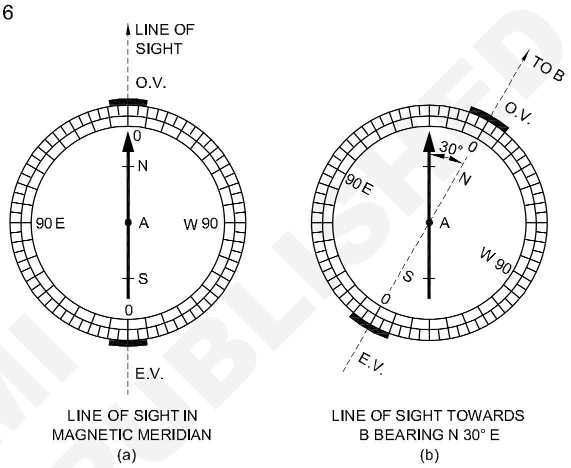
Fig 5



OBSERVATION AND READING IN PRISMATIC COMPASS

DCN224615

Fig 6



SYSTEM OF GRADUATION IN SURVEYOR'S COMPASS

DCN224616

– The magnetic needle floats freely over the pivot.

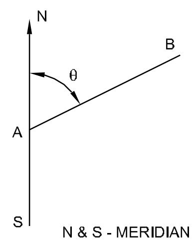
– No prism is attached to the eye vane and it is having a narrow vertical slit.

– Readings are taken directly with naked eye against the north end of the needle.

– The right is graduated in quadranted system of having 0° at north and south ends, 90ˆ at East and west ends. Fig 6a shows when the line of sight towards 'B' and the bearing is N 30° E.

Bearing of a line: It is the horizontal angle which a line make with some reference direction also known as meridian. The reference direction may be any of the following (Fig 7)

Fig 7



N & S - MERIDIAN
θ - BEARING

BEARING OF A LINE

DCN224617

– True meridian

– Magnetic meridian

– An assumed meridian

Comparison between prismatic compass and surveyors compass

No	Item	Prismatic compass	Survryor's compass
1	Magnetic needle	The needle is broad type and needle does not act as index.	The needle is of edge bar type of needle and acts as the index also.
2	Graduated ring	The graduated ring is attached with the needle. The ring does not rotate along with the line of sight. The graduations are in whole circle bearing system, having 0° at south end 90°at west, 180° at North and 270° at East. The graduations engraved are inverted.	The graduated ring is attached to the box and not the needle. The ring rotates along with the line of sight. The graduations are in Quadrantal bearing system having 0°at North system having 0°at North and South, 90° at East and West. East and west are interchanged.
3	Sighting vane	The object vane consists of metal vane with a vertical hair.	The graduations engraved are erect.
4	Reading	The reading taken with the help of a prism provided with the eye vane. Sighting and reading can be done simultaneously from one position of the observer.	The object vane consists of a metal vane with a vertical hair. The reading is taken by directly seeing through the top of the glass.
5	Tripod	It is used with or without Tripod.	Sighting and reading cannot be done simultaneously from one position of the observer. It cannot be used without a Tripod

True Meridian: The meridian of a place is a direction indicated by an imaginary circle passing round the earth through that place and the two north and south poles.

True Bearing: The horizontal angle between a line and the true meridian is called true bearings of the line. It is also called as azimuth.

Magnetic Meridian: The direction indicated by a freely suspended and properly balanced magnetic needle unaffected by local attractive forces is called the magnetic meridian.

Magnetic Bearings: The horizontal angle which a line makes with this meridian is called magnetic bearings or simply bearings of the line.

An assumed or Arbitary meridian: Arbitary meridian is any convenient direction towards a permanent and prominent mark or signal such as a church spire or top of a chimney. Such meridians are used to determine the relative positions of lines in a small area.

Arbitary Bearings: Arbitary bearings of a line is the horizontal angle which it makes with any arbitrary meridian passing through the one of the extremities or the horizontal angle between a line and this arbitrary meridian is called arbitrary bearing of the line.

Designation of Bearings: The bearings are expressed in the following two ways.

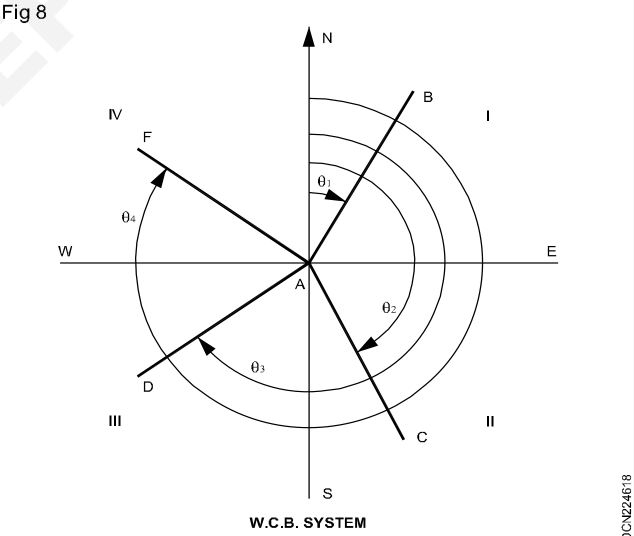
– Whole circle bearings.

– Quadrantal bearings.

Whole Circle bearing (W.C.B): In this system, the bearings of a line, is measured from the magnetic north in clockwise direction. The value of the bearing thus varies from 0° to 360°. The prismatic compass measures the bearings of lines in the whole circle system.

Referring Fig 8 the W.C.B of AB is θ1; of AC is θ1 and AC is θ^2; AD is θ3 and of AF is θ 4.

Fig 8



W.C.B. SYSTEM

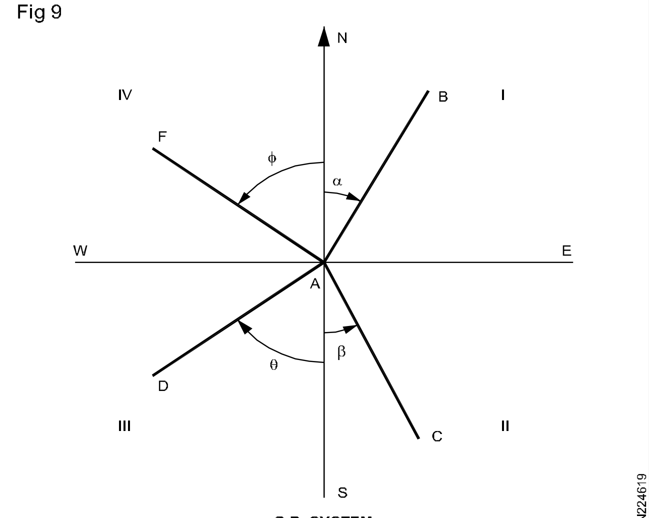
The Quadrantal bearings: In this system, the bearings of a line is measured east ward or westward from north or south whichever is nearer. Thus both North and South are used as reference meridians and the directions can be either clockwise or anticlockwise depending upon the position of the line. These bearings are observed by surveyors compass.

Referring Fig 9 the QB of the line AB is $\propto$ and it is written as N$\propto$ E

The bearing of Line AC is band it is written as S β E.

Similarly, the bearing of line AD and AF are written as S θ W and N ϕ W

Fig 9



Q.B. SYSTEM

Conversion of Bearings from one system to other system

Reduced bearing

When the whole circle bearings exceed 90^0, then it is to be converted or reduced to quadrantal bearing system which has the same numerical values of the trigonometrical function is known as reduced bearing (R.B)

i Referring Fig 8, W.C.B system, the conversion of W.C.B into R.B can be expressed in the following table.

ii Referring Fig 9 the conversion of R.B into W.C.B can be expressed in the following table.

Table 1

Line	W.C.B between	Rule for R.B	Quadrant
AB	0° and90°	R,B = W.C.B	NE
AC	90º and 180º	R,B =180º - W.C.B	SE
AD	180º and 270º	R.B = W.C.B - 180º	SW
AF	270º and 360º	R.B = 360º - W.C.B	NW

Table 2

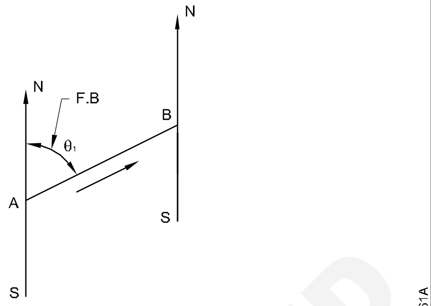
Line	R.B	Rule for W.C.B	W.C.B between
AB	N α E	W.C.B = R.B	0 AND 90
AC	S β E	W.C.B = 180- R.B	90 AND 180
AD	S θ W	W.C.B = 180+ R.B	180 AND 270
AF	N ϕ W	W.C.B = 360 - B	270 AND 360

Fore Bearings and Back Bearings: Every line has two bearings, observed one at each end of the line. The bearing of a line taken in the progress of the survey or in the forward direction is the fore or forward bearing (F.B) of the line. While its bearing taken in the reverse or opposite direction is known as reverse or back bearing (B.B)

Whole Circle bearing system

Fig 10 shows. The bearing of line AB expressed in the direction A to B is the F.B of AB.

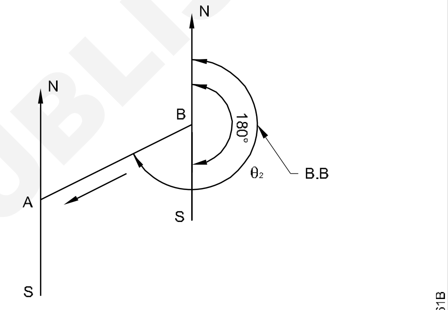
Fig 10



FORE BEARING OF A LINE AB
W.C.B. SYSTEM

The bearing of line AB when recorded in the opposite direction from B to A is BB (or) F.B of BA (Fig 11)

Fig 11



BACK BEARING OF A LINE AB
W.C.B. SYSTEM

In the whole circle system, the fore and back bearings of a line differ exactly by 180°

∴ B.B of a line = F. B ± 180° [Equation 1]

Use plus sign if the given F.B is less than 180° and minus sign if it exceeds 180°

Quadrantal bearing system

In the quadrantal system F.B and B.B are numerically equal but with opposite cardinal points. B.B of aline may, therefore be obtained by simply substituting N for S or S for N; and E for W or W for E in its fore bearings (Fig 12).

Supposing F.B of a line is n 30°E then its B.B is equal to S 30° W

Example

Problems on conversion of bearing

a Convert the following W.C.B to quadrantal bearings.

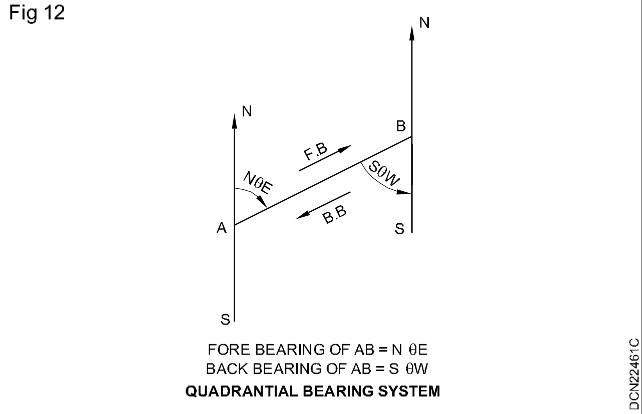
i 12° 30’

ii 160° 30’

iii 210° 30’

iv 285° 30’

Fig 12

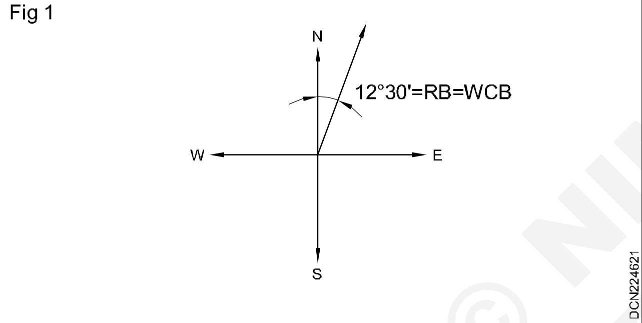


Solution

Applying the rules given in the table 1

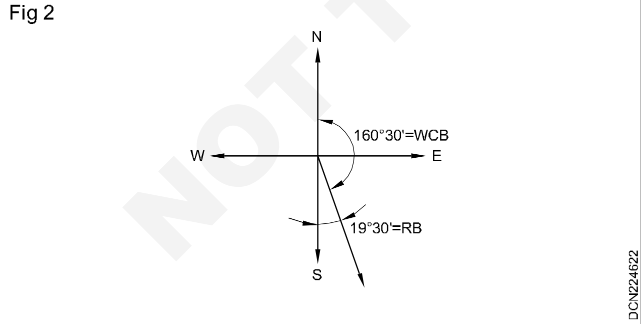
i	W.C.B	= 12° 30'
	W.C.B	= 12° 30 which is less than 90°
	∴ R.B	= N 12° 30' E (Fig 1)

Fig 1



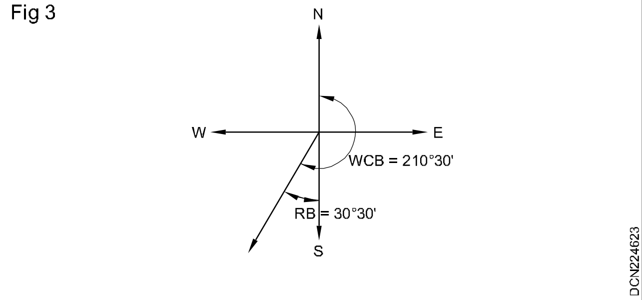
ii	W.C.B	= 160° 30'
	The W.C.B is within 90° to 180°	
	∴ RB	= 180° - W.C.B
		=180° - 160° 30'
		= S19° 30' E (Fig 2)

Fig 2



iii	W.C.B	= 210° 30'
	The W.C.B is within 180° to 270°	
	∴ RB	= W.C.B - 180°
		= 210° 30' – 180'
		= S 30° 30' W (Fig 3)
iv	W.C.B	= 285° 30'

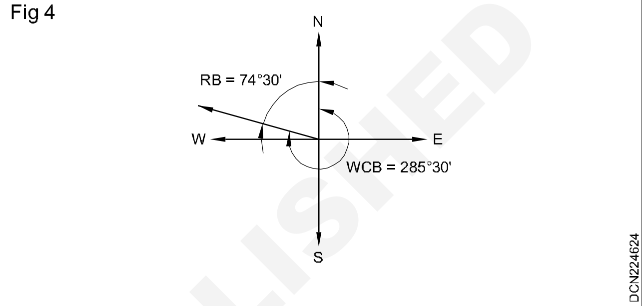
Fig 3



The W.C.B is within 270° to 360°

∴ R.B	= 360° - W.C.B
	= N 74° 30' W (Fig 4)

Fig 4



b Convert the following quadranted bearings to whole circle bearings.

i N 30° 30' E

ii S 70° 30'

iii S 36° 30W

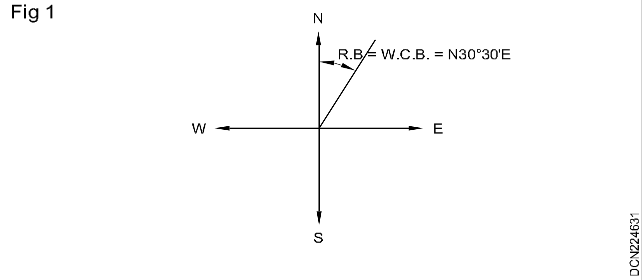
iv N 85° 30W

Solution

Applying the rules given in Table 2

i	Q.B	= N30° 30'E
	W.C.B	= RB = 30° 30' (Fig 1)

Fig 1



ii	Q.B	= S 70° 30'E
	W.C.B	=180° - R.B
		= 180° - 70° 30'
		= 109° 30' (Fig 2)
iii	Q.B	= S 36° 30'W
	W.C.B	= 180° + Q.B
		= 180° + 36° 30'
		= 216° 30' (Fig 3)

Fig 2

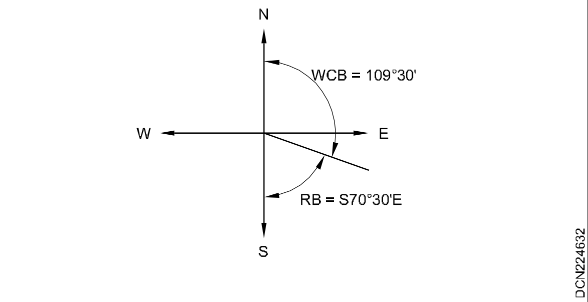
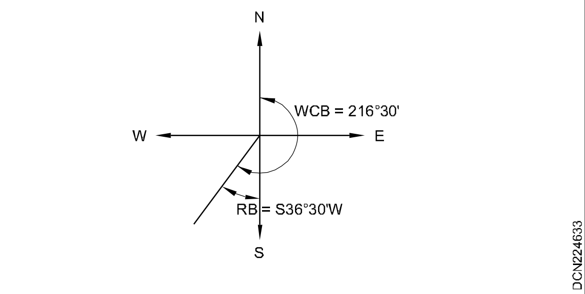


Fig 3

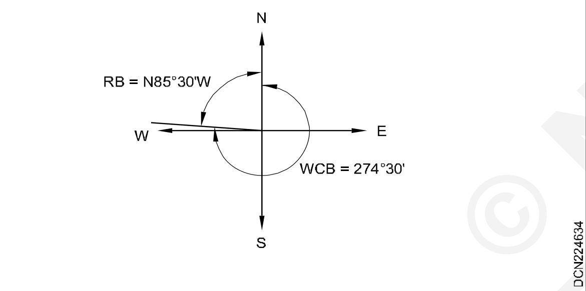


iv Q.B = N 85° 30’W

W.C.B = 360º - 85º 30’

= 274º 30’ (Fig 4)

Fig 4



Exercise

1 Convert the following W.C.B to R.B

a 87º 30’

b 120º 30’

c 210º 00

d 266º 30’

e 310º 30

f 359º 30’

2 Convert the following R.B to W.C.B

a N 46º 30’ E

b S 20º 30’ E

c S 10º 30’ W

d N 50º 30’ W

Example

Find back bearings of the following observed fore bearings of lines AB 63º 30’, BC 112º 30, CD 203º 30; DE 320º 30’

Solution

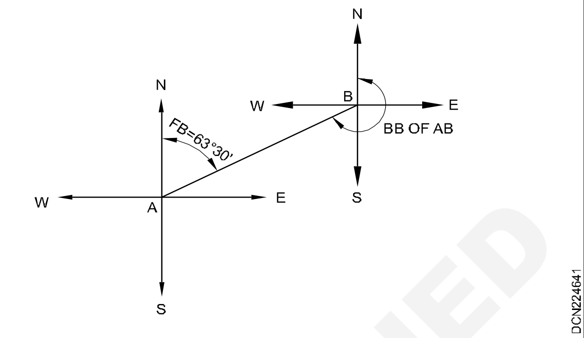
From the equation (1)

∴ B.B = F.B ± 180º

Using + sign when F.B is less than 180º and - sign more than 180º

i F.B of AB = 63º 30 (Fig 1)

Fig 1



∴ B.B of AB = F.B of AB + 180º

= F.B of AB + 180º

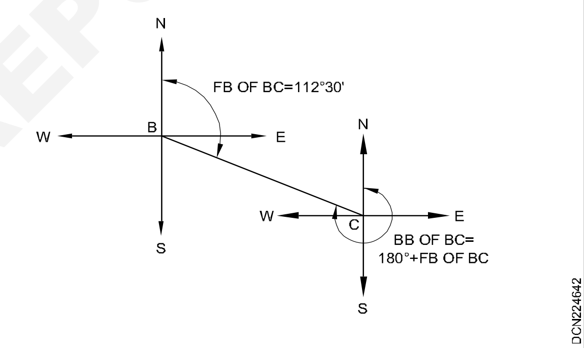
= 63º 30 + 180º

= 243º 30’

B.B of AB = 243º 30’

ii F.B of BC = 112º 30’ (Fig 2)

Fig 2



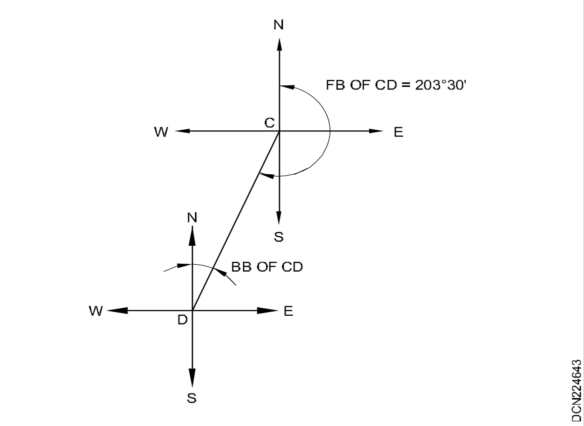
B.B of BC = F. B of BC + 180°

= 112º 30’ + 180

= 292º 30’

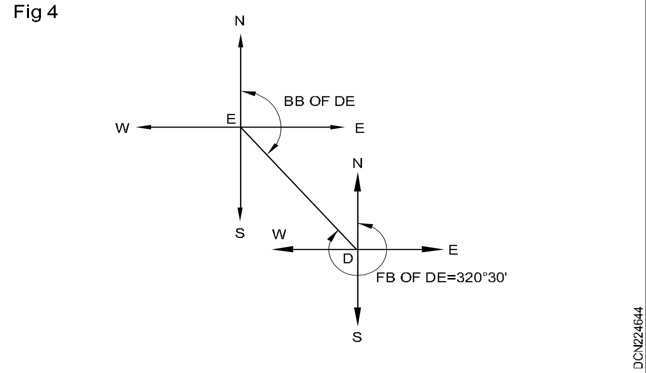
iii F.B of CD = 203º 30’ (Fig 3)

Fig 3



B.B of CD	= F.B of CD - 180º
	= 203º 30' – 180
	= 23º 30'
iv F.B of DE	= 320º 30' (Fig 4)

Fig 4



B.B of DE	= F.B of DE - 180º
	= 320º 30' - 180º
B.B of DE	= 140º 30'

Example

The fore bearing of the lines are as follows:

AB: N 32º 30E

BC: S 43º 30 E

CD: S 26º 30W

DE: N 65º 35, W

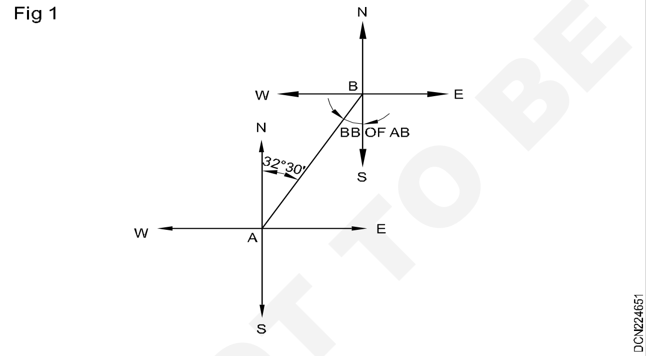
Find their back bearings

Solution

When bearings are expressed on the quadrantal systems, the back bearings of a line is numerically equal to its fore bearings but with opposite letters. Therefore

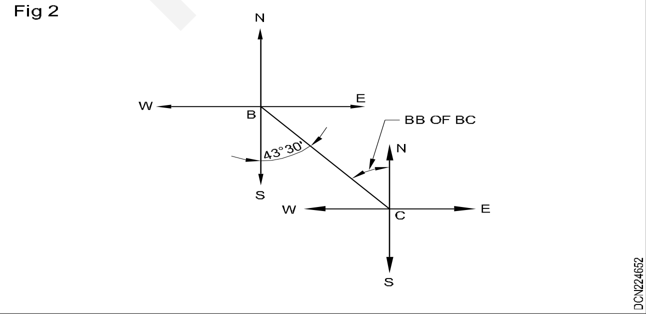
i F.B OF AB	= N 32º 30' E (Fig 1)

Fig 1



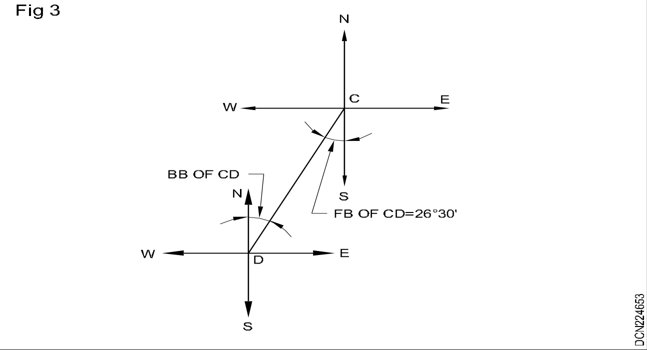
∴ B.B of AB	= S 32º 30' W
ii F.B of BC	= S 43º 30' E (Fig 2)

Fig 2



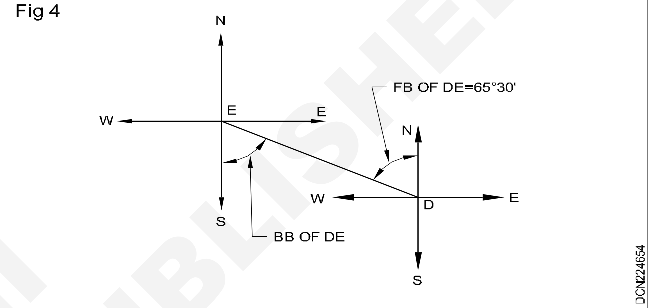
∴ B.B of BC	= N 43º 30' W
iii F.B of CD	= S 26º 30' W (Fig 3)

Fig 3



∴ B.B of CD	= N 26º 30' W
iv F.B of DE	= N 65º 30' W (Fig 4)

Fig 4



∴ B.B of DE	= S 65º 30'E

Exercise

1 The following are the observed Fore bearing of the lines:

AB = 88° 30';

BC = 142° 30';

CD = 209° 00';

DE = 324°30'

Find their back bearing.

2 The fore bearings of the lines are as follows:

AB = N26° 30' E;

BC = S 78° 30' E;

CD = S 69° 0' W;

DE = N32° 30 W,

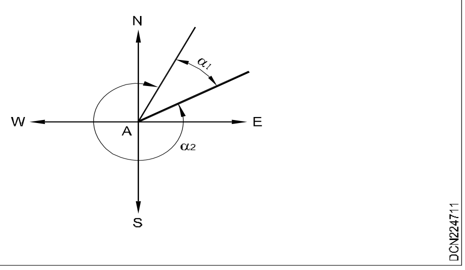
Find their back bearings.

Determining the bearings of a given triangular plot of ABC and calculation of included angles

Objectives : At the end of this lesson you shall be able to
- **calculate angles from bearings**
- **calculate bearings from angles.**

Calculation of Angles from Bearings: When two lines meet at a point 'A' two angles (interior and exterior) are formed. The sum of these two angles is equal to 360º (see Fig 1$\alpha_1 + \alpha_2 = 360º$)

Fig 1



The following rules may be adopted to find the included angle between two lines whose bearings are given.

Case 1: Given the bearings in whole circle bearing system

Both the bearings of the two lines being measured from a common station point 'A'.

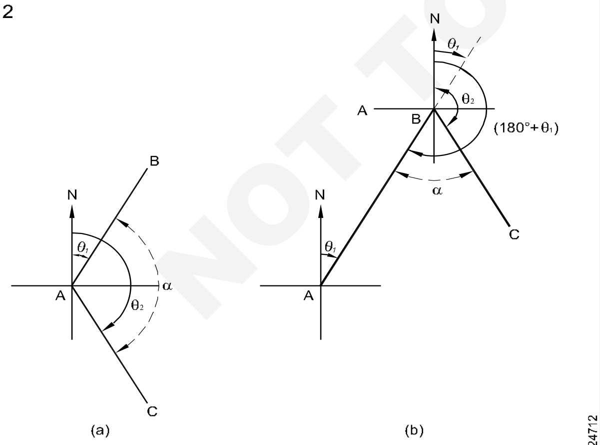
Rule: Subtract the smaller bearing from the greater bearing. The difference between the two bearings will give included angle at the station point 'A'.

From Fig 2a, the included angle 'α'between the lines AC and AB.

∠A = α = Bearing of AC - Bearing of AB

= $\theta_2 - \theta_1$

Fig 2



CALCULATION OF ANGLES FROM BEARINGS

Both the bearings of the two lines not being measured from a common station point.

Rule: Finding the back bearing of the previous line and the F.B the next line at that station and use the above rule for finding included angle.

From Fig 2b, the included angle 'α' between BC and BA

∠B = B.B of AB – F.B of BC

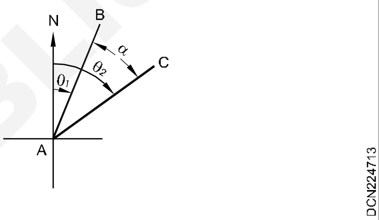
= $(180° + \theta_1) - \theta_2$

Note: If the difference is less than 180°, then it is an interior angle and if it exceeds 180⁰ , it is an exterior angle.

Case II: Given the bearings in Quadrantal system

i Referring to Fig 3, in which both the bearings have been measured to the same side of same meridian.

Fig 3



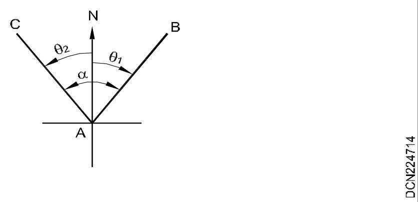
Rule: Included angle = difference between the two bearings AC and AB

The included angle is α = $\theta_2 - \theta_1$

= F.B of Line AC – F.B of line AB

ii Referring to Fig 4 both the bearings have been measured to the adjacent sides of the same meridian.

Fig 4



Rule: Included angle = sum of the two bearings AB and AC

The Included angle 'α = $\theta_1 - \theta_2$

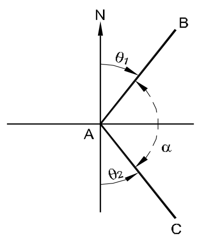
= F.B of Line AB + F.B of line AC

iii Referring to Fig 5 both the bearings have been measured to the same side of different meridians.

Rule: Included angle = 180° - sum of the bearings AB and AC

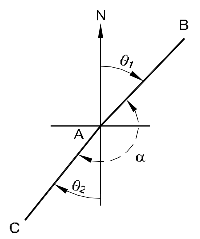
∠A, Included angle, $\alpha = 180° - (\theta_2 - \theta_1)$

Fig 5



iv Referring to Fig 6 both the bearings have been measured to the opposite side of different meridians.

Fig 6



Rule: Included angle = 180° - difference of the bearings AB and AC

L A, Included angle, α = 180° $(\theta_1 + \theta_2)$

Problems on calculation of angles from bearing

Example 1

Find the angle between the lines OA and OB, if their respective bearings are

a 32°30' and 148° 00'

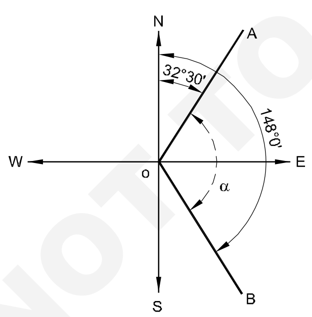
b 16°00' and 332° 30'

c 126°30' and 300°30'

Solution

a 32° 30' and 148°00' (Fig 1)

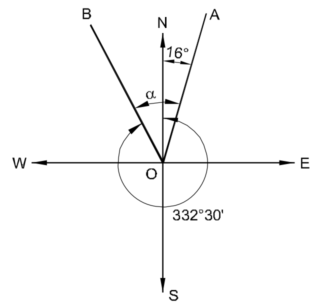
Fig 1



F.B of line OA	=	32° 30'
F.B of line OB	=	148° 00'
∴ angle LAOB or	=	F.B of line OB – F.B of line OA
	=	148° 00 -32° 30'
α	=	115° 30'

b 16° 00' and 332° 30' (Fig 2)

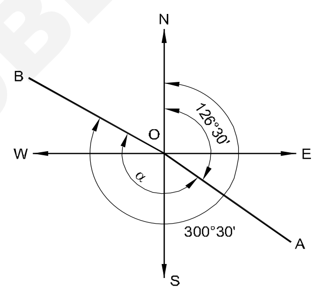
Fig 2



F.B of OA	=	16° 00'
F.B of OB	=	332° 30'
∴ angle ⌊ABOA or α	=	(360° - F.B of line OB)
	+	F.B of line OA
	=	(360° 00' - 332° 30')
+ 16° 00		
	=	27° 30' + 16° 00'
	=	43° 30'

C 126° 30' and 300° 30' (Fig 3)

Fig 3



F.B of OA	=	126° 30
F.B of OB	=	300° 30'
∴ angle LAOB or α	=	F.B of line OB – F.B of line OA
	=	300° 30' - 126° 30'
α	=	174° 00'

Example 2

The following bearings are given in quadrantal systems of lines AB and AC. Calculate in each case the angle BAC

	Line AB	**Line AC**
i	N 25° 30' E	S 85° 30' E
ii	N 20° 30' E	N 85° 30' E
iii	S 70° 00' E	S 10° 00' W
iv	N 50° 30' E	S 20° 30' W
v	N 40° 30' W	N 46° 0' E
vi	S 45° 30' W	N 60° 0' W

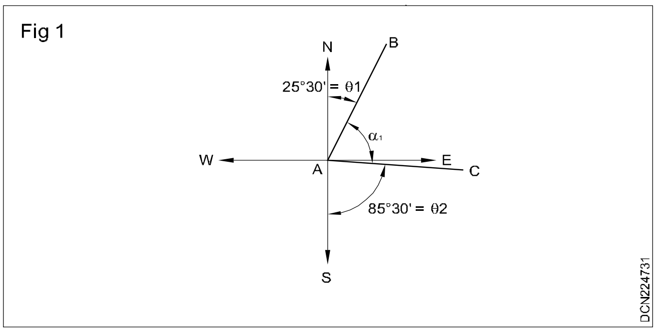
Solution

i **Line AB** **Line AC**

N 25° 30 E S 85° 30’ E

In Fig 1α_1” is the included angle at A or LBAC Ref. Case II (iii) both the bearings have bee measured to the same side of different meridians.

Fig 1



α_1 = 180° - ($\grave{e}_1$- $\grave{e}_2$)

= 180° - (25° 30’ + 85° 30’)

= 180° - 111° 0’

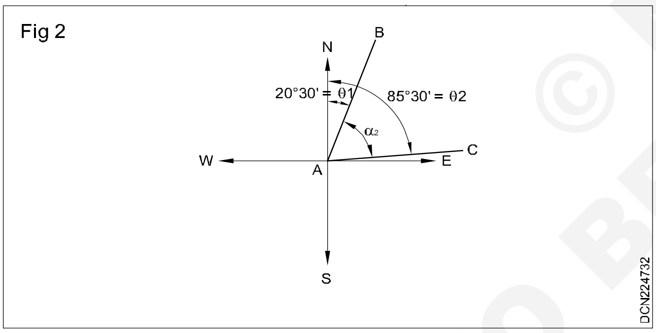
⌊BAC = 69° 0’

ii **Line AB** **Line AC**

N 20° 30 E N 85° 30’ E

In Fig 2 Refer case II (i) both the bearings have been measured to the same side on the same meridian.

Fig 2



The included angle, α_2 or

⌊BAC = FB of AC – FB of AB

$\alpha_{2=}$ = ($\grave{e}_2 - \grave{e}_1$)

= 85° 30’ - 20° 30’

⌊BAC = 65° 0’

iii S 70° 00 E S 10° 00 W

In Fig 3 Refer Case II (ii) both the bearings are measured to the adjacent sides of the same meridian.

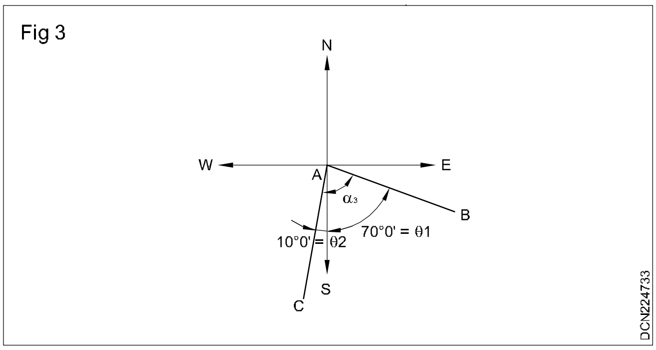
Included angle $\acute{a}_3$ = ($\grave{e}_1 - \grave{e}_2$)

= 70° 0’ + 10° 0’

⌊BAC = 80° 0’

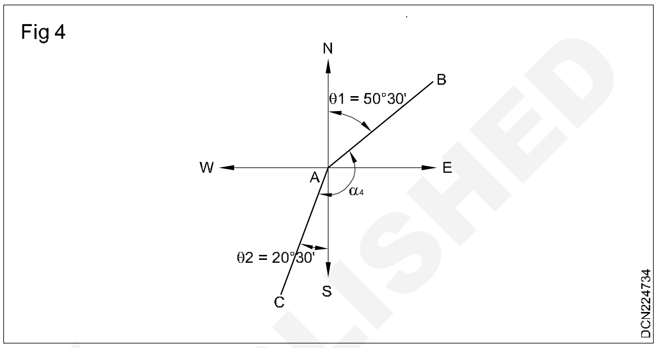
iv N 50° 30’ E S 20° 30’ W

Fig 3



In Fig 4 From Ref. case II (iv) both the bearings have been measured to the opposite side of different meridians.

Fig 4



$\acute{a}_4$ = ⌊BAC = 180° - ($\grave{e}_1 - \grave{e}_2$)

= 180° - (50° 30’ - 20° 30’)

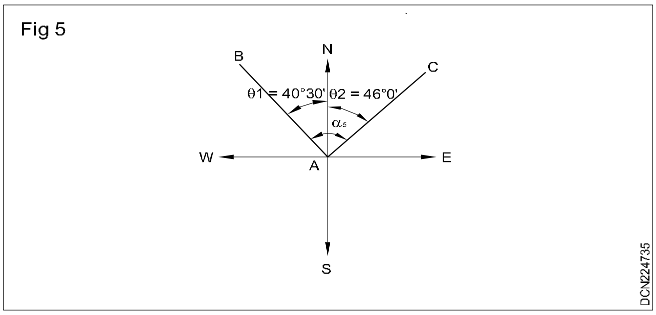
= 180° - 30° 00’

⌊BAC = 150° 00’

v N 40° 30, W N 46° 0’E

In Fig 5 Refer case II (ii), both the bearings have been measured to the adjacent sides of the same meridian, included angles

Fig 5



⌊BAC = $\theta_{5=}\theta_1\,\theta_2$

= 40 30’ + 46° 00’

= 86° - 30’

vi S 45° 30’ W N 60° 0’ W

In Fig 6 Refer case II (iii), both the bearings have been measured to the same sides of the different meridians.

Included angle $\acute{a}_6$ = ⌊BAC = 180° - ($\theta_1\ \theta_2$)

= 180° - (45° 30 + 60° 0’)

= 180° - 105° 30

⌊BAC = α = 74° 30’

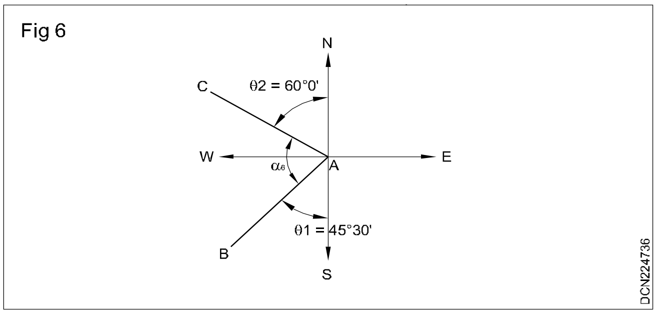


Fig 6

Example 3

Find the angle between the lines OA and OB if their respective bearings are

i 25° 30’ and 160° 30’

ii 25° 30’ and 340 °30’

iii 126° 0’ and 300° 30’

Solution:

i 25° 30’ and 160° 30’ (Fig 1)

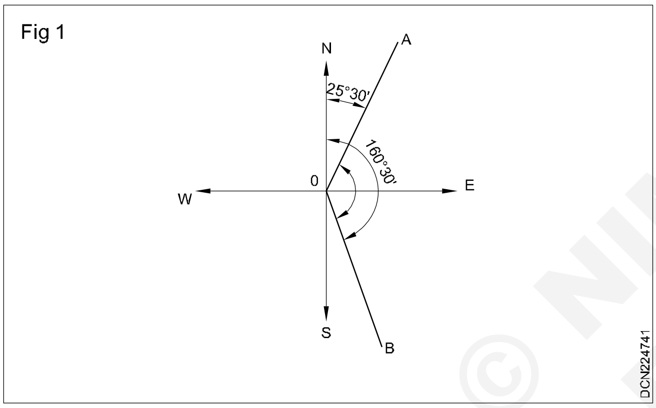


Fig 1

Bearing of OA	=	25° 30’
Bearing of OB	=	160° 30’

The included angle will be difference of the two bearings.

∠AOB	=	Bearing of OB – Bearing of OA
	=	160° 30’ - 25° 30’
∠AOB	=	135 °00’

ii 25° 30’ and 340° 30’ (Fig 2)

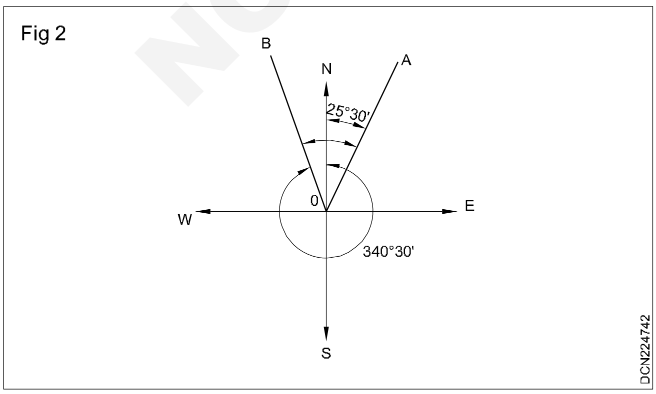


Fig 2

Bearing of OA	=	25° 30’
Bearing of OB	=	340° 30’

The included angles will be difference of the two bearings.

∠AOB	=	Bearing of OB – Bearing of OA
	=	340° 30’ - 25° 30’
∠AOB	=	315º 00’

Since difference is greater than 180° , it is an exterior angle, and to obtain the interior angle it

Must be subtracted from 360°

∴Interior angle ∠BOA	=	360° -315° 00’
	=	45° 00’

ii 126° 0 and 300° 30 (Fig 3)

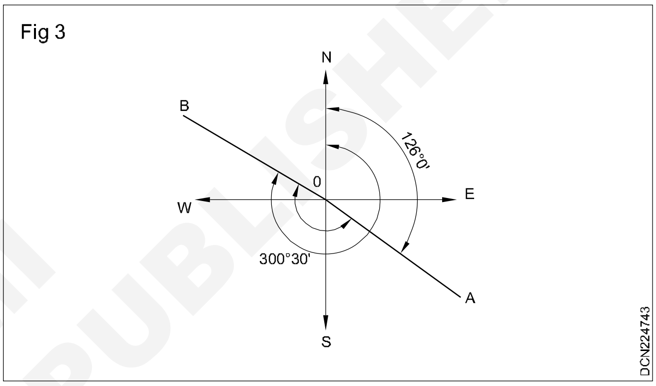


Fig 3

Bearing of OA	=	126° 0
Bearing of OB	=	300° 30’
AOB	=	Bearing of OB – Bearing of OA
	=	300 ° 30’ - 126° 0’
∠ AOB	=	174° 30’

Example 4

Find the angle between the lines AB and BC if their respective bearings are:

i 140° 30’ and 50° 30’

ii 65° 30’ and 117° 30’

Solution

i 140° 30’ and 50° 30’ From Fig 1

Bearing of AB	=	140° 30’
Bearing of BA	=	180° + 140° 30’
	=	320° 30’
Bearing of BC	=	50° 30’
∠ ABC	=	Bearing of BA – Bearing of BC
	=	320° 30’- 50° 30’
	=	270° 00 the exterior angle

∴ the interior angle ∠ ABC

= 360° - 270°00’

= 90° 00’

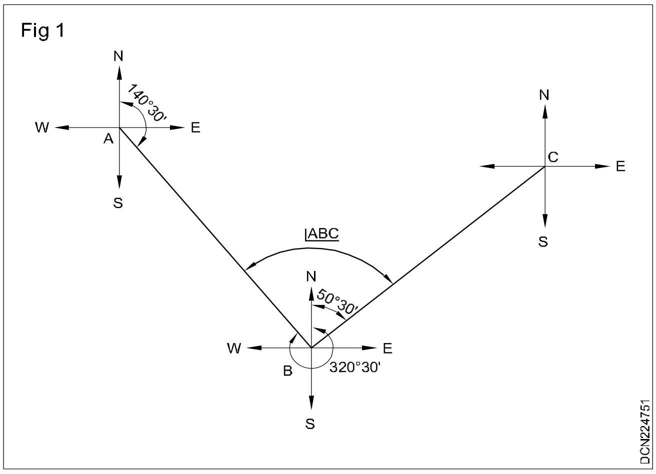


Fig 1

ii 65° 30’ and 117° 30’ (Fig 2)

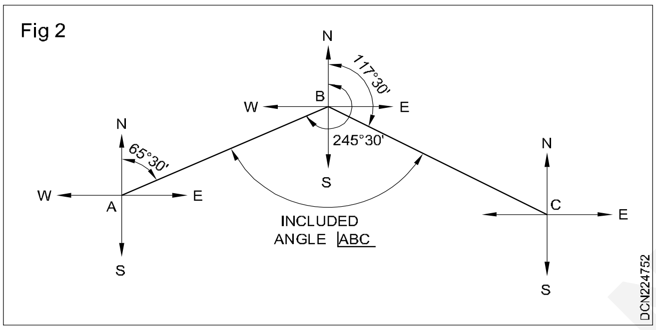


Fig 2

Bearing of AB	=	65° 30’
Bearing of BA	=	180° + 65° 30’
	=	245° 30’
Bearing of BC	=	117° 30’
∠ ABC	=	Bearing of BA – Bearing of BC
	=	245° 30’ - 117° 30’

∴ Including angle ABC

= 128° 00’

Example 5

The bearing of line AB is 164° 30’ and the angle ABC is 117° 30’what is the bearing of BC?

Solution

From the Fig 1

Find Bearing of BC?

Bearing of AB	=	164° 30’
Bearing of BA	=	180° + 164° 30’
	=	344° 30’
Now bearing of BC	=	Bearing of BA +∠ ABC
	=	344° 30’+117° 30
	=	462° 00’ It is more than 360°
∴ Bearing of BC	=	462° 00 - 360° 00’
	=	102° 00’

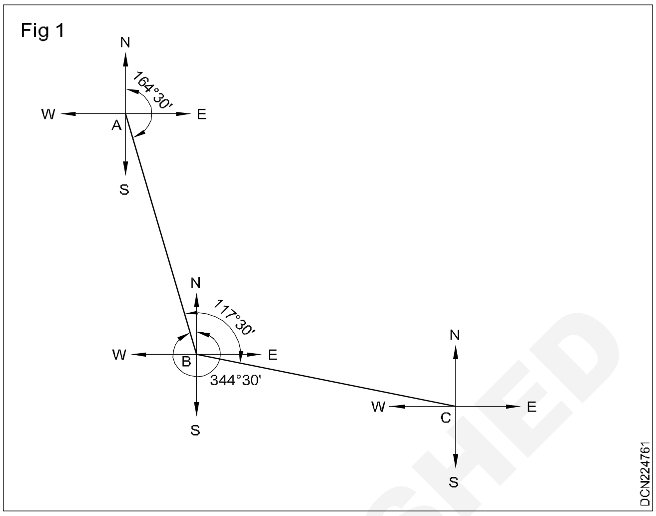


Fig 1

Example 6

The following bearings are observed in a triangular plot with a compass, calculate in the interior angles.

Line	Fore bearing
AB	50° 30’
BC	125° 30’
CA	270° 30’

Solution

From Fig1

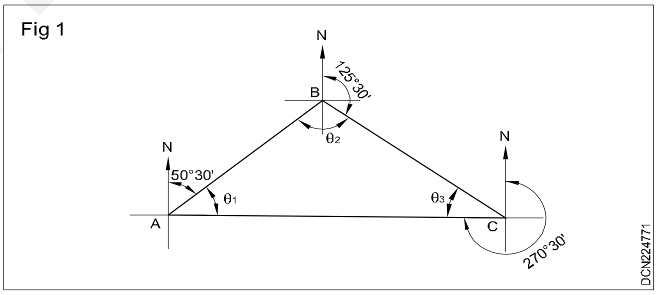


Fig 1

Included angle at A

⌊BAC = è1	=	BB of CA – FB of AB
	=	(270° 30’ - 180°0’) 50° 30’
	=	90° 30’ - 50° 30’
⌊A = è1	=	40°

Included angel at B,

⌊ABC = è2	=	BB of AB –FB of BC
CBA	=	(50° 30’ + 180° 00) - 125° 30’)
	=	230° 30’ - 125° 30’
⌊B	=	105°00’

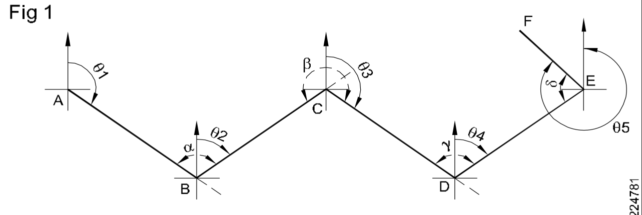
Included angle at C,

⌊BCA = è3	=	B.B OF BC – FB OF CA
ACB	=	(125° 30 + 180° 00) - 270° 30’
	=	305°30’ - 270° 30’
⌊C	=	35° 00’
Check: ⌊A +⌊B+⌊C	=	180°
40° + 105° +35°	=	180°

Calculation of bearing from angles:

Referring Fig 1

Fig 1



CALCULATION OF BEARINGS FROM ANGLES

Let $\alpha, \beta, \Upsilon, \delta$ be the included angles measured clockwise from back station.

θ_1 be the measured bearing of the line AB.

∴ The bearing of the next line BC

$= \theta_2 = \theta_1 + \alpha - 180°$

The bearing of the next line CD

$= \theta_3 = \theta_2 + \beta - 180°$

The Bearing of the next line DE

$= \theta_4 = \theta_{3+} + \Upsilon - 180°$

The bearing of the next line EF

$= \theta_5 = \theta_4 + \delta - 180°$

Note 1

$(\theta_1+\alpha)$, $(\theta_2+\beta)$ and $(\theta_{3+}+\Upsilon)$ are more than 180° , while $(\theta_4 +\delta)$ is less than 180° . Hence in order to calculate the bearing of the next line, the following (Rule in Note 2) statement can be made.

Note 2

“Add the measured clockwise angles to the bearing of the previous line. If the sum is more than 180°, deduct 180° If the sum is less than 180°, add 180°.

In a closed traverse, clock angles will be obtained if we proceed the traverse in anticlock wise direction.

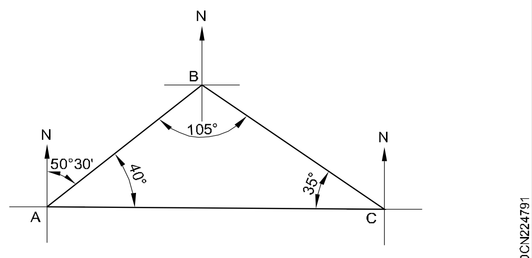
Example 7

The following angles were measured in a triangular plot. The bearing of AB is 50° 30’. Find the bearings of BC and CA if ⌊A= 40° .00,⌊B= 105°.00,⌊C= 35°.00.

Solution (Fig 1)

Bearing of BC	=	BB of AB -⌊B
	=	(50° . 30’ + 180) - 105° . 00’
	=	230° . 30’ - 105° . 00’
	=	125° . 30’
Bearing of CA	=	BB of BC - θC
	=	(125° . 30 + 180° .0) - 35° .00
	=	305°30’ - 35° 00
	=	270° 30’

Fig 1



Determining the bearings of a given pentagonal plot of ABCDE and calculating included angles

Objectives: At the end of this lesson you shall be able to
- **calculate the angles from bearings for a closed traverse**
- **calculate the bearings from angles for a closed traverse**
- **calculate the bearings of a pentagon.**

Example 1

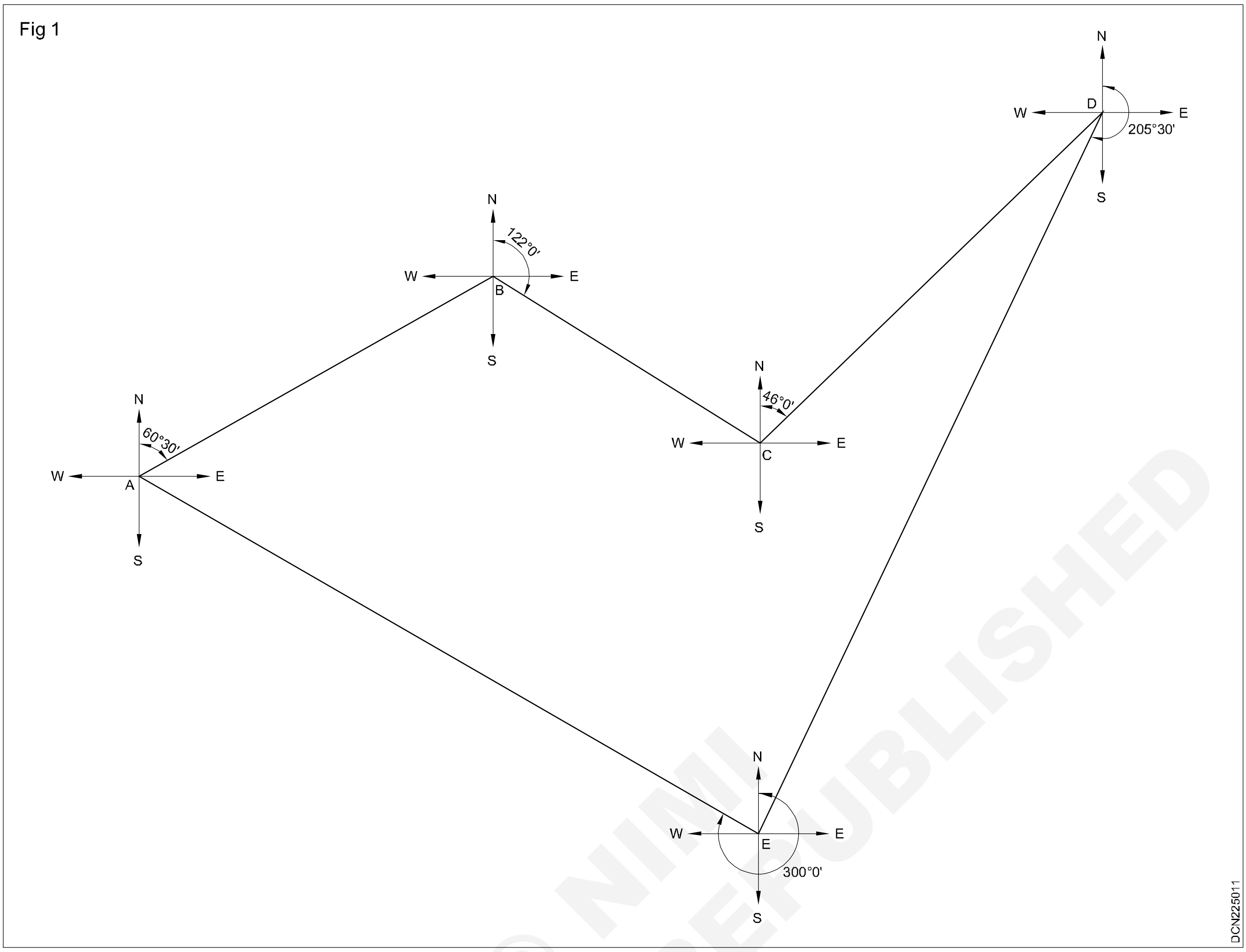
The following bearings were observed with a compass. Calculate the interior angles. (Fig 1)

Line	Fore Bearings
AB	60^0 30’
BC	122^0 00’
CD	46^0 00’
DE	205^0 30’
EA	300^0 00’

Solution:

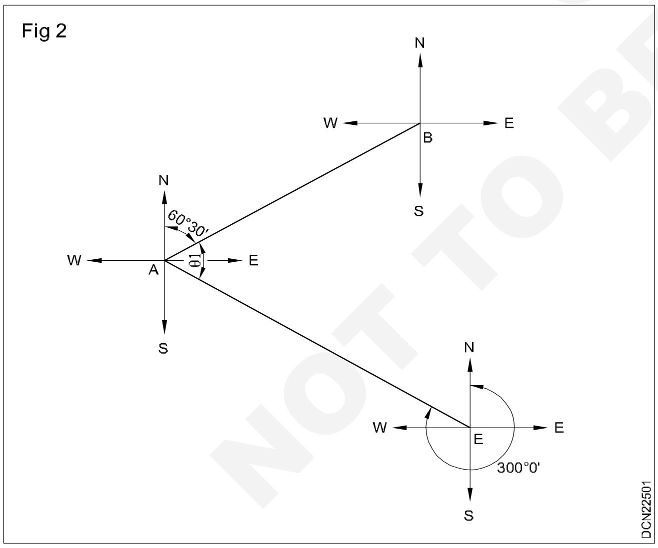
Fig 1 shows the plotted traverse by using the above given fore bearings.

Fig 1



Consider station A (Fig 2)

Fig 2



Included angle = Bearing of previous line - Bearing of Next Line

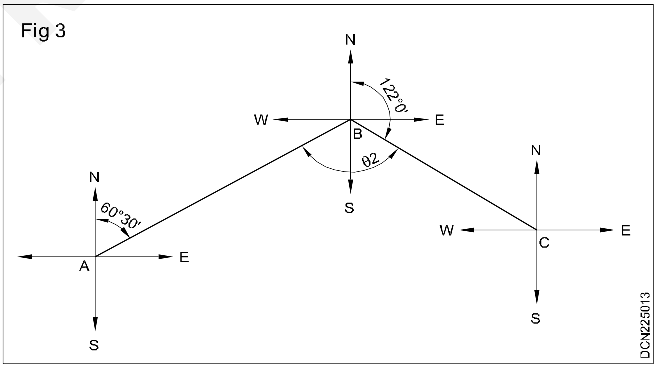
$\theta_1 = \angle A$ = Bearing of AE - Bearing of AB

= $(300^0 - 180^0) - 60^0\ 30'$

θ_1 = $59^0\ 30'$

Consider station B (Fig 3)

Fig 3



$\theta_2 = \angle B$ = Bearing of BA - Bearing of BC

= $(180^0 + \text{FB of AB}) - 122^0\ 0'$

= $(180^0 + 60^0\ 30') - 122^0\ 0'$

= $240^0\ 30' - 122^0\ 0'$

$\theta_2 = \angle B$ = $118^0\ 30'$

Consider station C (Fig 4)

$\theta_3 = \angle C$ = Bearing of CB - Bearing of CD

= $(180^0 + \text{FB of BC}) - 46^0\ 0'$

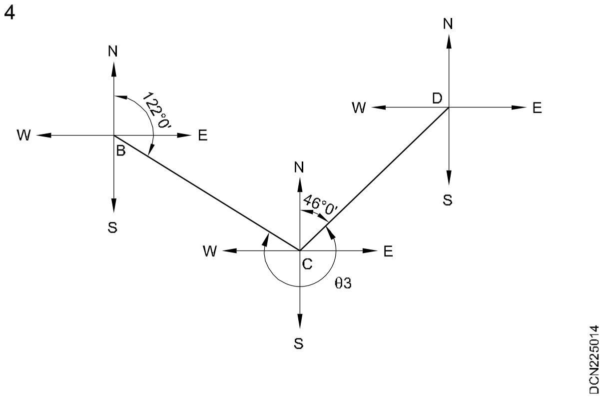
= $(180^0 + 122^0\ 0') - 46^0\ 0'$

= $302^0\ 0' - 46^0\ 0'$

$\theta_3 = \angle C$ = $256^0\ 00'$

In some of the cases in a closed traverse the calculated included angle exceeds 180^0 and that angle is known as interior angle according to the traverse as here at station 'C'.

Fig 4



Consider station C (Fig 5)

$\theta_4 = \angle D$ = Bearing of DC - Bearing of DE

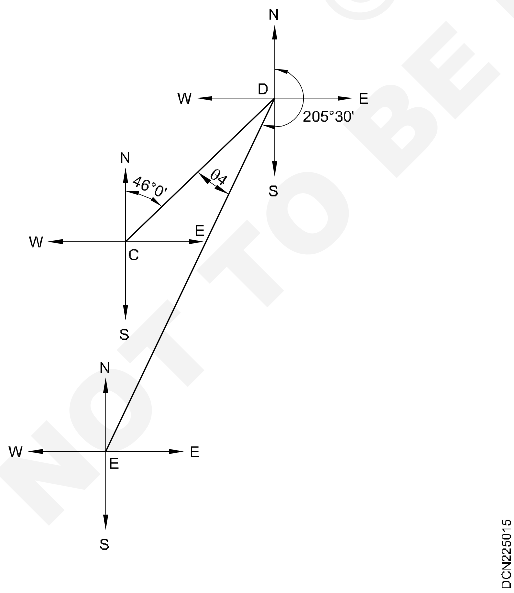
= $(180^0 + \text{FB of CD}) - 205^0\ 30'$

= $(180^0 + 46^0) - 205^0\ 30'$

= $226^0\ 00' - 205^0\ 30'$

$\theta_4 = \angle D$ = $20^0\ 30'$

Fig 5



Consider station E (Fig 6)

$\theta_5 = \angle E$ = Bearing of previous line - Bearing of next line

= $(\text{F.B of DE} - 180^0) - 300^0 + 360^0$

= $(205^0\ 30' - 180^0) - 300^0 + 360^0$

= $25^0\ 30' - 300^0 + 360^0$

$\theta_5 = \angle E$ = $85^0\ 30'$

$\therefore$ $\angle A$ = $59^0\ 30'$

$\angle B$ = $118^0\ 30'$

$\angle C$ = $256^0\ 00'$

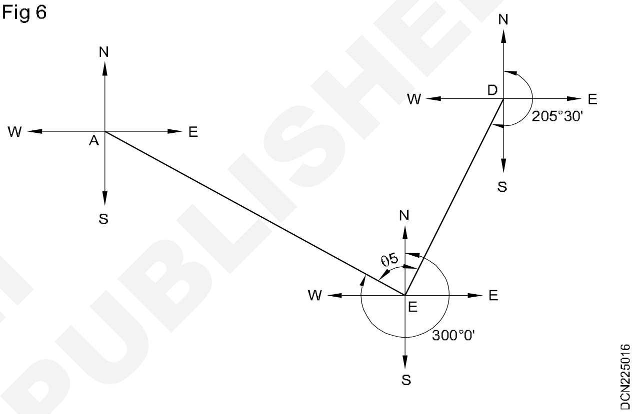
$\angle D$ = $20^0\ 30'$

$\angle E$ = $85^0\ 30'$

----

sum = $540^0\ 00'$

Fig 6



The sum of interior angle of a pentagon

= $(2n-4) \times 90^0$

= $(10 - 4)\ 90^0 = 540^0$

Where n = No. of sides

Example 2

The following are the bearings of the lines of a closed traverse ABCD (Fig 1)

Line	F.B
AB	N $56^0\ 30'$ E
BC	S $50^0\ 30'$ E
CD	S $19^0\ 30'$ W
DA	N $70^0\ 30'$ W

Calculate the interior angles of the traverse

Solution

For angle at A, (Fig 2)

F.B of AD = B.B of DA

For angle at B, (Fig 3)

F.B of BA = B.B of AB

= S $56^0\ 30'$ W

F.B of BC = S $50^0\ 30'$ E

Fig 1

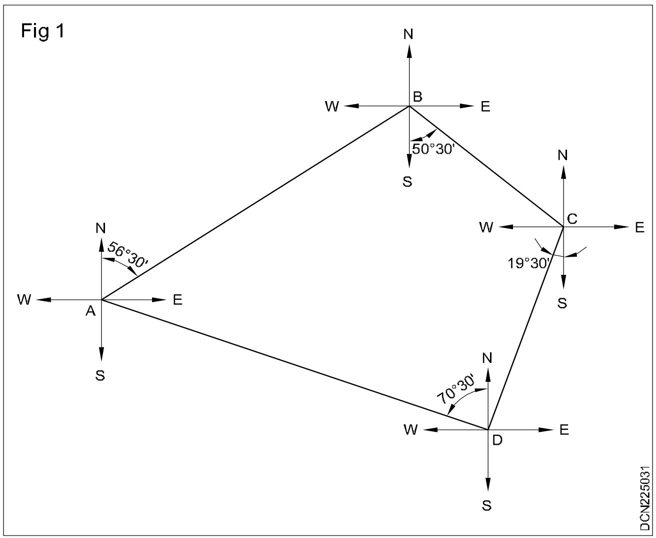


Fig 2

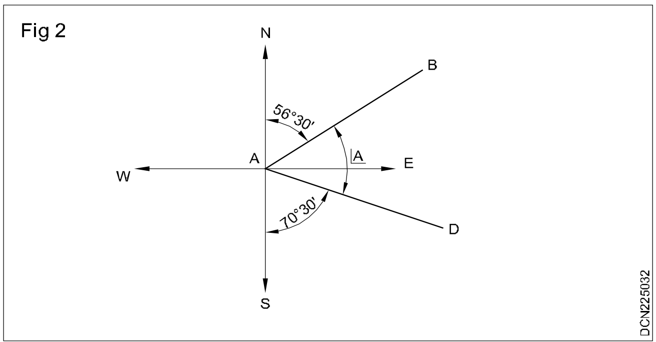
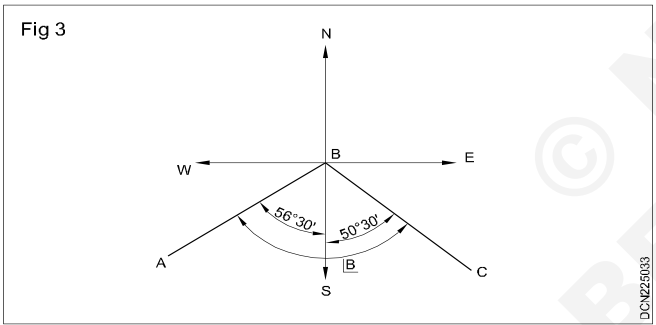


Fig 3



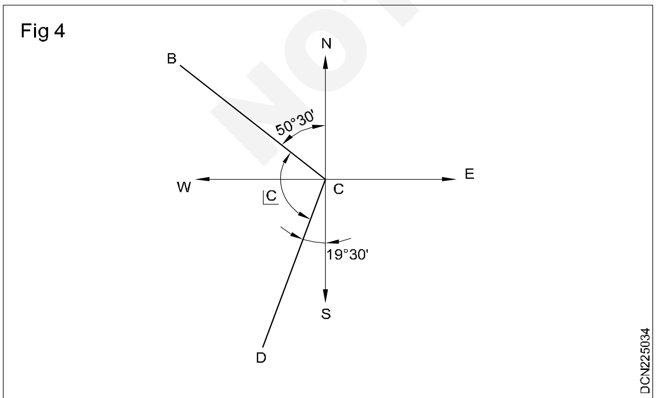
$\angle B$ = F.B of BC - B.B of AB

= 50^0 30' + 56^0 30'

= 107^0 00'

For angle at C, (Fig 4)

Fig 4



F.B of CB = B.B of BC = N 50^0 30' W

F.B of CD = S 19^0 30' W

$\angle C$ = 180^0 - (B.B of BC + F.B of CD)

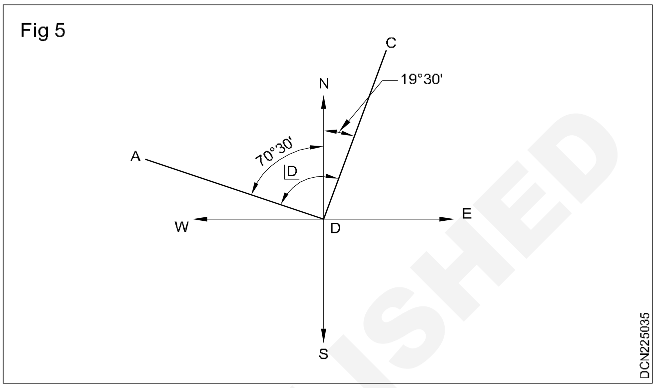
= 180^0 00' - (50^0 30' + 19^0 30')

= 180^0 00' - 70^0 00'

$\angle C$ = 110^0 00'

For angle at D, (Fig 5)

Fig 5



F.B of DC = B.B of CD = N 19^0 50'E

F.B of DA = N 70^0 30'W

$\angle D$ = F.B of DA - B.B of CD

= 70^0 30' + 19^0 30'

$\angle D$ = 90^0 00'

Check :

$\angle A + \angle B + \angle C + \angle D$ = (2n-4) 90^0

53^0 0' + 107^0 0' + 110^0 + 90^0 = [(2 x 4)-4 x 90^0]

360^0 00' = 4 x 90^0

360^0 = 360^0

Example 3

Find the bearing of the sides of a regular hexagon observed by going over in a C.W manner if the bearing of one side is 50^0.

Solution

The sum of interior angle of a regular hexagon

= (2n-4) x 90^0

$$= \frac{(2\times6-4)90^{\circ}}{6} = 120^{\circ}$$

∴ The deflection angle i.e. the angle between any side produced and the side following, (180^0 - the interior angle)

= 180^0 - 120^0 = 60^0

The bearing of AB = 50^0

It is clear from the Fig 1, that the bearings of each of the remaining sides taken in a clockwise direction may be determined by adding 60 to the bearing of the proceeding side.

Thus we have,

Bearing of AB = 50^0

Add = 60^0

Bearing of BC = 110^0

Add = 60^0

Bearing of CD = 170^0

Add = 60^0

Bearing of DE = 230^0

Add = 60^0

Bearing of EF = 290^0

Add = 60^0

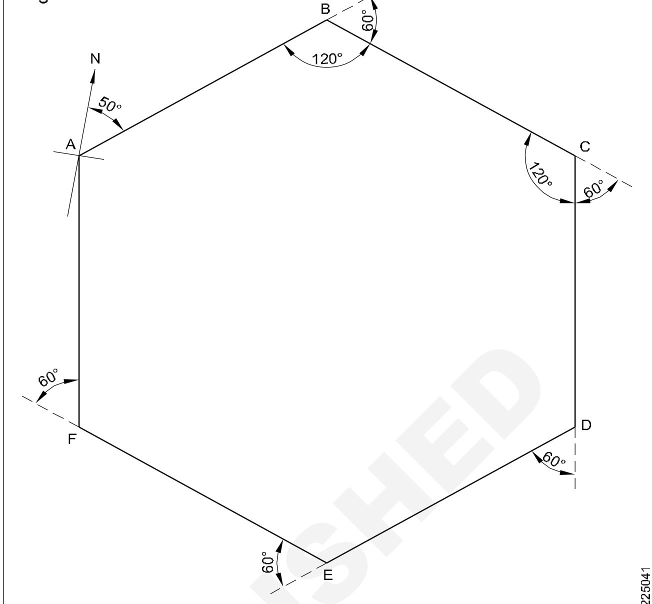
Bearing of FA = 350^0

Add = 60^0

Bearing of AB = $410^0 - 360^0 = 50^0$

Which is the bearing of the starting line AB.

Fig 1



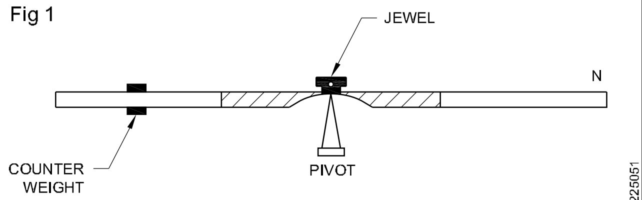
HEXAGON

Magnetic declination and local attraction

Objectives: At the end of this lesson you shall be able to
- **define the dip of the magnetic needle**
- **state the magnetic declination and variations**
- **calculate true bearings**
- **state local attraction and its elimination**
- **explain about errors and its limits**
- **state the testing the prismatic compass.**

Dip of the Magnetic Needle: Before Magnetisation, the needle remains in the horizontal position if it is properly balanced, but after being magnetised, it cannot remain in the same position due to the magnetic influence of the earth. One end of the needle deflects downward towards the magnetic pole. In northern hemisphere the north end of the needle is deflected downward, and in the southern hemisphere the south end points downward. This inclination of the needle with the horizontal is known as the dip of the needle. (Fig 1)

Fig 1



THE MAGNETIC NEEDLE

The amount of the dip is not uniform, but it varies in different parts of the earth. It varies from 0^0 to 90^0 (zero at equator and 90^0 at the poles)

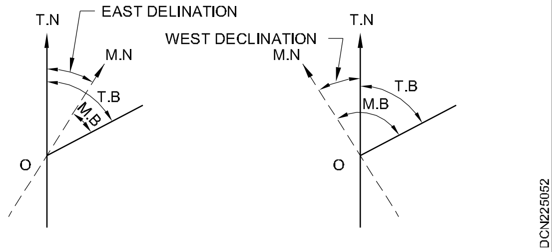
> **To keep the needle in the horizontal position, it is balanced by placing a brass sliding weight or rider at a suitable point over the higher end of the needle.**

Magnetic declination: In certain places, the magnetic meridian at a place does not coincide with the true meridian at that place. The horizontal angle which the magnetic meridian makes with the true meridian is known as magnetic declination or declination.

When the needle is deflected towards east of the true meridian it is called east declination and west declination when it is deflected towards west of the true meridian. (Fig 2)

The magnetic meridian differs from time to time on the earth's surface.

Fig 2



Calculation of True bearings:

Rule 1 : True bearing of a line = Magnetic bearing of the line ± declination.

Use + sign when the declination is east
Use - sign when the declination is west

Rule 2 : Magnetic bearing of a line = True bearing of the line ± declination

Use + sign when the declination is west
Use - sign when the declination is east

Variations in Declination: The declination is not constant for any places, but it changes from time to time and place to place.

The variations may be regular or irregular.

1 **Regular variations:** This variations may itself be analysed into several components of different periods and amplitudes. They are (i) Secular (ii) annual and (iii) diurnal or daily

- **Secular variation:** The magnetic meridian swings like a pendulum. It swings in one direction for a long period and gradually comes to rest and then swings in the opposite direction.
- **Annual variation:** It has a period of one year and therfore it is known as annual variations. The amount of variation is in difficult places 0 to ±12 minutes, but it is not remain constant at any place.
- **Diurnal or daily variation:** It is an oscillation of the needle from its mean position during the day. The amount of this variation varies from 1 minute to about 12 minutes at different places.

2 **Irregular variations:** These are occured by magnetic storms such as earth quakes or volcanic eruptions and their amount may be even 1^0 or 2^0 at a time. It mat occured at anytime. It cannot be predicted.

Calculate true bearing problems on magnetic declination:

Example 1

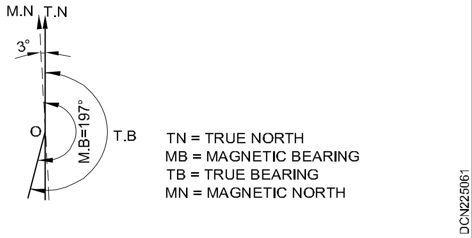
The magnetic bearing of line is 197^0. Find its true bearing, if the magnetic declination is 3^0 W

Solution (Fig 1)

Using Rule 1

True bearing of the line = Magnetic bearing of the line ± declination.

Fig 1



Use - sign because the declination is west.

True bearing of the line = Magnetic bearing of the line - declination.

$= 197^0 - 3^0$

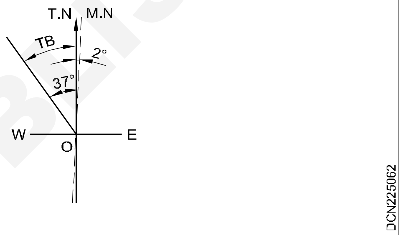
$= 194^0$

Example 2

If the magnetic bearing of the line is N 37^0 W and the magnetic declination is 2^0 E Find the true bearing.

Solution (Fig 2)

Fig 2



From Rule I

True bearing of a line = Magnetic bearing of line ± declination

$= N(37^0 - 2^0)$ W

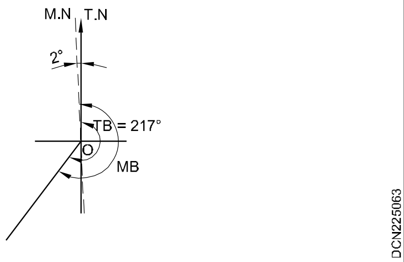
$=$ N 35^0 W

Example 3

True bearing of a line is 217^0 and magnetic declination is 2^0 w. Find the magnetic bearing.

In Fig 3 Magnetic bearing of the line

Fig 3



= True bearing of line + declination.

$= 217^0 + 2^0$

$= 219^0$

Use + sign declination in west.

Example 4

The magnetic and true bearing of a line are 327^0 14' and 324^0 37' respectively. Find the value of the magnetic declination at the place of observations.

If the annual change is 3' West what would be the magnetic and True bearing of the line four years since the date of the above measurement.

Solution

Magnetic bearing of the line = 327^0 14'

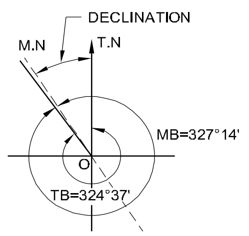
True bearing of the line = 324^0 37'

∴ Declination = 327^0 14' - 324^0 37'

= $2^0$37'

From Fig 4,

Fig 4



declination is west, ie 2^0 37'

Annual variation = 3' west

Variation in 4 years = 4 x 3' = 12' W

Total declination after 4 years

= 2^0 37' + 12'

= 2^0 49' W

True bearing of a line after 4 years

= 324^0 37'

(Same as above)

magnetic bearing after 4 years

= 324^0 37' + 2^0 49'

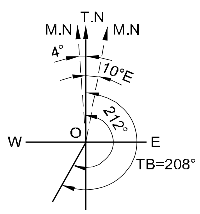
= 327^0 26'

Example 5

A line was drawn as its magnetic bearing 212^0 on an old map when the magnetic declination was 4^0W. To what bearing should if be set now if the present declination is 10^0E.

Solution (Fig 5)

Fig 5



When the declination was 4^0W.

True bearing of the line = Magnetic bearing of the line - declination

= 212^0 - 4^0

= 208^0

When declination is 10^0 East,

Magnetic bearing of the line

= True bearing of the line - declination.

= 208^0 - 10^0

= 198^0

∴ To set the line now to the bearing of 198^0

Example 6

Find the magnetic declination if the magnetic bearing of the sun at noon is

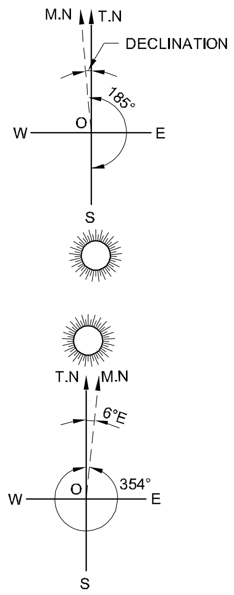
1 185^0

2 354^0

Solution (Fig 6)

Fig 6(i)

Fig 6(ii)



i Magnetic Bearing of the line - 185^0 (Fig 6 (i)

At noon the sun is exactly on the True meridian. Since the magnetic bearing of the sun is 185^0 it is at south pole

Magnetic declination = 185^0 - 180^0 = 5^0 W.

ii Magnetic bearing of the line is 354^0 (Fig. 6(ii))

The magnetic bearing of the True north is 354^0

Magnetic declination = 360^0 - 354^0

= 6^0 to the east of the true meridian.

Magnetic declination = 6^0 E

Exercise

1 The magnetic bearing of a line AB is 125^0. Find its true bearing if the magnetic declination at A is

a 9^0 0'W

b 5^0 30'E

2 The true bearing of a line CD is 138^0 30' Find its magnetic bearing if the magnetic declination at c is

a 5^0 30'W

b 3^0 15'E

3 A line has a true bearing of 255^0 . The declination is 3^0 30' E. Calculate the magnetic bearing on whole circle and reduced bearing systems.

4 Find the magnetic declination if magnetic bearings of the sun at noon, are,

a 182^0 00'

b 178^0 30'

c 359^0 0'

5 The true bearing of a line is N 30^0 30'E compute the magnetic bearing of the line if the magnetic declination is

a 4^0 15'E and

b 5^0 30'W.

Local attraction: A magnetic meridian of a place is established by the magnetic needle which is not attracted by other attractive forces. Always the magnetic needle pointing to the magnetic north.

If the compass is placed under the external attractive forces, like magnetic rock, iron ore, and also by steel structures, rails, electric cables, conveying electric current iron pipes. Iron lamp post etc. may affect the magnetic needle of the compass. Due to these external attractive forces, we cannot able to find the normal position of the magnetic meridian. Such a disturbing force is known as local attraction.

Detection of Local attraction: The local attraction at a particular place can be detected by observing the fore and back bearings of each line and finding its difference. If it differs exactly by 180^0 there is no local attraction at both stations, provided instrumental and observational errors are eliminated. But if the difference is not equal to 180^0 then local attraction exists there either one or both stations.

Elimination of Local attraction

If there is local attraction at a station all the bearings measured at that place will be incorrect. The amount of error will be equal in all the bearings. There are two methods for eliminating the effects of local attraction.

First method

The amount and direction of error due to local attraction at each of the affected station is to be calculated.

If the observed bearings are in the **whole circle system**, then the correction applied by using the following rule after finding the nature of error.

Rule: If at a station, observed bearing of a line is more than that of its correct one, the error at this station is +ve and the correction is -ve and if the error is -ve at this station, the correction is +ve.

If the observed bearings are in the quadrantal system the corrections must be applied in proper direction.

In I and III quadrants the numerical value of bearings increased in clockwise direction and II and IV quadrants they increase in anticlock wise direction. Hence +ve corrections are applied for clockwise and -ve corrections applied for anticlockwise directions.

Example 1

The following bearing was observed in running a closed transverse

Line	FB	BB
AB	75^0 00'	254^0 30'
BC	115^0 30'	296^0 30'
CD	165^0 30'	345^0 30'
DE	225^0 00'	44^0 00'
EA	304^0 30'	125^0 00'

Find the error due to local attraction. Determine the correct bearings.

Solution

Line	FB	BB	Error
AB	75^0 00'	254^0 30'	0^0 30'
BC	115^0 30'	296^0 30'	1^0 00'
CD	165^0 30'	345^0 30'	NIL
DE	225^0 00'	44^0 00'	1^0 00'
EA	304^0 30'	125^0 00'	0^0 30'

From the above calculation we came to know that the stations C and D are free from local attraction and all other stations are having local attractions. Hence the observed bearings at the stations C and D are correct.

Commencing from the fore bearing of 'DE' all other incorrect bearings can be calculated as follows.

Observed F.B of DE = 225^0 00'

Deduct = 180^0 00'

Corrected B.B of DE = 45^0 00'

Observed B.B of DE = 44^0 00'

Error at station E (-) 1^0 00'

Observed FB of EA = $304^0$30'

Correction at station E

= (+) 1^0 00’

Corrected FB of EA = 305^0 30’

Deduct = 180^0 00’

Correct B.B of EA = 125^0 30’

Observed B.B of EA = 125^0 00’

Error at station A (-) 0^0 30’

Observed F.B of AB = 75^0 00’

Correction at station A (+)0^0 30’

Corrected FB of AB = 75^0 30’

Add = 180^0 00’

Corrected BB of AB = 255^0 30’

Observed BB of AB = 254^0 30’

Error at station ‘B’ (-) 1^0 00’

Observed F.B of BC = 115^0 30’

Correction at station ‘B’

= (+) 1^0 00’

Corrected FB of BC = 116^0 30’

Add = 180^0 00’

Corrected B.B of BC = 296^0 30’

Observed B.B of BC’ = 296.30

				Corrected	
Line	F.B	B.B	Correction	FB	BB
AB	75^0 00’	254^0 30’	(+) 0^0 30’ at ‘A’	75^0 30’	255^0 30’
BC	115^0 30’	296^0 30’	(+) 1^0 00’ at ‘B’	116^0 30’	296^0 30’
CD	165^0 30’	345^0 30’	Nil at ‘C’	165^0 30’	345^0 30’
DE	225^0 00’	44^0 00’	Nil at ‘D’	225^0 00’	45^0 00’
EA	304^0 30’	125^0 00’	(+) 1^0 00’ at ‘E’	305^0 30’	125^0 30’

Example 2 : The following bearings were taken in traversing with a compass in a place where local attraction was suspected.

Line	F.B	B.B
AB	N 46^0 00’E	S 46^0 00’W
BC	S 60^0 30’E	N 61^0 30’W
CD	S 10^0 30’E	N 9^0 00’W
DA	N 79^0 00’W	S 79^0 30’E

At what station do you suspect local attraction? Determine the correct bearings of each line.

Solution : If the numerical value of Fore and Back bearings of a line is same there is no local attraction. Examining the above problem the station A and B are free from local attraction. The stations C and D are having local attraction and to be corrected.

Fore and Back bearings of AB are correct.

Fore bearing of BC = S 60^0 30’E

Corrected B.B of BC = N 60^0 30’ W

Observed B.B of BC = N 61^0 30’ W

Difference = (+) 1^0 00’ error at ‘c’

Observed F.B of CD = S 10^0 30’E

Correction at C’ = (-) 1^0 00’

Corrected FB of CD = S 9^0 30’E

Corrected B.B of CD = N 9^0 30’W

Observed B.B of CD = N 9^0 00’ W

Difference (-) 0^0 30’ error at D

Observed F.B of DA = N 79^0 00’W

Correction at D = (+) 0^0 30’

Corrected F.B of DA = N 79^0 30’W

Corrected B.B of DA = S 79^0 30’E

Observed BB of DA = S79^0 30’ E

Hence error at A is NIL.

	Corrected		Remarks	Observed	
Line	F.B	B.B	FB	BB	Correction
AB	N 46^0 00’E	S 46^0 00’W	NIL at ‘A’	N 46^0 00’ E	S 46^0 00’ W
BC	S 60^0 30’E	N 61^0 30’W	NIL at ‘B’	S 60^0 30’ E	N 60^0 30’ W
CD	S 10^0 30’E	N 9^0 00’W	-1^0 00’ at C	S 9^0 30’ E	N 9^0 30’ W
DA	N 79^0 00’W	S 79^0 30’E	+ 0^0 30’ at D	N 79^0 30’ W	S 79^0 30’ E

Example 3

The following bearings were recorded for a closed compass transverse

Line	F.B	B.B
AB	74^0 30’	256^0 00’
BC	107^0 00’	286^0 30’
CD	224^0 30’	44^0 30’
DA	308^0 00’	127^0 00’

Which stations are affected by local attraction. Determine the correct bearings. Find the true bearings if the declination was 2^0 00’ west

Solution

Fore and Back bearings of the line CD differ exactly by 180^0, therefore stations C and D are free from local attraction. Consequently bearings taken at these stations are correct.Fore and back bearings of CD are correct.

F.B of DA = 308^0 00’

Subtract = 180^0 00’

Corrected B.B of DA = 128^0 00’

Observed B.B of DA = 127^0 00’

Difference (-) 1^0 00’ error at A

Observed F.B of AB = 74^0 30’

Correction = (+) 1^0 00’

Corrected F.B of AB = 75^0 30’

Add = 180^0 00’

Corrected B.B of AB = 255^0 30’

Observed B.B of AB = 256^0 00’

Difference (+) 0^0 30’ error at ‘B’

Observe F.B of BC = 107^0 00’

Correction at B = (-)0^0 30’

Corrected F.B of BC = 106^0 30’

Add = 180^0 00’

Corrected B.B of BC = 286^0 30’

Observed B.B of BC = 286^0 30’

Hence O.K

Which agrees to the given B.B of BC observed at the station C which is free from local attraction. Having corrected the bearings of the lines, their true bearings may be determined by subtracting 2^0 00’ from the corrected bearings of the lines, since the magnetic declination is west. The results may be tabulated as follows.

Line	Observer		Correction	Corrected		Declination	True		Remarks
	F.B	B.B		F.B	B.B		F.B	B.B	
AB	74^0 30’	256^0 00’	(+) 1^0 at A	75^0 30’	255^0 30’	Declination being 2^0 00’ W T.B of a line = MB - 2^0	73^0 30’	253^0 30’	Stations C and D are free from local attraction
BC	107^0 00’	286^0 30’	(-) 0^0 30’ at B	106^0 30’	286^0 30’		104^0 30’	284^0 30’	
CD	224^0 30’	44^0 30’	0^0 at C	224^0 30’	44^0 30’		222^0 30’	42^0 30’	
DA	308^0 00’	127^0 00’	0^0 at D	308^0 00’	128^0 00’		306^0 00’	126^0 00’	

Second method

In this method the included angles for all stations are computed from the observed bearings and check it with the sum of theoritical angles and correct the angles. Then commencing from the unaffected line and using these included angles the correct bearings of the successive lines are computed.

Example 4

The observed bearings of the lines AB, BC, CD and DA are as follows, Find which station is free from local attraction and workout the correct bearings.

Line	F.B	B.B
AB	46^0 00’	226^0 00’
BC	119^0 30’	299^0 00’
CD	170^0 00’	351^0 00’
DA	280^0 00’	99^0 30’

Solution : On examining the values of the observed bearings of the lines, it will be seen that Fore and Back bearings of the line AB only differ by 180^0. Stations A and B are therefore both free from local attraction and the observed Fore and Back bearings of AB are correct. Now the true included angles between the lines are computed from the observed bearings of the lines.

From the Fig 1

$\angle$A = 99^0 30’ - 46^0 00 = 53^0 30’

$\angle$B = 226^0 00’ - 119^0 30’ = 106^0 30’

$\angle$C = 299^0 00’ - 170^0 00’ = 129^0 00’

$\angle$D = 351^0 00 - 280^0 00 = 71^0 00’

$\angle$A = 53^0 30’ Theoretical Check

$\angle$B = 106^0 30’ $(2n - 4)\ 90^0$

$\angle$ C = 129^0 00’ $(2 \times 4 – 4)\ 90^0$

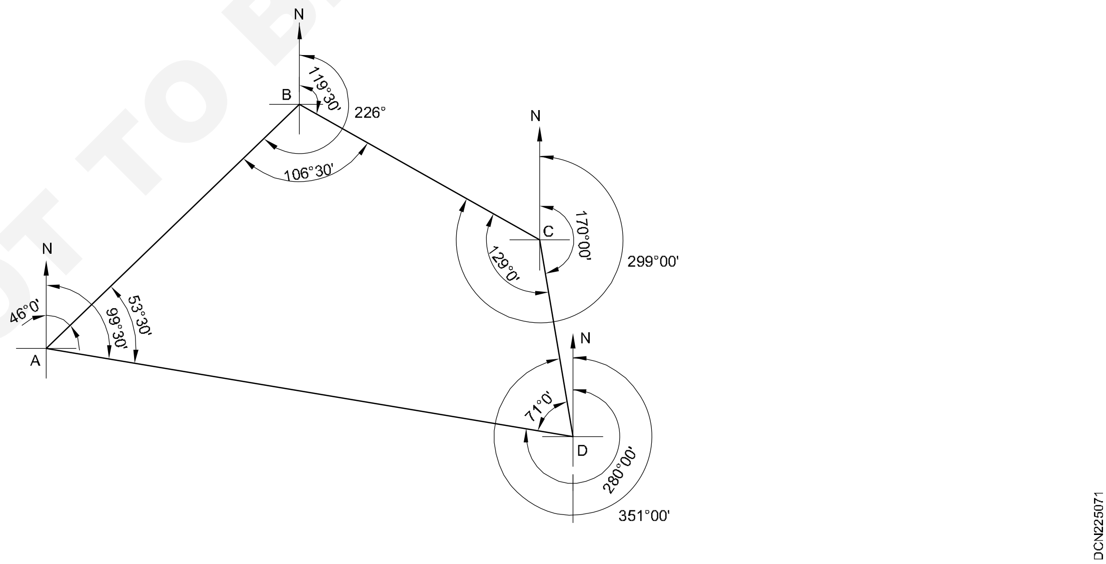
$\angle$ D = 71^0 00’ $4 \times 90^0 = 360^0$

Total 360^0 00′

Fore bearings of AB	=	46^0 00’
Add	=	$180^0$00’
B.B of AB	=	226^0 00
Subtract $\angle$B	=	106^0 30’
Fore bearing of BC	=	119^0 30’
Add	=	180^0 00’
Corrected B.B of BC	=	299^0 30’
Subtract $\angle$ C	=	129^0 00’
Corrected fore bearing of CD	=	170^0 30’
Add	=	$180^0$00’
Corrected B.B of CD	=	350^0 00’
Subtract$\angle$D	=	71^0 00’
Corrected fore Bearing of DA	=	279^0 30’
Subtract	=	180^0 00’
Fore bearing of AB	=	46^0 00’

Which agrees to the given FB of AB observed at station A, which is free from local attraction.

Fig 1



Exercise 1

The following bearings were observed on a compass traverse.

Line	F.B	B.B
AB	80^0 30’	260^0 00’
BC	$130^0$30’	$311^0$30’

CD	240^0 30’	60^0 30’
DA	$290^0$30’	$11^0$00’

Make correction for local attraction and declination of $1^0$30’ W and calculate true bearings.

Exercise 2

The following are the bearings taken on a closed compass traverse.

Line	F.B	B.B
AB	S 37^0 30’E	N 37^0 30’ W
BC	S 43^0 15’W	N 44^0 15’ E
CD	N 73^0 00’W	S 72^0 15’ E
DE	N12^0 45’ E	S13^0 15’ W
EA	N60^0 00’ E	S59^0 00’’ W

Compute the interior angles and correct them for observational errors.

Permissible Error in compass surveying: The Permissible Error should not exceed 7½minute. But due to magnetic changes and variations of declination the error should not exceed 10 minutes.

Plotting of a compass traverse

Before plotting traverse on the drawing sheet, first to draw a rough sketch on the paper.

From this we can able to know the size and shape of the plan and also the best way to arrange it on the drawing sheet.

From the observed bearings, corrected bearings are calculated before plotting.

The following methods are used for plotting a traverse survey.

By parallel meridian through each station (Fig 1)

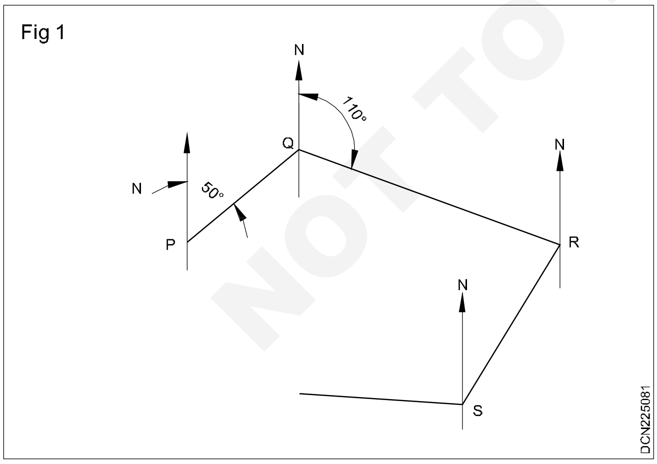


Fig 1

First fix the position of the starting point P on the paper.

From this point P draw the magnetic meridian.

Plot the bearing of the line PQ with the protractor.

Cut the length of the line PQ with suitable scale.

Now the station point Q is fixed.

From Q, draw a line which is parallel P to magnetic meridian.

Plot the bearing of the line QR and cut off the length of line QR.

Repeat the same process until all the lines are drawn.

If the traverse is a closed one the last line must coincide with the starting station P.

If not the error is called as closing error.

By included angle method (Fig 2)

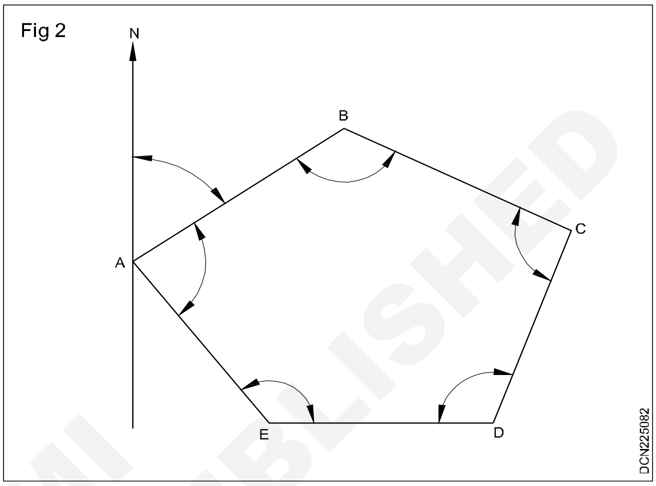


Fig 2

Before plotting the included angle method of the corrected bearings are calculated first, from the observed bearings.

From the corrected bearings, the included angles are calculated.

From the starting station A, draw a line representing the magnetic meridian.

From A, draw the bearing of the line AB, and cut off the length AB according to scale, thus fixing of the station ‘B’

From B draw the included angle ABC.

The same process may be repeated at each successive stations.

By paper protractor (Fig 3)

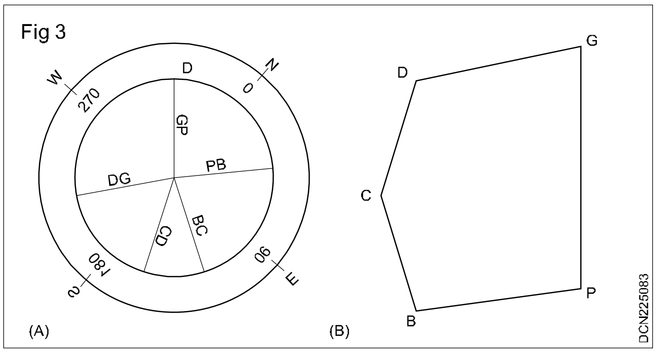


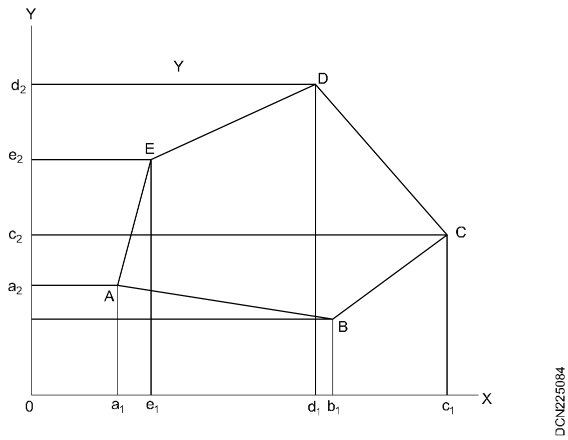
Fig 3

First mark any point ‘O’ on the paper and draw the bearing of each line with reference to the magnetic meridian by using large circular paper protector is shown in Fig a.

Transfer the direction of all the lines to their proper positions and taking length of each lines is shown in Fig b.

By rectangular co-ordinate method (Fig 4)

Fig 4



Firstly, the points of traverse are plotted by their coordinates with respect to x-axis and y-axis. The x axis and y axis are intersecting at 'O'

- The line OX is representing the magnetic meridian.
- Every point is plotted independently with reference to the axes.

Firstly, the co-ordinates of each point are calculated.

This method is mainly used in plotting of traverse by using Theodolite instrument.

- It is more accurate method of plotting.
- In this method the errors are not accumulate.

Closing Error and its graphical Adjustments: While plotting a closed traverse the starting and the ending points will coincide otherwise if the ending points fails to meet with the starting one is called the closing error or error of closure.

> **The closing error occurs due to wrong measurement of lengths and bearing of lines in the field are due to faulty plotting.**
>
> **When the closing error exceeds permissible limit, the field work is repeated. But the error is found to be within the permissible value, the traverse may be adjusted.**

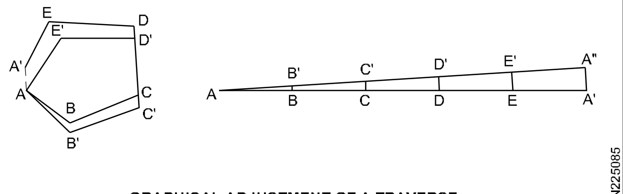
When the angular and linear measurements are of equal precision graphical adjustment of the traverse may be used. This method is based on the Bowditch's rule.

> **The correction may be applied both lengths as well as to bearings of the lines in proportion to their lengths.**

The adjustment of a compass traverse graphically, may be made as under.

Procedure (Fig 5) : Let ABCDEA be a closed traverse as plotted from the observed magnetic bearings and linear measurements of the traverse lengths. A is the starting station and A is the location of the station a as plotted. Hence, A' A is the closing error.

Fig 5



GRAPHICAL ADJUSTMENT OF A TRAVERSE

Adjustment

1. Draw a straight line AA' equal to the perimeter of the traverse to a suitable scale.
2. Draw A'A" parallel and equal to the closing error AA' and join AA".
3. Draw a parallel line through B, C, D and E to meet the B', C', D' and E'
4. Draw parallel lines through the plotted station B, C, D and E and plot the errors equal to BB', CC', DD' and EE' in direction parallel to A'A".
5. Join the points AB'C, D'E A to get the adjusted traverse.

Sources of Error in Compass Survey

The errors in compass instrument may be:

1. Instrumental errors.
2. Errors due to manipulation and sighting.
3. Errors due to external influence.

I Instrumental Error:

1. The needle not being straight.
2. The pivot being bent.
3. The needle having lost is magnetism.
4. The pivot point being blunt.
5. The needle neither moving quite horizontally nor moving freely on the pivot due to the dip of the needle.
6. The plane of sight not being vertical.
7. The vertical hair being to thick or loose.
8. The line of sight not passing through the centre of the graduated circle.

II Errors due to manipulation and slighting

1. Inaccurate centering of the compass
2. Carelessness in reading
3. Carelessness in recording
4. Improper bisecting and ranging.
5. Inaccurate levelling.

III Errors due to external influences.

1. Variations in declination
2. Local attraction

3 Magnetic changes.

4 Irregular variations due to magnetic storms earthquakes etc.

Testing and adjustments of the compass

The compass should be tested and adjusted as explained below.

1 When the compass is levelled the needle or ring should be horizontal if not, slide the rider on the higher end of the needle to make it horizontal.

2 The needle should be sensitive so that it may not come to rest in a direction other than the magnetic meridian. To ascertain if the needle is sluggish, take a reading in any position of the needle being in rest. Then displace the needle by bringing near it a piece of steel or bunch of keys etc. and let it come to rest and then again take the reading.

The reading will be the same if there is no friction on the pivot and the needle is not sluggish. If reading is not the same, then the pivot point should be sharpened by a fine oil stone and the needle should be remagnetised by a bar magnet.

3 To see if the sights are fixed diametrically opposite to each other, stretch a fine horse-hair between the sights. It will pass over the N and S marks.

4 To detect if there be any error due to careless working on external influence, take the fore and back bearing of a line and this differ exactly by 180º if the work is correct and there is no external influence.

Instrument used in Plane table surveying

Objectives : At the end of this lesson you shall be able to
- **state plane tabling**
- **name the instruments and accessories used in plane tabling**
- **state the construction and uses of instruments and accessories of plane tabling**
- **explain about Levelling, centering and orientation in plane tabling**
- **explain the methods of plane tabling.**

Plane tabling: Plane tabling is graphical method of surveying in which field observations and plotting are done simultaneously on a plane table.

It is most suitable for filling in the various details between the stations previously fixed by triangulation.

It is commonly used for preparing small scale mapping or medium size mapping. This type of survey is employed when great accuracy is not required such as Topographical surveys.

Instruments used in plane tabling

- Plane table with Tripod
- Alidade

Accessories used in plane tabling

- Spirit level
- Trough compass
- Plumbing fork with plumb-bob & water proofing cover.

Plane Table with Tripod etc: Plane table is made of well-seasoned good quality teak or pine wood and is available in different sizes.

- Small: 50cm x 40cm x 1.5cm
- Medium: 50cm x 50cm x 1.5cm
- Large: 75cm x 60cm x 1.5cm

It is mounted on a Tripod in such a way that it can be levelled, rotated about a vertical axis and clamped in any position. The upper surface of the board must be perfectly plane. The tripod is generally of the open frame type and can be folded (Fig 1) for convenience of transportation.

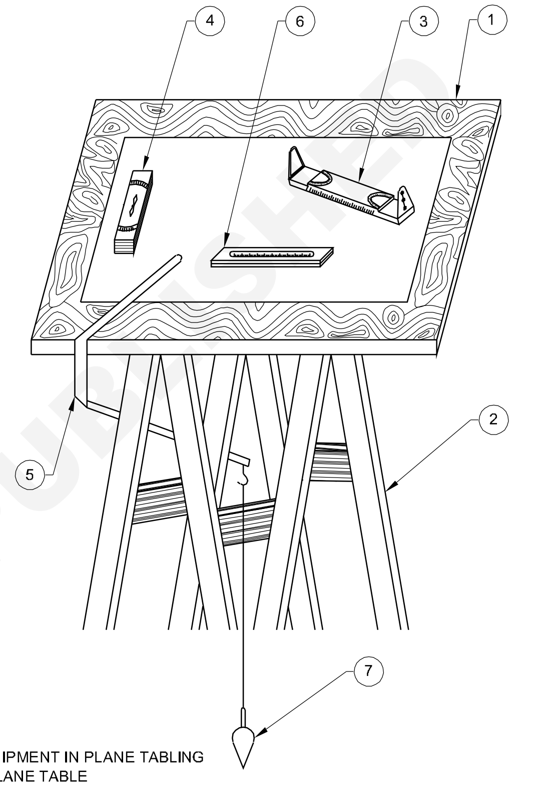
Qualities of a Good Plane Table:

- The butterfly nuts which clamp the legs to the clamping head should not be free.
- The clamping assembly should fit the plate at the bottom of the plane table.

The Alidade: The Alidade is a straight edge with some form of sighting device. Two types of alidades are generally used.

- Plain Alidade
- Telescopic alidade

Fig 1



EQUIPMENT IN PLANE TABLING
1. PLANE TABLE
2. TRIPOD STAND
3. ALIDADE
4. TROUGH COMPASS
5. U-FRAME
6. SPIRIT LEVEL
7. PLUMB-BOB

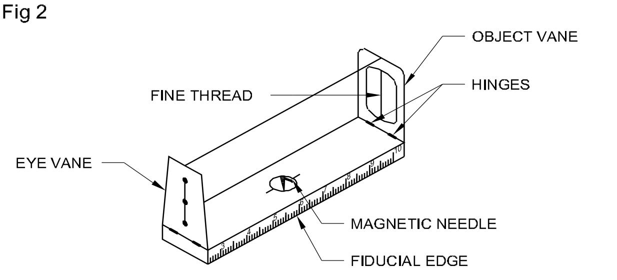
PLANE TABLE

Plain Alidade: It consists of a metal or wooden rule with two vanes at the ends. Vanes are hinged and can be folded on the rule when the alidade is not in use (Fig 2)

One of the vanes known as sight vane is provided with a narrow slit with three holes, one at the top, one at the bottom and one in the middle.

The other vane which is known as object vane is open and carries a hair stretched between the top and bottom of the slit. With the help of the slit, a definite line of sight may be established parallel to the ruling edge of the alidade. The alidade can be rotated about the point which represents the location of the instrument station on the sheet so that the line of sight passes through the station sighted. The two vanes should be perpendicular to the ruler as well as surface of the plane table. The working edge of the alidade is called fiducial edge.

Fig 2

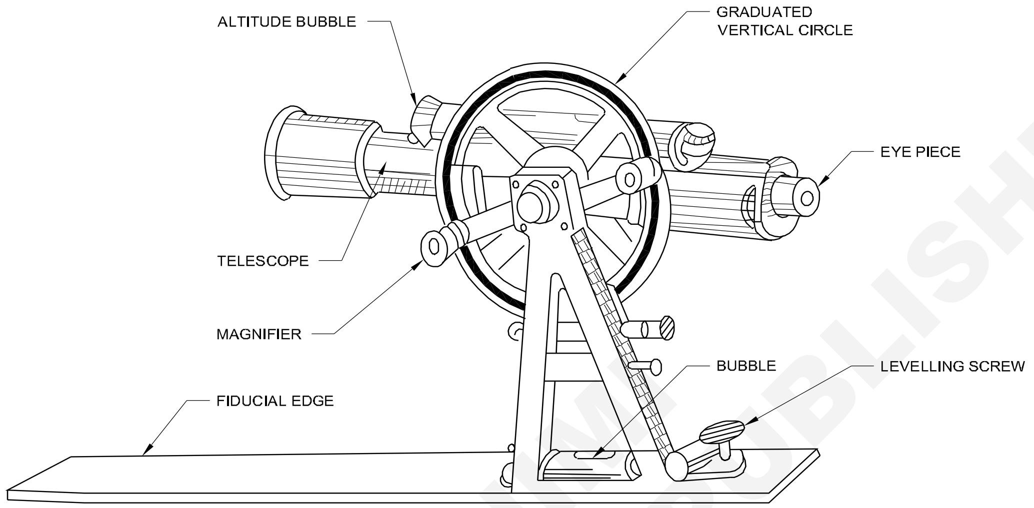


A PLAIN ALIDADE

The plain alidade can be used when the elevations or depressions of the objects are low.

Telescopic Alidade: It is generally used when it is required to take inclined sights. The telescope increases the range and accuracy of the sights. It consists of a small telescope with a level tube. A graduated scale is mounted on a horizontal axis. The horizontal axis rest on a A-frame which is supported on a heavy metal ruler. One side of the ruler is used as working edge. (Fiducial edge) along which lines may be drawn. The angles both elevation and depression can be read on the vertical circle (Fig 3).

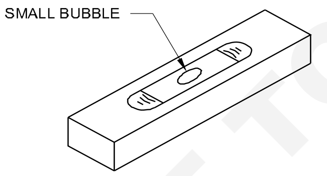
Fig 3



A TELESCOPIC ALIDADE

Sprit Level:A spirit level consists of a small metal tube which contains a small bubble at centre. The Base of spirit level must be flat so that it can be laid on the table. When table remains central, the table is truly level (Fig 4)

Fig 4



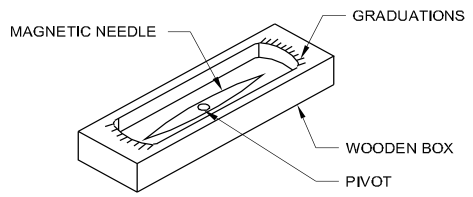
SPIRIT LEVEL

Trough compass or magnetic compass: A box compass consists of a magnetic needle pivoted at its centre freely. It is used for making the direction of the magnetic meridian on the sheet. So it is also used for orienting the plane table to magnetic north. Both the edges of a compass are straight, and bottom surface is flat. The magnetic needle should be fairly sensitive and play freely (Fig 5)

Plumbing fork with bob: The fork consists of a hair pin shaped light metal frame having two arms of equal length, in which a plum-bob is suspended from the end of the lower arm (Fig 6)

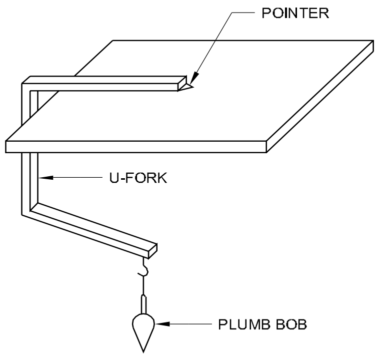
The fitting can be places with the upper arm lying on the top of the table and the lower arm below it, the table being centered when the plumb-bob hangs freely over the ground mark and the pointed end of the upper arm coincides with the equivalent point on the plan.

Fig 5



TROUGH COMPASS

Fig 6



PLUMBING FORK WITH PLUMB BOB

It is used for centering the table over the point or station occupied by the plane table when the plotted position of that point is already known on the sheet. In the beginning of the work it is meant for transferring the ground point on to the sheet so that the plotted point and the ground station are in the same vertical line.

Setting up the plane Table

The setting up the plane table involves three operations.

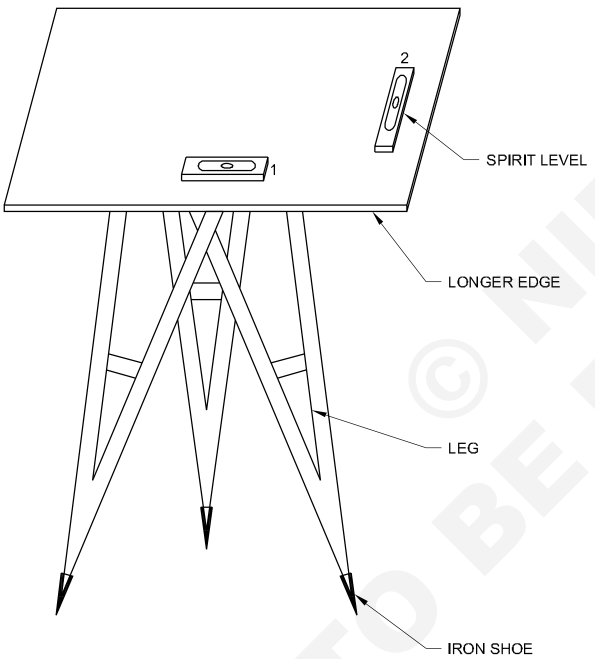
1 Levelling the plane Table

2 Centering the plane Table

3 Orienting the plane Table.

Levelling the plane Table: In this operation, the table top is made truly horizontal. For rough and small scale works, levelling of table can be done by eye estimation, and for large scale works levelling of table can be done by using spirit level. The levelling is specially important in hilly terrain where some of the control points are situated at the higher level and some other at lower level (Fig 7).

Fig 7

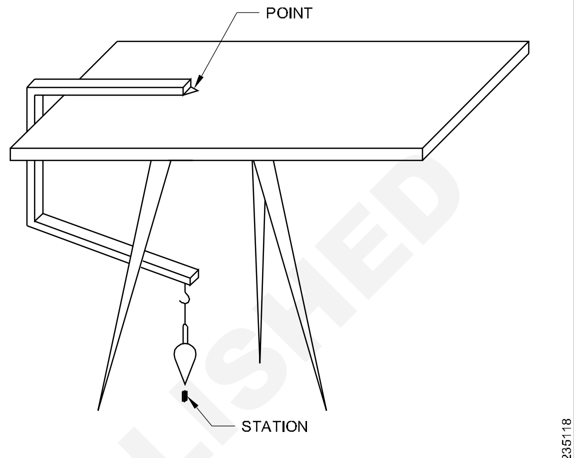


LEVELLING THE PLANE TABLE

Centering the plane Table: In this operation, the location of the plane table station, on the paper is brought exactly vertically above the ground station position. For rough works exact centering of the station is not necessary but for large scale maps and accurate works exact centering is required . (Fig 8)

Orienting the plane table: It is the process of putting the plane table in to some fixed direction so that the line representing a particular direction on the plan is parallel to the direction on the ground. Orientation is necessary when more than one instrument station is to be used. If orientation is not done, the table will not be parallel to itself at different positions resulting in an overall distortion of the map. The process of centering and orientation are dependent on each other. For orientation, the table will have to be rotated about its vertical axis, thus disturbing the centering.

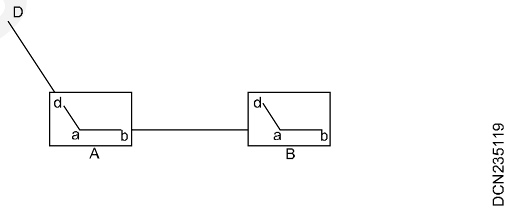
Fig 8



CENTERING THE STATION

Orientation by back sighting (Fig 9)

Fig 9



The table is set up on the station B and it is represented as 'b' on the paper which is plotted by means of a line ab from the back station A. Now, the orientation is bringing ba on the paper over. BA on the ground. Placing of alided on ba, turn the table till the station 'A' is bisected. The clamp the load in this position.

Orientation by magnetic needle

For orientated the table at any station other than the first station, but the trough compass on the meridian already drawn on the paper at the first station and turn the table till the ends of the needle are opposite the zeros of the scale towards north – south direction. At this position clamp the board. This is the quick method but unsuitable for magnetic area.

Method of plane table survey

Objectives : At the end of this lesson you shall be able to
- **methods of plane table survey**
- **radiation method of plane table survey**
- **intersection method of plane table survey.**

The following arethe four methods of plane table survey.

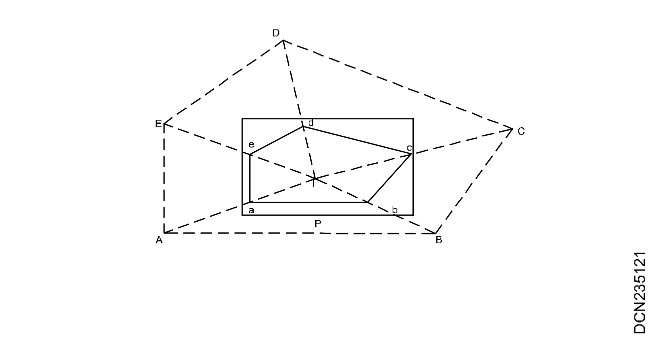
- Radiation
- Intersection
- Traversing

- Resection

Radiation Method

The Plane table is set up at only one station and various points are located by radiating lines drawn from the instrument station to each of the points and plotting to scale along the ray drawn with the distance measured from the station to the point sighted. (Fig 1)

Fig 1



- Select a point P such that all the points to be located are visible from the point.
- Set up and level the table at P and clamp it.
- Select a point ‘p’ on the sheet and make it vertically above ‘P’ on the ground by the use of ‘U’ frame.
- The point ‘p’ represents on the sheet as the station ‘P’ on the ground.
- Mark the direction of the magnetic meridian with the trough compass in the top corner of the sheet.
- With the alidade touching ‘p’ sight the various points A, B, C, D and E etc to be located and draw radial lines towards them along the fiducial edge of the alidade.
- Measure the radial distance PA, PB, PC, PD and PE with the tape.
- Plot the distance to scale along the corresponding rays. Join the points a, b, c, d, e on the sheet.

> **Note: This method is suitable for the survey of small areas which can be commanded from single station.**

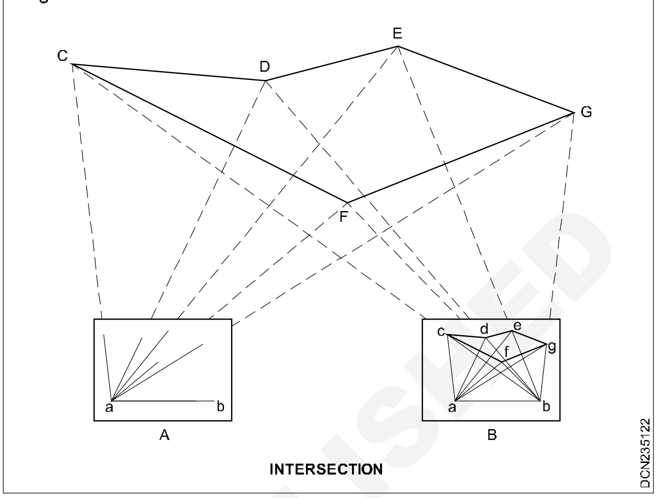
It is also useful in combination with other methods for surveying details within a tape length from the station.

Intersection Method:

- In this method of the positions of the points are fixed on the sheet by the intersection of the rays drawn from two instrument stations.
- The line joining these two stations are termed as base line.
- This is the only linear measurement taken in the field.
- It is largely employed for locating details and for locating the points to be used subsequently as instrument stations.
- It is also used for plotting the distant and inaccessible objects, broken boundaries, river etc.
- It is more suitable for surveying hilly country where it is not possible to measure the horizontal distances, difficult to measure the horizontal distances.

Procedure (Fig 2)

Fig 2



INTERSECTION

- Select two points A and B on the ground, so that all points to be plotted are visible from both the station.
- Set up and level the plane table at station A and mark a suitable point ‘a’ on the paper, so that it is vertically above the instrument station A on the ground.
- Mark the direction of magnetic meridian on the top corner of the sheet by means of a trough compass.
- With the alidade touches on the point ‘a’ sight the station B and other points 1,2,3 etc to be located and draw rays towards them.
- Make the respective lines by letter b, 1,2,3 etc to avoid confusion.
- Measure the base line AB with a steel tape or chain cut off distance ‘ab’ to scale along the ray from ‘a’ B.
- This is the position ‘b’on the sheet of the station ‘B’ on the ground.
- Shift the instrument and set it up and level at ‘B’ such that the point ‘b’ is exactly above the point B on theground.
- Orient the table by placing the alidade along ‘ba’ turning the table till the line of sight stricks ‘A’ and clamp it.
- With the alidade pivoted on ‘b’ draw rays sighting towards the same objects (ie) 1,2,3,4 etc.
- The intersections of these rays with the respective rays from “a” determine the positions of the object 1,2,3,4 on the sheets.

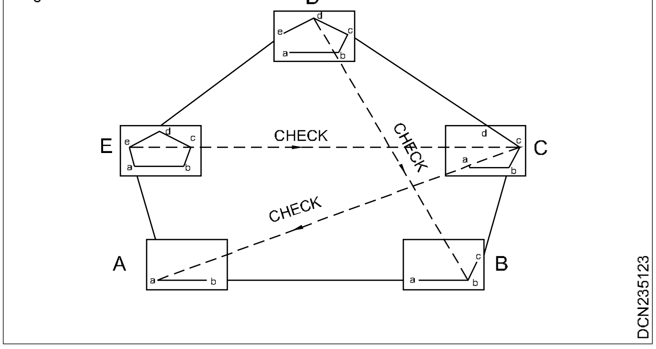
Traversing method of plane table survey

Objectives : At the end of this lesson you shall be able to
- **state traverse method of plane table survey**
- **conduct traverse method of plane table survey.**

Traversing

- This is main method of plane tabling and similar to that of compass or Theodolite traversing.
- It is used for running survey lines of a closed traverse or open traverse. (Fig 1)

Fig 3



- The details may be located by offsets taken in the usual manner (i.e.) by the radiation or by inter section method of plane tabling.

Procedure

- Select the traverse station A, B, C, D etc. on the ground.
- Set up the table over one of them say 'A' select a point 'a' suitably on the sheet. Level and centre the table over 'A'.
- Mark the direction of the magnetic meridian on the top corner to the sheet by means of the trough compass.
- With the alidade touching 'a' sight 'B' and draw a ray.
- Measure the distance AB and Scale off 'ab'. Thus fixing of the position of 'b' on the sheet which represents the station 'B' on the ground.
- Locate the near by details by offsets taken in the usual manner or by radiation and distant objects by intersection method.
- Shift the table and set it up at 'B' with 'b' over 'B' and orient it by placing the alidade along ba, turning the table till the line of sight strikes 'A' and then clamp it.
- With the alidade touching 'b' sight 'C' draw a ray.
- Measure the line BC and cut off 'bc' to scale.
- Locate the surrounding details are taken before in station 'B'.
- Proceed similar to the other stations, in each case orienting by a back sight before taking the forward sight until all the remaining stations are plotted.

Check

- Intermediate checks should be taken wherever possible. If 'A' is visible from C, the work done, up to 'C' can be checked by sighting 'A' with the alidade touching 'C' and noting if the edge touches 'a' similarly other check lines DB, EC etc can be used to the check the work.
- When no other stations are visible from the station occupied, take some well-defined object such as corner of a building which has been previously fixed on the sheet and it should be used to check the work.

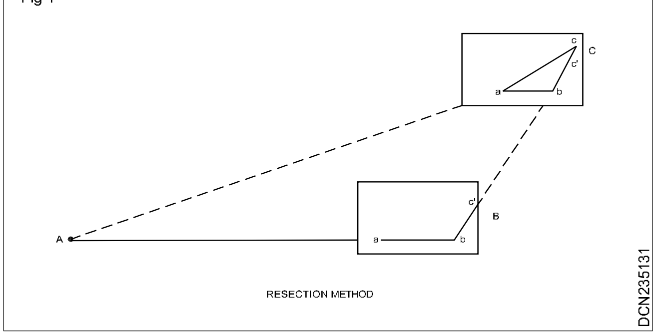
Resection method of plane table survey

Objective : At the end of this lesson you shall be able to
- **state the resection method of plane table survey.**

Resection Method (Fig 1)

- It is used for locating the station points only.
- The main feature of resection is that the point plotted on the sheet is the station occupied by the plane table.
- After stations are fixed the details are taken by radiation or intersection, or sometimes both.
- Select a base line AB on the ground.
- Measure the distance accurately and then plot 'ab' in a convenient position.
- Set up and level the table at 'B' so that 'b' lies vertically above B and orient the table by placing the alidade along 'ab' and turning the table till 'A' is bisected and then clamp it.

Fig 1



- With the alidade touching 'b' sight the station 'C' which is to be plotted by resection and draw a ray.
- Estimate the distance BC by judgement only and move the point 'C' and along a ray to represent the approximate position of 'C'

- Shift the table and set it up with C, on the ground point ‘C’.
- Orient the table by taking back sight on ‘B’ and clamp it.
- With the alidade pivoted on ‘a’ sight the station ‘A’ and draw a ray.
- The point of intersection of this ray and that previously drawn from ‘b’ gives the required point ‘C’ (i.e.) true position of ‘C’.
- It necessary locate the other station in the above manner. It is also know as back ray method.

Locate and plot new building by two point and three point problem

Objectives : At the end of this lesson you shall be able to
- **define about resection**
- **state two and three point problem**
- **describe Lehman’s rule**
- **list out the errors in plane tabling**
- **describe the advantages and disadvantages.**

Resection Method

The process of determining the location of the station points occupied by the plane table, by means of drawing back rays from the stations whose locations have already been plotted on the sheet is called resection.

This method consists of drawing rays from known points whose locations are already available on the sheet. The intersection of these rays will be at a point if the orientation of the table was correct before rays are drawn. The problem, therefore, lies in orienting the table at the unknown occupies station.

It may be solved by any one of the following methods.

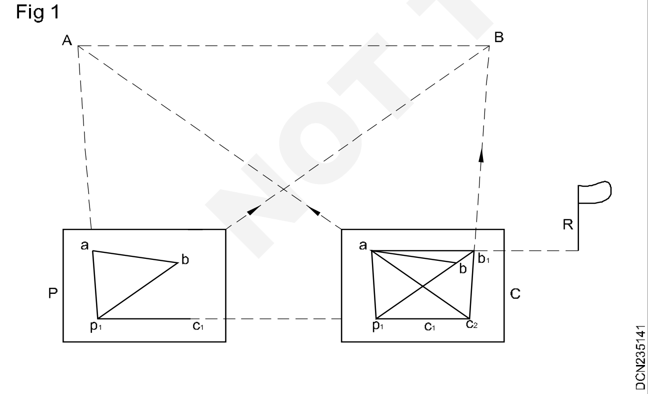
1 Two-point problem

2 Three point problem

Two-point problem: The two-point problem consist in establishing the position of the instrument station on the plan by making sights towards two well defined objects which are visible from the instrument station and whose positions have already been plotted on the plan.

In Fig 1, A and B are the well-defined objects, ‘a’ and ‘b’ their plotted positions on the plan.

Fig 1

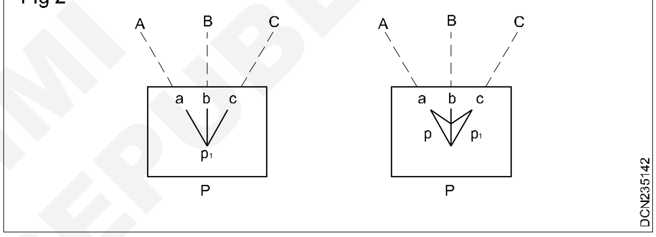


‘C’ is the instrument station and ‘c’ is its required position on the plan. ‘P’ is the helping station to find out the instrument station which is to be occupied by the plane table. ‘R’ is the position of Ranging rod.

Three-point problem: Three point problem consists in establishing the position of the instrument station on the plan by making sights towards three well defined objects which are visible from the instrument station and whose positions have already been plotted on the plan.

Fig 2 shows A, B and C are three well defined objects a, b and c their plotted positions on the plan. P is the instrument station and ‘p’ is its required position the plan.

Fig 2



The three points problem may be solved

1 By mechanical method (Tracing paper method)

2 By graphical method (Bessel’s method)

3 By trial and Error method

Mechanical or Tracing Paper Method: In this method a tracing paper is used over the drawing sheet in which the plotted positions of (a, b and C) the known objects (A, B and C) are drawn. The back rays are drawn on the tracing paper by sighting the known objects. The intersection of the above three rays will give instrument position on the tracing sheet. By unfastening and adjusting the tracing paper over the plotted positions of the object on the drawing sheet will give the new instrument position of the station occupied by the plane table.

Graphical or Bessel’s method: In this method any two of three known object points and its plotted positions on the drawing sheet are taken for solving the problem.

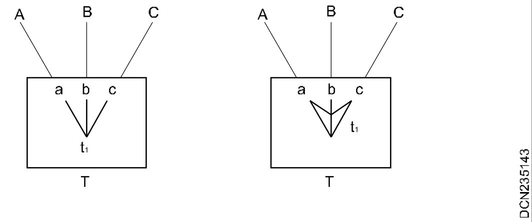
Mechanical Method

It is also called as tracing paper method.

- Set up the plane table at ‘T’
- Orient the table as nearly in its proper position using by trough compass and clamp the board.

- Put the tracing paper over the plane table sheet and select a point 't', on the tracing paper approximately representing the station point 'T' (Fig 3)

Fig 3



- With the help of alidade touching on t1 (pivoted on t1) sight the station points A, B and C and draw rays towards them.
- Unfasten the tracing paper and move it over on the plane table sheet, till the three rays are simultaneously pass through a, b and c. Prick the point t1 on the drawing sheet with fine needle point. The obtained point it is the required point 'T' (Fig 3)
- Remove the tracing paper.
- Unclamp the plane table and orient by placing the alidade ta and turning the board till the station 'A' is bisected.
- For a check, sight the station points B and C with the help of alidade centered on b and c, and draw the rays.

These rays must pass through T if the work is correct. If not, a small triangle error is formed and this may be eliminated by trial and error method.

Bessel's Method

It is the simplest graphical method and is commonly used.

Set up and level the plane table at the instrument station at 'T'.

Turn the table till the station 'P' is sighted. i.e. (P is towards P)

Clamp the plane table.

The alidade is touching r and sight ϕ and draw a ray rϕ (Fig 4 A)

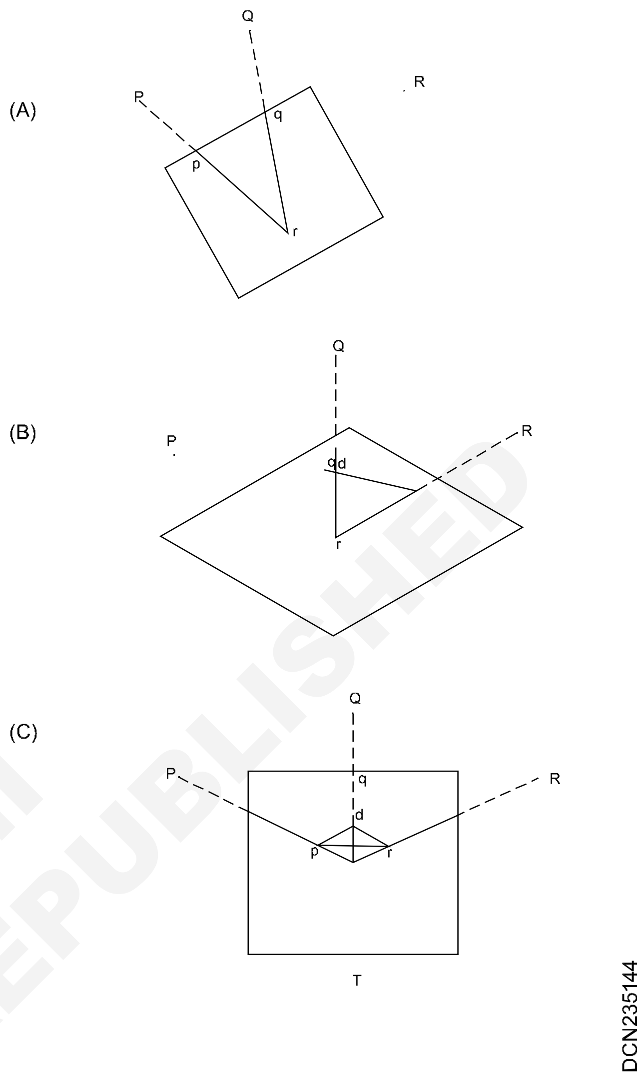
Unclamp the plane table. Put the alidade along rp and turn the plane table till R Station R is bisected. i.e(r is towards R) (Fig 4 B)

The clamp the plane table. The alidade touching on P and sight Q and draw a ray PQ intersecting the previous ray rQ in the point at d.

Put the alidade along dq, turn the plane table till Q is sighted and clamp the table. This is the correction orientation e.e (P must lie on dq and also PQ and Rr. (Fig 4 C)

Put the alidade on P Sight P and draw a ray. This ray will intersecting the ray dq in p which is the instrument station P.

Fig 4



As for the checking purpose, centre the alidade on r and bisect 'R' and draw ray. This ray Rr should pass through P if the work is correct.

By trial and error method: From the above three methods trial and error method is quick and accurate method. It is also known as triangle of error method. The position of the instrument station occupied by the plane table on the drawing sheet is found by Trial and Error method.

In this method the plane table is set up infront of the known object positions A,B and C with the plotted positions as 'a','b' and 'c' on the sheet. The table is roughly oriented by using compass or by eye judgement. Using the alidade and sight the objects through the plotted points respectively and draw back rays. Because of rough orientation the rays will not pass through a single point but will form a small triangle known as triangle error.

By repeated trials, this triangle is eliminated so that the three rays Aa, Bb and Cc pass through one point, which is the required point (p). The position of point (p) is estimated from the triangle of error by the application of Lehmann's Rules.

The triangle formed by joining the ground points A, B and C is called the great triangle. The circle passing through these points is called as the great circle.

Lehmann's Rules

– The distance of the point 'P' from each of the rays, Aa,Bb and Cc is in proportion to the distance of A, B and C from 'p' respectively.

– When looking in the direction of each of the distant points A, B and C the point 'p' will be found on the same side of the three rays Aa, Bb and Cc i.e. it is either to the left or to the right of each of the three rays. (Fig 5 (ii)

– It follows from the above two rules that if the instrument station 'P' lies outside the great triangle 'ABC', the triangle of error falls outside 'abc' and the required point 'p' is outside the triangle of error. (Fig5 (ii) and (iii)

– Similarly if the station P lies with in the great triangle 'ABC' the triangle of error falls inside the triangle 'abc' and the point 'p' must within the triangle of error (Fig 5 (i)

The above rules surface for the solution of the problem, yet two more rules are given for assistance:

– When the station - point 'p' is outside the great circle, the point' p' is always on the same side of the ray drawn to the most distant point as the intersection (e) of other two rays. (Fig 5(ii).

– When the station point' P' is outside the great triangle 'ABC' but inside the greatcircle i.e. within one of the three segments of the great circle, formed by the sides of the great triangles, the ray drawn towards the middle point lies between the point p and the intersection (e) of the other two rays (Fig 5 (iii).

Fig 5

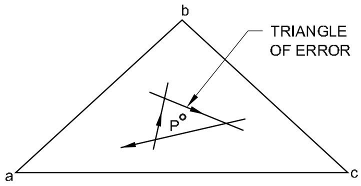


FIG.(i)

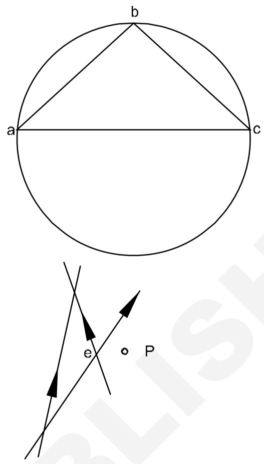


FIG.(ii)

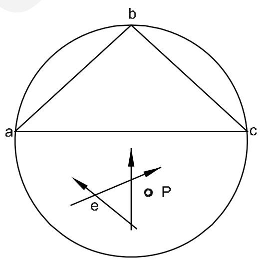


FIG.(iii)

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Errors in plane tabling

The common sources of error in plane tabling are,

1 Instrumental Error

2 Errors or manipulation and sighting

3 Errors of plotting.

Instrumental Error

– The top surface of the board not being a perfect plane

– The edge of the alidade not being a straight line.

– The sights of the alidade not being perpendicular to its base.

– The fittings of table and tripod being loose.

– Error due to defective trough compass.

Errors of manipulation and sighting

– The board not being horizontal

– The table not being accurately centered

– The table not being properly clamped

– The objects not being correctly sighted.

– The alidade not being correctly centered on the station point on the sheet.

– The rays not being accurately drawn through the station point.

– The table not being correctly oriented.

Errors of Plotting

– By using the good quality of paper and stretching it correctly on the board.

– By taking care in drawing and in the use of scales.

Advantages and Disadvantages of plane table surveying

Advantages

– It is the most rapid method.

– Field notes are not required, hence the mistakes in booking is eliminated.
– The angles and linear measurement are not observed since they are obtained graphically.
– As plotting is done directly in the field; there is no chances of omitting necessary measurements.
– The amount of office work is less.
– Checking of plotted details can be done easily on the spot itself.
– The principles of intersection and resection are conveniently used to avoid computation.
– It is less costly than other types of surveys.
– No great skill is required.

Disadvantages

– The absence of field notes is sometimes inconvenient, if the survey is to be replotted to a different scale.
– It is not used for large scale surveys and accurate work.
– The instrument is heavy and having many accessories, being loose are likely to be lost
– In rainy season and cold wind affect the progress of survey.
– This survey cannot be done in dense wooded areas.
– Only day time can be availed for field and plotting works when comparing other types of surveying.

Testing and adjustment of plane table

i The board

The upper surface of the board should a perfect plane.

Test and adjustment

- Check the straight edge in all the directions.
- If the surface of the board is not perfectly plane, remove the parts by sand papering or by planning.

ii The surface of the board should be perpendicular to the vertical axis of the instrument.

Test

- Set up and level the plane table over a station.
- Bringing the bubble in the central position by placing of a spirit level on the table.
- Turn the table through 180º and check the bubble in central or not.
- Then place the spirit level at 90º to the previous position and check the bubble in the central and repeat.
- If the bubble in central on reverse to the vertical axis of the instrument. Therefore, the adjustment is correct.

Adjustment

- If the bubble is not central position, the apparent error (half of the error) by packing between the underside of the board.
- Repeat the same process till the buddle in central after reversal in each case.

iii The Fiducial edge (or) ruling edge of the alidade should be a straight line.

Test

- Select any two points on the drawing sheet at a distance equal to length of the alidade.
- Join these two points along the edge of the with fine line.
- Reverse the alidade (End for end)
- Place the alidade at the end points and draw a line.
- If the two lines are in inner line the alidade is a corrected one.

Adjustment

If not, correct the edge by filling and again testing.

iv The axes of the spirit levels mounted on the alidade should be parallel to the base of the alidade.

Test

- Place the alidade on the table.
- Bring the bubble of one of the levels of the alidade in central by means of foot screws of the table.
- Mark this position of the alidade.
- Lift and reverse the alidade into 180º and replace it with in the mark.
- If the bubble is in central the adjustment is correct.

Adjustment

- If the bubble is not in central, bring the bubble in central by adjusting the half the error by means of level tube and other half by foot screws.
- Repeat the same procedure till the bubble is in centre.
- The same way test and adjust the second level tube.

v The sight vanes of the alidade should be perpendicular to the base of the alidade.

Test

In case of plain alidade

- Suspend a plumb line at a distance from the instrument.
- Place the alidade on the levelled table. Observe the sighting slit and vertical hair of the object vane appear parallel to the plumb line.

Adjustment

- If they are not in parallel to the plumb line, adjust by tilting of the base of the sights. (sometimes packings of the base of the sights also)

In case of telescopic alidade:

Adjustment

1 The line of collimation should be perpendicular to the horizontal axis of the telescope.

2 The horizontal axis must be parallel to the base of the alidade.

3 The vertical circle must zero when the line of sight is horizontal.

4 The axis of the telescope level should be parallel to the line of sight.

General instructions while surveying plane table:

The following points are kept in mind while plane table:

The stations on the ground should be marked A, B, C, D etc to be denoted by corresponding small letters a,b,c,d etc. when plotting on the sheet.

- The plane table should be turned, only on orientation. After orientation the board is clamped in position.
- While sighting objects, the table should be clamped in position. Only the alidade should be moved on the table to bisect the objects.
- The working edge of the alidade (fiducially edge) must touching the plotted station point on the sheet while sights are observed.
- It is advisable the alidade should be centred on the same side of the station pin throughout the survey. keep the alidade on the left of station pin is more idled.
- The drawing should be cleaned as for as possible.

The plane table is always placed in every station which is parallel to the position occupied at the first station, which is called as the principle of plane table.

Always orientation by back sighting is preferred it is most reliable than magnetic needle method.

Carpentary joints - I

Objectives: At the end of this lesson you shall be able to
- **define the term carpentry and joinery**
- **state the different technical terms in carpentry**
- **state the principle of joints**
- **enumerate classification of joints**
- **explain the types of lenthening joint.**

Introduction : Now a days wood is a valuable building material, which is not easily available everywhere, so one has to learn with more care about carpentry joints and fasteners and fixtures. By the study of these a trainee can select a right joint for a right position and to make that joint in the right way.

Technical Terms in Carpentry : The following technical terms are commonly used in carpentry.

Sawing : It is the art of cutting wood by means of a saw.

Shooting : It is the art of dressing of edges of timber pieces as to make them straight and square with the face.

Chamferring : It consists, of taking off the edge or corner of a wooden member. The Chamfered member has a slopping edge which is usually has a slope of 45^0. If the angle of chamfer is other than 45^0 then it is known as a bevel.

Planing : It is the process of taking off the shaving from wood, with the help of a tool known as planer. By planing, timber surfaces are made smooth.

Mitring and scribing : Mitring is the process of joining two wooden members at a angle, if one end of moulding is cut to suite the profile of another moulding it is known as scribing.

Moulding : It is the process of shaping various units of construction either by hand or by machine.

Rebating : It is the process of cutting a rectangular groove on the edge of a timber piece so as to enable the edge or tongue of another timer piece to fit into the former.

Housing : It is the process of sinking of edge of one piece of timber into another by cutting grooves across it grain.

Groove and grooving : Grooving is a term used to indicate a recess formed in a timber member. If the groove is made parallel to the grain, it is known as plough grooving. If the groove is made across the grains, it is known as cross grooving.

Nosing : Nosing is the edge of portion overhanging a vertical surface.

Studding : It is the term applied to the fixing of small timber battens to timber walls to which laths and boards are to be nailed.

Battens : It is a narrow strip of wood which is nailed over joints of boards.

Veneering : It is the process of covering of entire or part of exposed surface of timber by means of veneers for decorative purpose.

Bead : It is the rounded or semicircular moulding provided on the edge or surface of wood.

Principles covering the construction of joint

- Each abutting surface of a joint should be as far as possible, normal to the line of pressure coming upon the joints.
- Each abutting surface of a joint should be designed for the maximum compressive stress likely to come upon it.
- The surface of a joint should be formed and fitted accurately so that there is even distribution of pressure.
- The fastenings, used to connect members may be so proportional that they possess equal strength in relation to the member which they connect.
- The fastening should be placed and designed so as to avoid failure of a joint by shear or crushing.

The joint should be simple as far as possible.

Classification of Joints

Joints are classified into the following six categories.

i Lengthening joints.

ii Widening joints

iii Angle joints

iv Oblique – shouldered joint

v Bearing joint

vi Framed joint.

Lengthening Joint

These joints are also known as longitudinal joints or spliced joints. These joints are used to increase the length of wooden member. The method of lengthening depends upon the situation of a member in a framed structure. Lengthening joints are of various types.

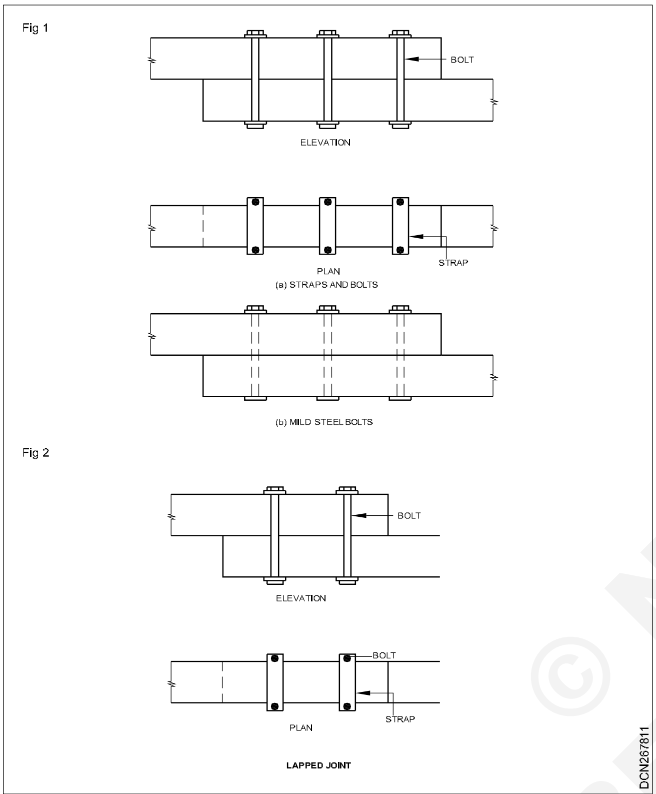
1 Lapped joint

2 Fished joint

3 Scarfied joint

4 Tabled joints

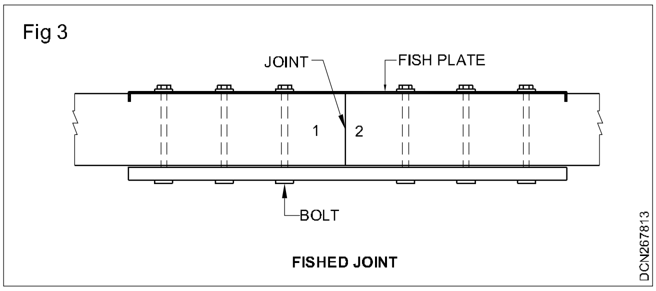
Lapped joint (Fig 1 & 2) : This is the simplest form of joint and is formed by putting two timber pieces one over the other for a short distance and then binding them together by means of iron straps or stirrups, iron straps are provided with bolts on sides for additional strength if the member has to resist a tensile stress, the bolts passing through both the pieces may be provided.

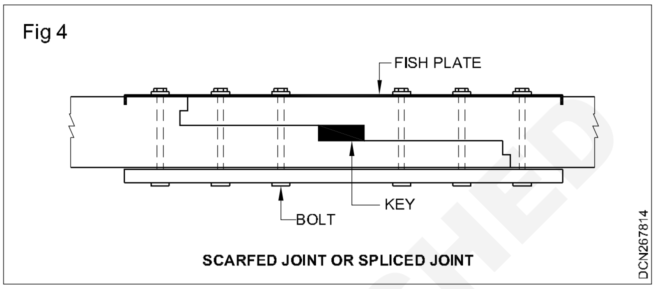


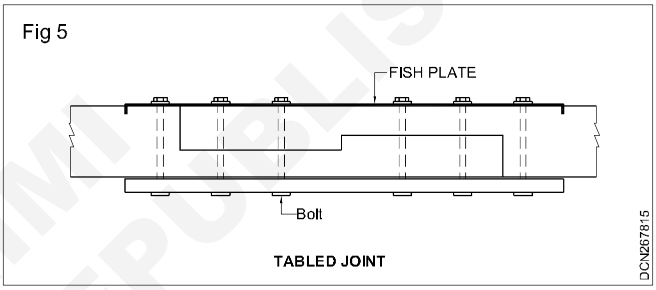
Fished Joint (Fig 3) : In this joint the end of the two members are cut square and placed touching each other. They are then jointed together placing wooden or iron fish plate on opposite faces and securing these by passing boths through them. The bolts are arranged in zig-zag fashion in plan. So that there is only one bolt hole at any cross-section. The ends of fish plate should be slightly bent and pressed into the timber pieces, to increase the strength of joints. Keys and intended fish plates are also provided to the strengthening the joints. It is used for rough and temporary structure such as scaffolding, centering, shoring and form work etc.

Scarfied joint or spliced joint (Fig 4) : In this type of joint, the projections are made at the end of one piece and corresponding depressions are formed on the other piece. Two pieces are then secured together by means of bolts, straps, fish plates and keys. Such joints give good appearance, since the uniform depth of the member is obtained.

Tabled joint (Fig 5) : These joints are formed when the member is subjected to both tension as well as compression. It is similar to spliced joint but is formed by cutting special shape in both pieces and securing then with fish plate, bolts, keys etc.

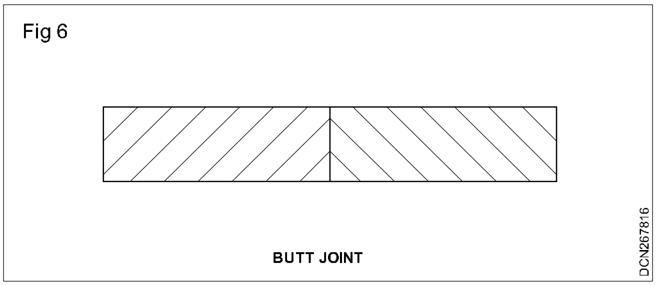






ii Widening Joint : These joints are also called side joints or boarding joints and are used for extending the width of boards or planks. The members are placed edge to edge. These are used for wooden doors, floors, tables etc.

a Butt joints (Fig 6) : These are also known as square plain or ordinary joints are it is used for ordinary purposes.

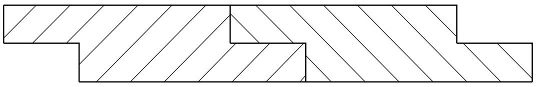


b Rebated joints (Fig 7) : It is formed by overlapping cut portions. The joint remains dust proof after the shrinkage of timber.

Rebated and filleted joints (Fig 8) : It is formed by introducing wooden fillet in the rebated portions, having small depression. It is used for floors of factories etc.

Ploughed and Tongued joint (Fig 9) : It is formed by introducing wooden fillet in the grooves cut in the two pieces.

Fig 7



REBATED JOINT

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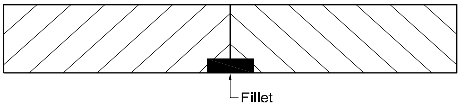
Fig 8



REBATED AND FILLETED JOINT

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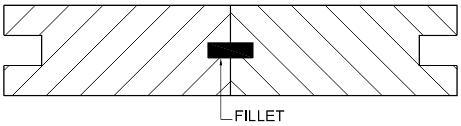
Fig 9



PLOUGHED AND TONGUED JOINT

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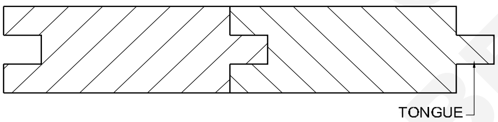
Tongued and grooved joint (Fig 10) : It is formed by making fillet in one piece and groove in the other.

Fig 10



TONGUED AND GROOVED JOINT

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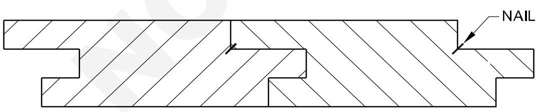
Rebated, tongued and grooved joint (Fig 11) : It is formed by forming a rebate in addition to tongue and groove. Nail is placed in such a way that it cannot be seen.

Fig 11



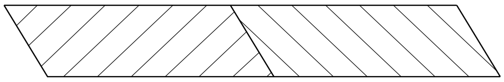
REBATED, TONGUED AND GROOVED JOINT

DCN26781B

Splayed Joint (Fig 12) : It is formed by splaying the ends of the timber pieces. This joint is used for ordinary purpose but it is superior to butt joint.

Dowelled Joint (Fig 13) : It is formed by making grooves in the centre portion at the end of each piece and inserting dowels of gun metal brass, bronze or copper. This joints is very strong.

Fig 12



SPLAYED JOINT

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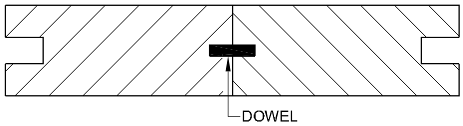
Fig 13



DOWELLED JOINT

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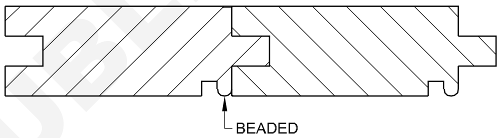
Matched and beaded joint (Fig 14) : This joint is formed by tongued and grooved arrangement and has special moulding on one silde to give good appearance.

Fig 14

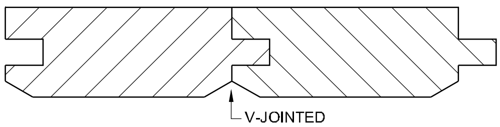


MATCHED AND BEADED JOINT

DCN26781E

Matched and V- Jointed Joint (Fig 15) : This is a similar to the beaded joint expect that it is chamfered in shape of V.

Fig 15



Matched and v-Jointed Joint

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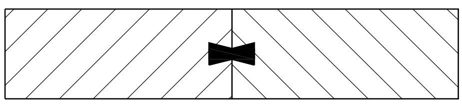
Dovetailed joint (Fig 16)

It is formed by providing dovetail shaped keys to fit in the corresponding grooves in the connecting members.

Fig 16



DOVETAILED JOINT

DCN26781G

Carpentry joints - II

Objectives: At the end of this lesson you shall be able to
- **explain the bearing joints**
- **explain the angled joint (corner joints)**
- **explain different types of fastenings and their uses.**

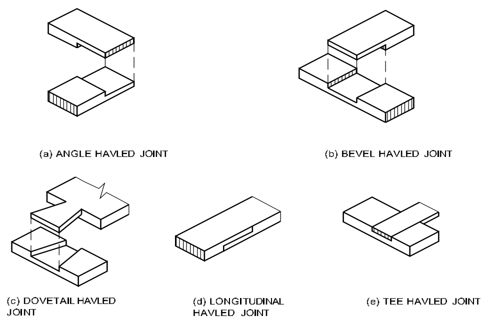
Bearing joint

Bearing joints are provided when two members meet at right angles to each other.

Bearing joints are of the following types

1 Halved Joint (Fig 1)

Fig 1



HALVED JOINT

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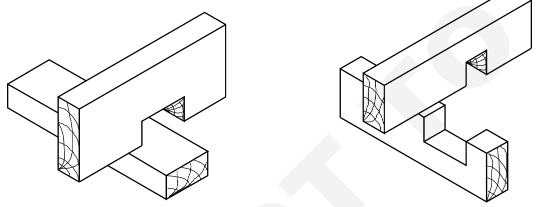
These joints are formed by cutting through half the depth of each member meeting at right angle, so that top surfaces of both the members flush. Various forms of halved joints are angle halved joint, longitudinal halved joint, tee-halved joint, bevelled halved joint and dovetail halved joint.

2 **Notched Joint (Fig 2) :** This joint is formed by cutting notch in one or both pieces. The former is known as single notched joint while the latter is known as double notched joint.

Fig 2



NOTCHED JOINT

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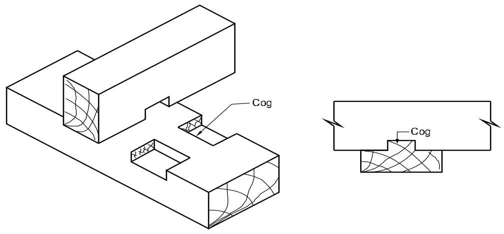
3 **Cogged joint (Fig 3) :** This joint is formed by cutting small notch in the upper timber member and providing notches on the lower member with a projection in the centre. The projection is known as cog. The upper piece in which small notch has been formed, accommodates this cog.

4 **Housed Joint (Fig 4) :** It is formed by fitting the entire thickness of the end of one member for a short distance into another piece. It is used in stairs in which the ends of risers and treads are housed in the strings.

Fig 3



COGGED JOINT

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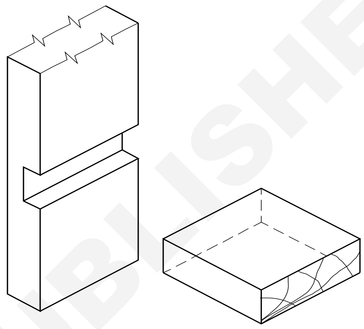
Fig 4

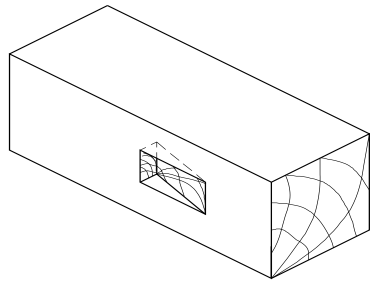


HOUSED JOINT

DCN267824

5 **Chase – Mortise joint (Fig 5) :** This is used for joining a subsidiary member to a primary member already fixed earlier. A wedge shaped recess is formed in the main member while a tenon of corresponding shape is formed in the secondary member.

Fig 5



CHASE-MORTISE JOINT

DCN267825

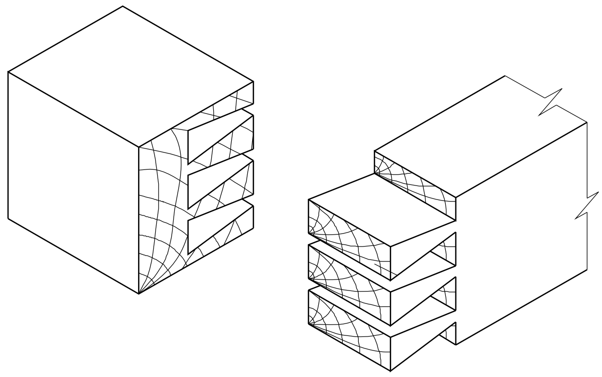
6 **Dove –tailed joint (Fig 6) :** This joint is formed by cutting wedge shaped pieces from each member and by hooking the projection of one member into other. This joint is used for curves of sky-lights and corners of boxes, cabinets, drawers etc.

7 **Mortise and tenon joint (Fig 7) :** This joint is formed by cutting projection known as tongue or tenon in one member which fits into a slot called mortise, cut into the other member.

8 **Joggle or Stump or Stub tenon Joint (Fig 8) :** This is used for framing studs into the sill of wooden

partition all. It is similar to mortice tenon joint except that the tenon is short in length and does not extend for full depth of mortised member.

Fig 6



DOVE-TAILED JOINT

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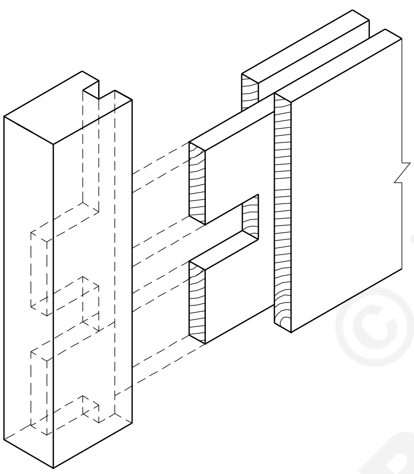
Fig 7



MORTICE AND TENON JOINT

DCN267827

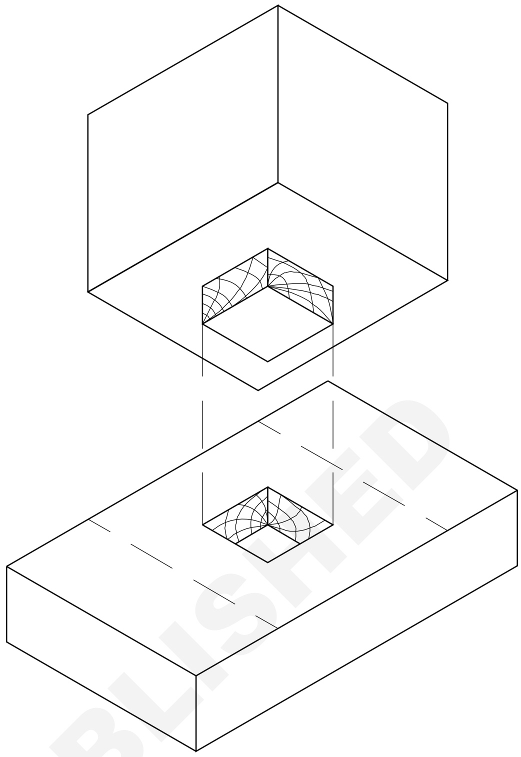
9 **Bridle Joint (Fig 9) :** This joint is commonly used in wooden trusses at the junction of struts and ties. It is formed by cutting a type of mortise at the end of one piece to fit in the bridle or projection left upon another piece.

10 **Fox-tail Wedging joint (Fig 10) :** This joint is formed by cutting a slightly dovetail shaped mortice to have a lesser depth than the member. The tenon is cut and two sockets are made in the tenon in which wedges are inserted. The entire assembly is then inserted in the mortice.

11 **Tusk-tenon joint (Fig 11) :** This joint is very strong and is commonly used to join timber pieces for construction. The joint is formed of tenon, tusk and horn. It is employed for joining members of equal depth, meeting each other at right angle.

Angle Joint (Corner Joint) : Corner Joints are used when two members are to be jointed so as to form a corner or angular edge. These joints are very often secured by nails and glue.

Fig 8



JOGGLE OR STUMP OR STUB TENON JOINT

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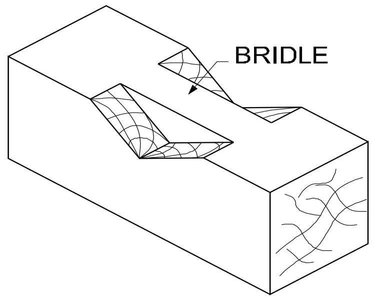
Fig 9



BRIDLE JOINT

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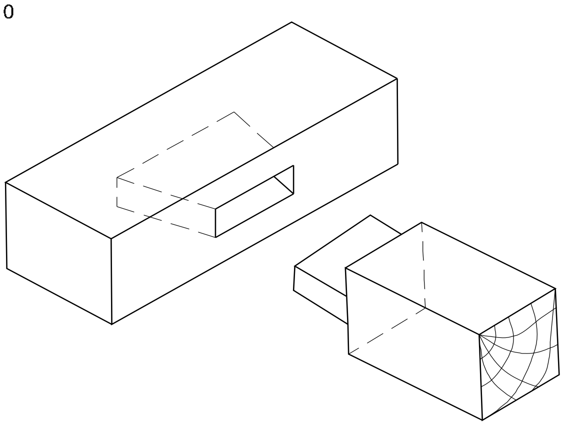
Fig 10



FOX-TAIL WEDJING JOINT

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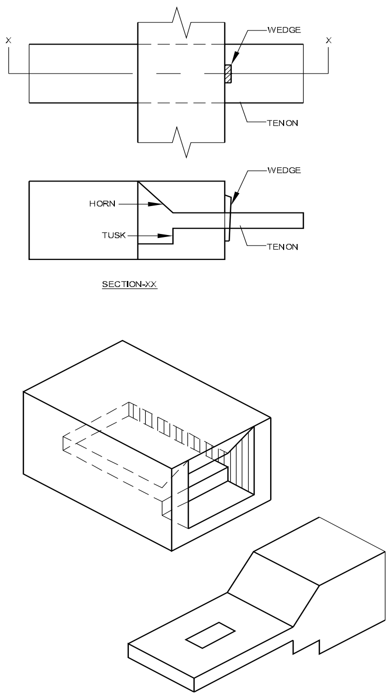
Following are the commonly used angle joints

1 **Butt joint (Fig 12) :** The members are connected by joining them edge to edge. The joints may be rebated

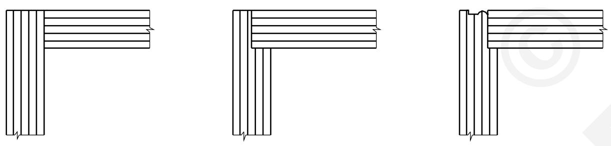
and beaded to give better appearance. The joints may also be tongued.

Fig 11



TUSK-TENON JOINT

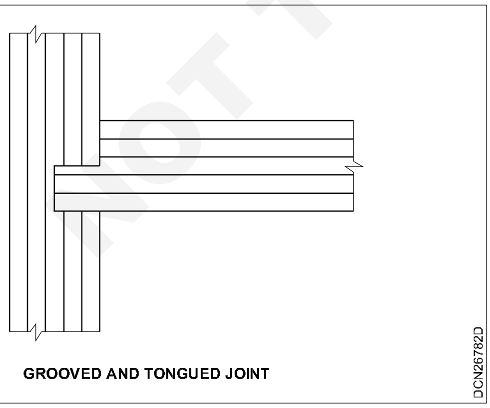
Fig 12



BUTT JOINT

2 **Grooved and tongued joint (Fig 13) :** The joint is formed by fitting the projection of one member into the groove of the other.

Fig 13

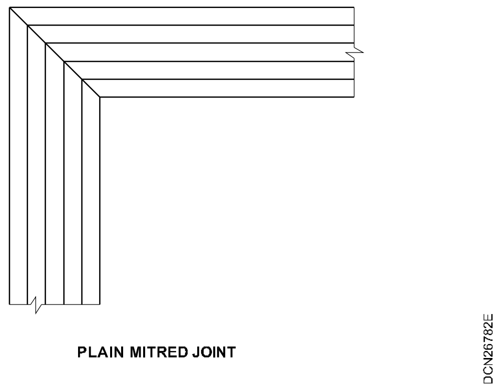


GROOVED AND TONGUED JOINT

3 **Plain Mitred Joint (Fig 14) :** The joint is formed by cutting the edge of both the members by an angle.

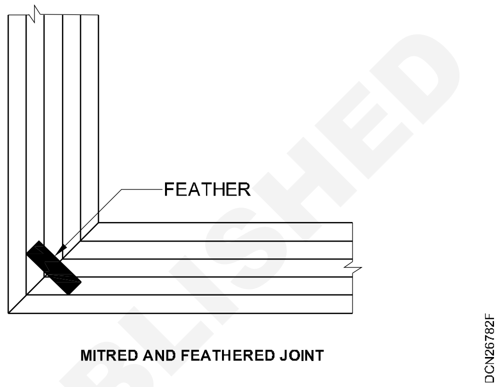
4 **Mitred and feathered joint (Fig 15) :** In this an additional wooden member called feather is inserted in the middle of the mitred joint.

Fig 14



PLAIN MITRED JOINT

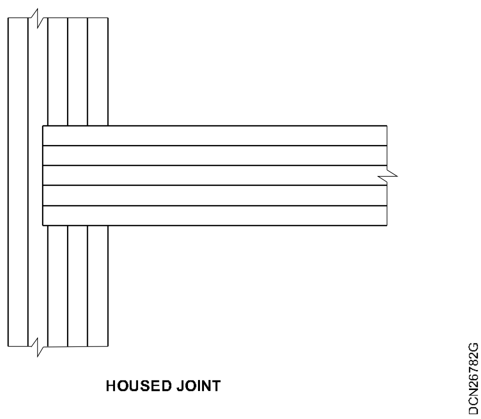
Fig 15



MITRED AND FEATHERED JOINT

5 **Housed Joint (Fig 16) :** The joint is formed by fitting one member completely into the depression of the other.

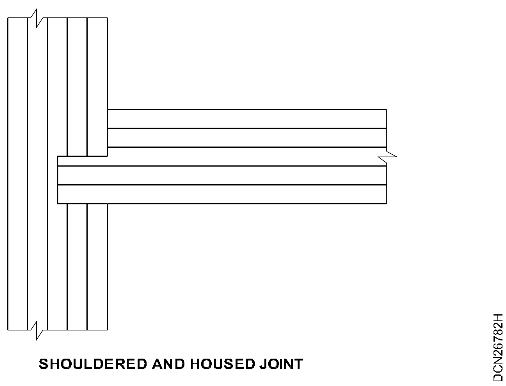
Fig 16



HOUSED JOINT

6 **Shouldered and house joint (Fig 17) :** In this joint only a part of one member is fit into the corresponding depression of the other.

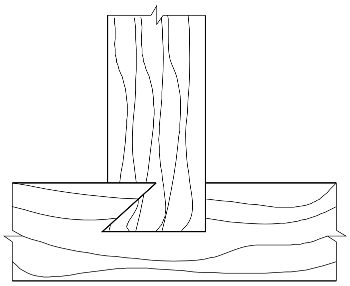
Fig 17



SHOULDERED AND HOUSED JOINT

7 **Dove tailed housed joint (Fig 18) :** This is a special type of housed joint in which one member is housed into the other by dovetail shapped projection and cut.

Fig 18



DOVETAILED HOUSED JOINT

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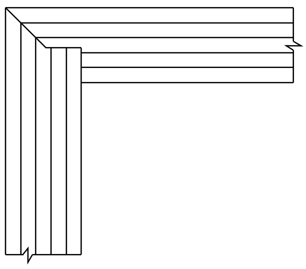
8 **Mitred and rebated joint (Fig 19) :** The joint is formed by using rebate in addition to the mitre.

Fig 19

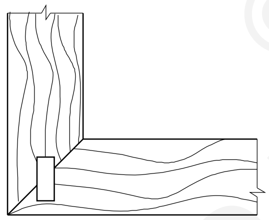


MITRED AND REBATED JOINT

DCN26782J

9 **Mitred, rebated and feathered joint (Fig 20) :** The joint is formed by inserting a feather in the mitred and rebated joint.

Fig 20

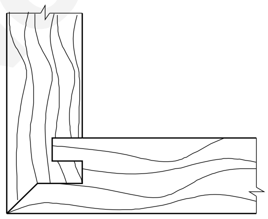


MITRED, REBATED AND FEATHERED JOINT

DCN26782K

10 **Tongued Grooved and Mitred Joint (Fig 21) :** This joint is formed by making tongue and groove in the lower edge of the mitred, to give improved appearance.

Fig 21



TONGUED GROOVED AND MITRED JOINT

DCN26782L

Oblique-shouldered Joint : These joints are used when two members meet at an angle other than right angle, such as in timber truss construction.

Following are the different types of oblique joints

1 Bridle Joint

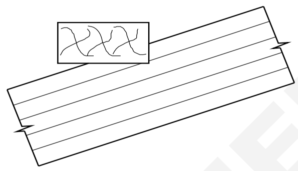
2 Mitred Joint

3 Dove-tailed halved joint

These joints are similar to those discussed earlier except that members will meet at an angle other than right angle

4 **Birds Mouth Joint (Fig 22) :** This joint is formed by cutting angular notch called birds mouth, in the main member to which the other member is partially inserted and fitted.

Fig 22



BIRDS MOUTH JOINT

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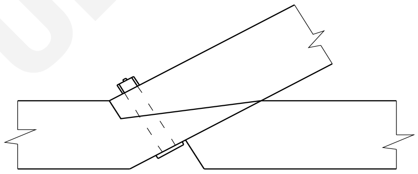
5 **Oblique – tenon Joint (Fig 23) :** This is used for connecting horizontal member to an inclined member, both the members being bigger in size. The tenon of an inclined member is oblique, which is fixed into the corresponding mortise of the horizontal member. The joint is further strengthened by bolt, key, strap etc.

Fig 23



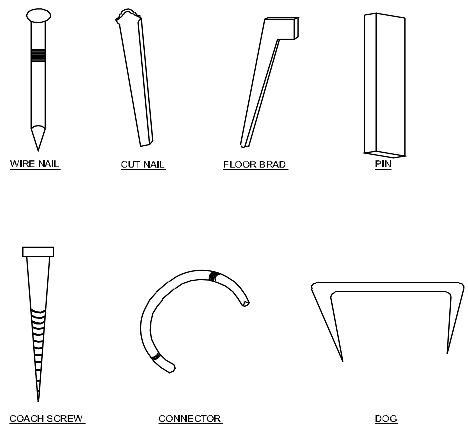
OBLIQUE-TENON JOINT

DCN26782N

Framing Joint : Framing joints are used to construct the frames of doors, windows, ventilators etc. These joints are similar to bearing joints except that they are not supposed to carry stress as compared to bearing joints. To get the desired architectural effects, these joints are suitably modified.

Fastenings and Tools : The timber joints are secured in position with the help of following fastenings. (Fig 24)

Fig 24



FASTENINGS

DCN26782O

1 **Wire-nails:** These are circular or oval in shape made of wrought iron or steel.

2 **Cut-nails:** These are trapezoidal in section, and are smaller in length.

3 **Floor boards:** These are tapering nails of rectangular section with head at one end and are used for securing floor boards.

4 **Pins:** These are small wooden pieces used for securing joints of door and window shutters.

5 **Screws:** They make the joint stronger because of the greater holding power. These may be round headed or counter sunk.

6 **Coach Screw:** It has a square head which is turned by a spanner.

7 **Bolts:** These are used for large size members; Washers are used with nuts to prevent damage to timber.

8 **Spikes:** These are large nails of 10-15cm length used to secure heavy members.

9 **Connectors:** These are metal rings or corrugated sheet pieces which are driven into the member after abutting them.

10 **Dog:** A dog is a v-shaped wrought iron fastening with pointed ends, which is driven to connect the members. It is used for temporary structures.

11 **Dowels:** These are small wooden pieces which are driven in the members to keep their faces in one plane.

12 **Socket:** These are made of wrought iron or cast iron and are used to protect the end of the members. Sockets are called shoes when they are fixed to the bottom end of the member.

13 **Straps:** These are bands of steel or wrought iron which can be used to join two pieces of timber. The breath of strp is about 40mm-50mm and thickness depends upon the stress coming upon it.

14 **Fish plate:** These are wooden or iron plates which are placed on the opposite faces of timber joint. The fish plates are secured in position by bolt passing through the timber pieces.

15 **Wedger:** These are tapering pieces of wood, used in securing mortice and tenon joint.

Types of doors - I

Objectives: At the end of this lesson you shall be able to
- **define doors & windows**
- **explain the features & location of doors & windows**
- **enlist the technical terms**
- **determine size of doors**
- **explain door frame**
- **enumerate types and classifications of doors**
- **explain types of doors according to arrangement of components Introduction.**

A door or window is an unavoidable part of building, which may be a frame work of wood, steel, glass to give access to men, materials, light and ventilation.

Definition

Door may be defined as an openable barrier secured in a wall opening. A door is provided to give an access to the inside of a room of a building.

Basically a door consists of two parts:

1 Door frame and

2 Door shutter.

The door shutter is held in position by the door frame which in turn is fixed in the opening of the wall by means of hold fasts.

A window is also a vented barrier secured in a wall opening. The function of the window is to admit light and air to the inside of building and to give a view to the outside.

A window also consists of two parts:

1 Window Frame.

2 Window shutter.

The frame is secured to the wall opening with the help of hold fasts. And window shutters are held in position by the window frame.

Location of doors and windows

The following points should be kept in mind while locating doors and windows.

1 The number of doors in a room should be kept minimum since large number of doors causes obstruction and consume more area in circulation.

2 The location of door should meet functional requirements of a room. It should not be located in the centre of the length of a wall. A door should preferably be located near the corner of a room, nearly 20cm away from the corner.

3 If there are two doors in a room, then they should preferably be located in opposite walls facing each other, so as to provide good ventilation and free air circulation in the room.

4 The size and number of windows should be decided on the basis of important factors, such a distribution of light control of ventilation and privacy of occupants.

5 The location of a window should also meet the functional requirements of the room such as interior decoration, arrangement of furniture etc.

6 A window should be located in opposite walls, facing door or another window, so that cross ventilation is achieved.

7 From the point of a view of fresh air, a window should be located on the northern side of a room or located in the prevalent direction of wind.

8 The Sill of a window should be located about 70cm-80cm above floor level of the room.

Size of Doors : The size of door should be such that it would allow the movement of largest object and tallest person likely to use. As a rule, the height of door should not be less than 1.80M. The width of door should be such that two persons can pass through it walking shoulder to shoulder. The common widths – height relation used in india is as follows.

1 Width = 0.40 to .0.60 height

2 Height= (width +1.2) metre.

The following are the generally adopted sizes of doors for various types of buildings.

I Doors of residential building.

a External door = 1.00 x 2.00m to 1.10 x 2.00m

b Internal door = 0.90 x 2.00m to 1.00 x 2.00 m

c Doors of bathrooms and closets

= 0.70 x 2.00 to 0.8 x 2.00m

d Carriage of cars

= 2.25m (height) x 2.25m width to 2.25m (height) x 2.40 width

II Public building such as schools, hospitals, libraries, etc.

a 1.2m x 2.00m

b 1.2m x 2.10m

c 1.20m x 2.25m

Indian standard Institution recommends that the size of door frame should be derived after allowing a margin of 5mm all round an opening for convenience of fixing. The width and height of an opening is in directed by no.of modules where each modules is of 100mm.

For example a designation of 8 DS 20 denotes a door opening having width equal to 8 modules (is 8x 100=800 mm) and height=20 modules (is 20 x 100 = 2000 mm) with single shutter.

The letter 'D' denotes a door opening and letter's' stands for single shutter. Illrly the designation 10DT 21 of door opening denotes.

Width of opening = 10 x 100 = 1000 mm

Height of opening = 21 x 100 = 2100 mm

D - Stands for door, T-stands for double shutter. The thickness of shutter shall be 20,25 or 30 mm depending upon size.

Door frame : A door frame is an assembly of horizontal and vertical members forming an enclosure to which door shutters are fixed. The vertical members are known as jambs, posts, while the horizontal top member connecting the posts is called the head which has horns on both sides. The size of the frame is determined by allowing a clearance of 5 mm to both the sides and top of an opening

Door frame are made of following materials.

1 Timber

2 Steel Section.

3 Aluminum section.

4 Concrete.

5 Stone.

Out of these, timber frames are more commonly used. However in factories, workshops etc steel frames are used. Aluminium frames are costlier and are used only for residential buildings where more funds are available. With the increasing cost of timber, concrete frames are more popular in urban areas.

Classifications

According to arrangement of components	On the basis of method of manner of Construction	On the basis of working operation	Metal doors
Battened and ledged doors	Framed and paralled door	Revolving door	Mild steel door
Battened ledged and braced doors	Glazed or sash door	Sliding door	Corrugated steel door
Battened ledged and framed	Flush door	Swing door	Hollow metal door
Battened ledged, braced and framed doors	Louvered doors	Collapsible door	Metal covered plywood door
	Wire gauged doors	Rolling steel shutter door	

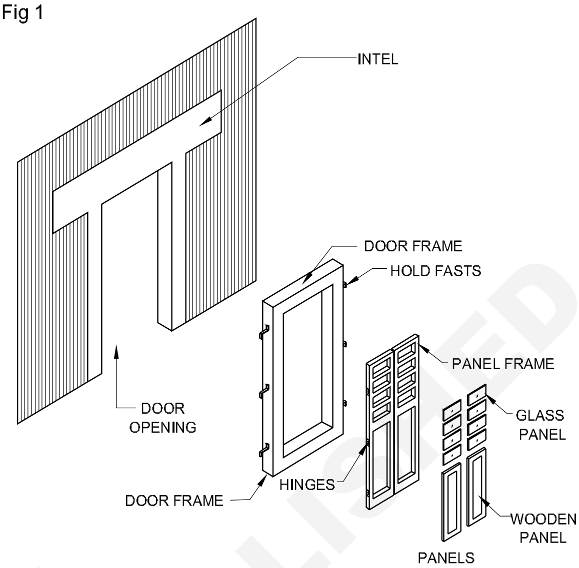
Battened and ledged doors (Fig 4) : This is the simplest type doors, specially suitable for narrow opening when strength and appearance are not important. These doors are formed of vertical boards known as battens which are usually tongued and grooved and are fixed together by horizontal supports known as ledges. Batterns are 10-15cm wide and 20mm-30mm thick. Ledges are generally provided at the top, middle and bottom. The door is hung to the frame by means of T-Hinge of iron.

Battened ledged and braced doors (Fig 5) : These doors are similar to ledged doors except that diagonal members known as braces are provided as shown in figure. The braces are generally 10cm – 15 cm wide and 30 mm thick. The brace give rigidity to the door and hence doors of this types are useful for wide opening. It should be noted that braces must slope upwards from the hanging side as they have to work in compression and not in tension.

Technical terms

Sl No.	Terms	Figure
1	**Frame:** It is an assembly of horizontal and vertical members forming an enclosure to which the shutters are fixed.	
2	**Shutters:** Openable part of a door or window.	
3	**Head:** Topmost horizontal part of a frame.	
4	**Sill:** Lowermost horizontal part of a frame.	
5	**Horn:** Horizontal projection of head or sill.	
6	**Style:** Vertical outside member of the shutter frame.	
7	**Top rail:** Top most horizontal member of a shutter.	
8	**Lock rail:** Middle horizontal member of door a shutter.	
9	**Bottom rail:** Lower most horizontal member of a shutter.	
10	**Cross rail:** Additional horizontal rails, fixed between the top and bottom rails of a shutter.	
11	**Panel:** Area of shutter enclosed between the adjacent rail and styles.	
12	**Mullion:** Vertical member of a frame, which is employed to sub-divide a window or a door.	
13	**Transom:** Horizontal member of a frame which is employed to sub-divide a window opening horizontally.	
14	**Hold fast:** Mild steel flats, generally bent into Z-shape, to fix or hold the frame to the opening.	

Fig 1



DOORS

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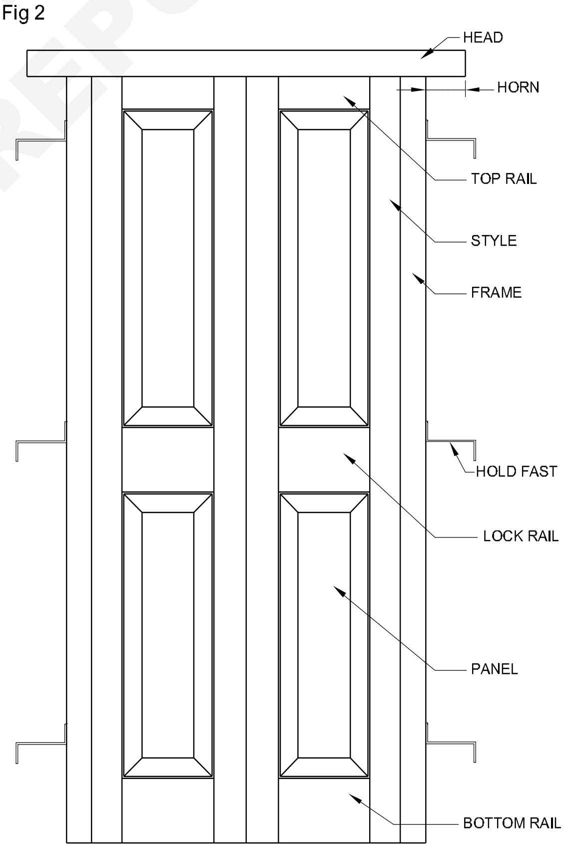
Fig 2



DOOR

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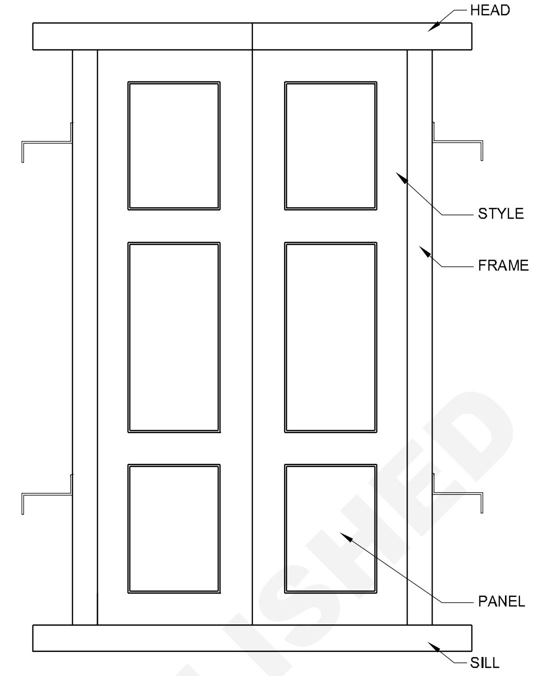
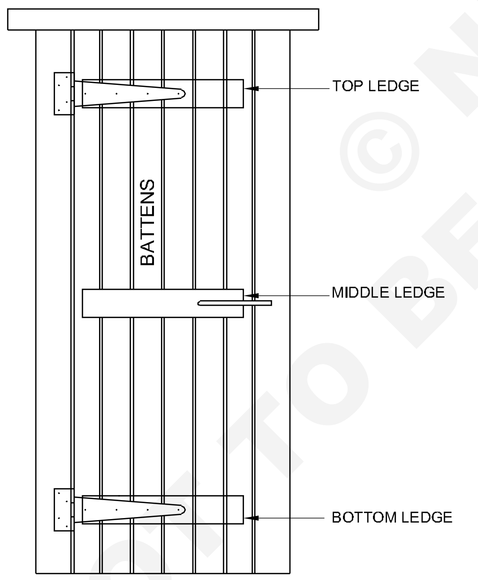
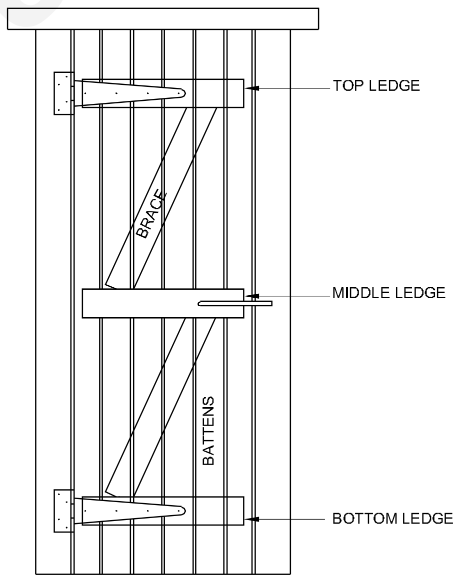
Sl No.	Terms	Figure
15	**Rebate:** Depression or recess made inside the door frame, to receive the door shutter.	Fig 3 
16	**Sash:** Special type of frame, made of light sections and designed to carry glass.	
17	**Louvers:** A piece of timber which is fixed is in inclined position within a frame.	
18	**Architrave:** A strip of wood, usually moulded or splayed which is fixed around the sides and head of opening	

Fig 4



LEDGED DOOR

Fig 5



LEDGED AND BRACED DOOR

Battened ledged and framed doors : In this type of doors a frame work for shutters are provided to make the door stronger and better in appearance as shown in figure. Styles are generally 10cm wide and 40mm thick. The ledges are provided as usual. The total thickness of styles is made equal to the thickness of ledges & thickness of batterns.

Battened ledged framed and braced doors

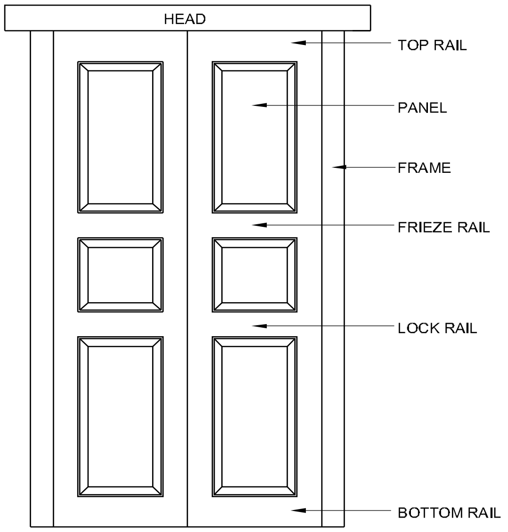
This is just similar to the battened ledged and framed doors, except that brace are introduced. This type of door is durable and stronger and hence it can be used for external use. The brace must stop upward from hanging side.

Types of doors - II

Objectives: At the end of this lesson you shall be able to
- **explain types of door according to manner of construction (framed and panelled door, glazed or sash door)**
- **explain types of door according to manner of construction (flush door, louvered door and wire gauged door)**

Framed and panelled door (Fig 1)

Fig 1



FRAMED AND PANELLED DOOR

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These type of doors are widely used in almost all types of buildings since they are strong and give better appearance than battened doors. This door consists, of frame-work in the form of vertical members called styles and horizontal member called rails which are grooved along the inner edge of the frame to receive the panels. The panels are made from timber, plywood, block boards, A.C sheet or even glasses. Panalled doors are of various types such as.

Single panelled doors

Two panelled doors

Three panelled doors

Multiple panelled doors

Panelled doors may contain single leaf for small opening or may contain two leaves for wider openings. In double leaf door each leaf has separate frames each hinged to the corresponding jamb post of the door.

Features of framed and panelled door : The styles are made continuous from top to bottom that is they are in single pieces.

Various rail (in top rail, bottom rail and intermediate rail) are jointed to the styles at both the ends.

The styles and rails are jointed by tenon and mortised joints.

The bottom and lock rail are made wider than top and frieze rails.

The entire frame is grooved on all the inside face to receive panels.

Additional timber beading is provided on one or both the sides to improve the elevation of the door.

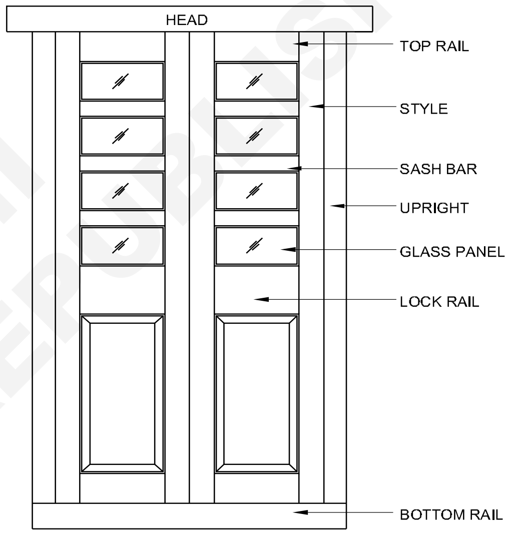
The minimum width of the style is kept as 100mm. The minimum width of bottom rail and top rail is kept as 150mm.

If panels are made timbers, its minimum width should be 150mm and minimum thickness should be 20mm.

However the maximum area of single panel of timber should not be more than $0.5m^2$. These districtions do not apply to panel of plywood, particles boards on hard board.

Glazed or sash door (Fig 2)

Fig 2



GLAZED OR SASH DOOR

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Glazed or sash door are provided where additional light is required to be admitted to the room through the door or where the visibility of the interior of the room is required from the adjacent room. Such doors are commonly used in residential as well as public buildings like hospitals, schools colleges etc. The doors may be within fully glazed or they may be partially glazed and partially paneled. In the letter case the ratio of glazed portion to the paralled portion is kept 2:1 is bottom 1/3rd height is paralled and top 2/3 height is glazed. The glass is required into the rebate provided in the wooden sash bars and secured by rails and putty. Partially glazed doors are sometimes provided with styles which gradually get diminished at lock rail to improve the elevation or to permit more area for the glazed panels. Such style which decrease in width at lock level are called diminishing style or gun stock rail or gun stock style.

Flush Door : Flush doors are becoming popular these days because of their pleasing appearance, simplicity of construction, less cost, and greater durability. They are used both for residential as well as public and commercial buildings. These doors consist of solid or semi-solid skeleton or core covered both sides with plywood, or veneers etc. This door presents a flush and joint less surface which can be neatly polished.

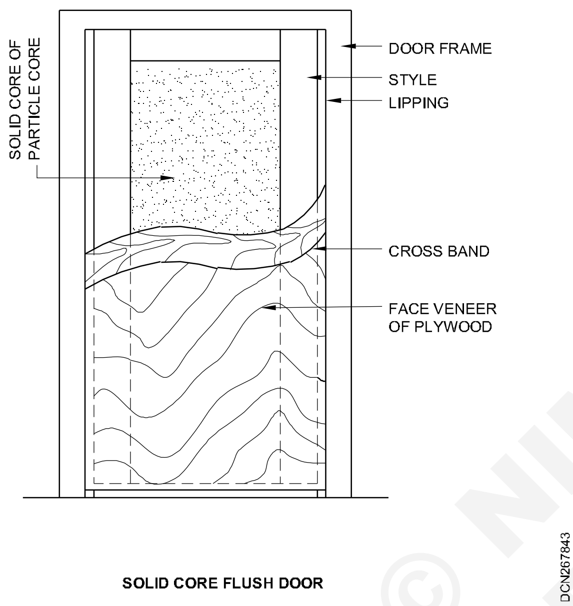
Flush dooors are of two types

a Solid core or laminated core flush door

b Hollow core or cellular core flush door (framed)

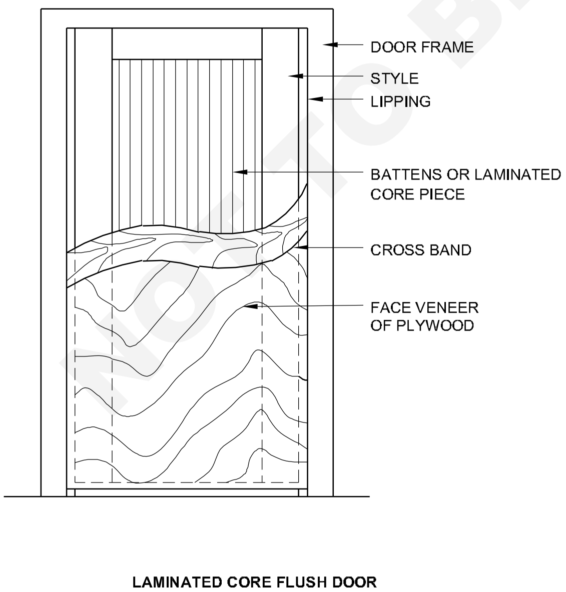
a Solid core or laminated core flush door (Fig 3 & 4)

Fig 3



SOLID CORE FLUSH DOOR

Fig 4



LAMINATED CORE FLUSH DOOR

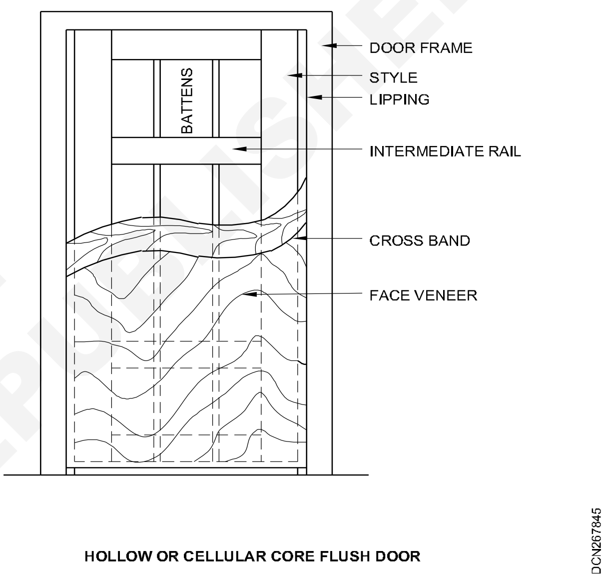
Solid core flush door consists of framework in the form of styles, top and bottom rails of not less than 75 mm width. The inner space of the frame is provided with block board or particle board.

In the laminated core flush door the wooden strips of maximum width 25mm are glued together and length of each strip is equal to the length of the laminated core. It is housed in the outer frame made of styles, top and bottom rails of not less than 75 mm width.

In each type of core, plywood sheets are glued under pressure to the assembly of core housed in the frame on both faces. Alternatively separate cross bands and face veneers can be glued on both the faces, with the grains of core at right angles to that of the cross bands. Such doors are quiet strong but are heavy and require more materials.

b Hollow or cellular core flush door (Framed flush door) (Fig 5)

Fig 5



HOLLOW OR CELLULAR CORE FLUSH DOOR

A hollow core flush door consists of frame made up of styles, top and bottom rails and a minimum of two intermediate rails, each of minimum 75 mm width. The inner spaces of the frame is provided with equally spaced battens each of minimum 25 mm width, such that the area of voids is limited to 500 cm^{2}.

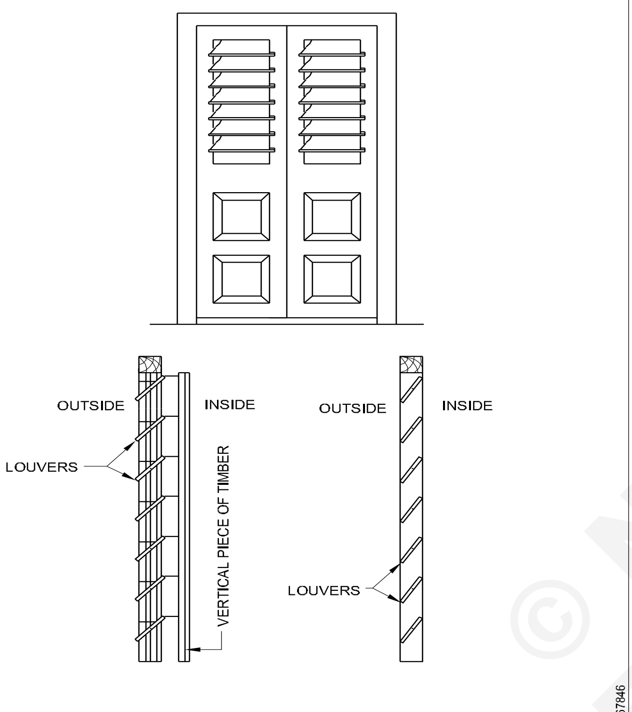
A cellular core flush door consists of frame work made of style, top and bottom rails each of 75 mm width. The voids space is filled with equally spaced battens of wood or plywood, each of minimum 25mm width. The battens are so arranged that the voids space between the adjacent vertical and horizontal batterns does not exceed 25 cm^2 in area. Total area of voids does not exceed 40% of the area of the shutter.

In both types, shutters are formed with, plywood sheets or cross bands and face veneers which are glued under pressure to both the faces of core.

Louvred or Venetian Door (Fig 6) : Louvered doors permit free circulation of air through them and at the same time maintain the privacy of the room. However these doors catch dust which is very difficult to be cleaned. These doors are generally used for latrine and bathrooms of residential and public buildings. The doors may be either louvered to its full height or it may be partially louvered and partially. Panelled. The louverds are arranged and partially paneled. The louvers are arranged at such an inclination that vision is obstructed while they permit free passage of air. This is achieved by fixing the upper back edge of a louver, higher than the lower front edge of the louver just above it. Louvers may be either movable or fixed. In the case of movable louvers, a vertical piece of timber is provided to which louvers are attached through hinges. The movement of louver is activated by the vertical piece of timber. Louvers may be made of either timber or glass or plywood.

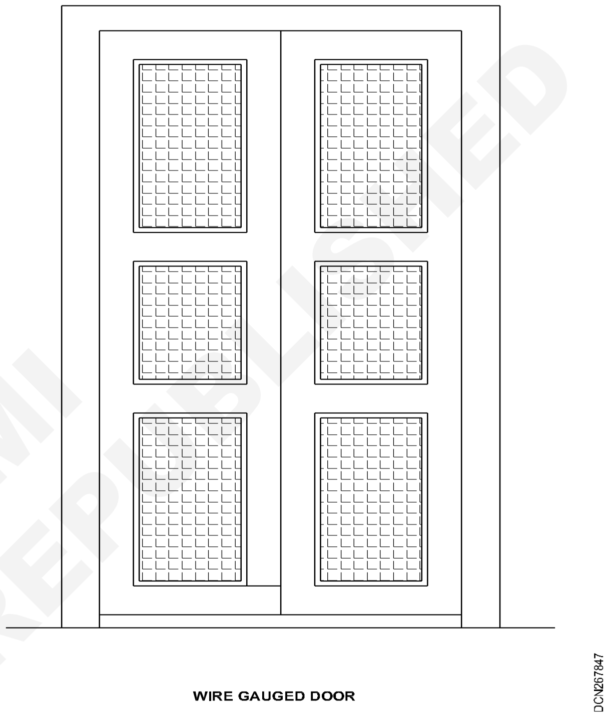
Wire gauged doors (Fig 7) : These types of doors are provided to check the entry of flies, mosquitoes, insects etc. Wire mesh is provided in the panels and therefore they permit free passage of air. Such doors are commonly used for refreshment room, hotels, cup-boards containing estables in sweet shops etc. The door is formed of wooden framework consisting of vertical styles and horizontal rails and the panel opening are provided with fine mesh of galvanized wire gauges. The wire gauge is fixed by means of nails and timber beadings. Generally the door has two shutter is fully panelled and the outer shutter has wire gauged panels.

Fig 6



LOUVERED OR VENITIAN DOOR

Fig 7



WIRE GAUGED DOOR

Types of doors - III

Objectives: At the end of this lesson you shall be able to

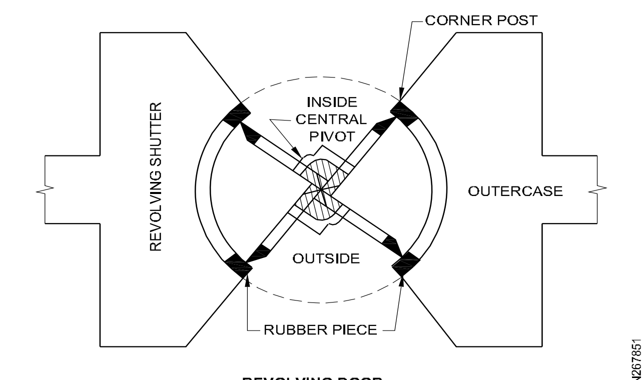
- **explain types of doors according to working operation.**

1 Revolving Doors (Fig 1) : Such doors are provided only in public buildings such as libraries, museums, and banks etc. where there are constant visitors. Such doors provide entrance to one person and exit another person simultaneously and close automatically when not in use. This door is also suitable for air conditioned buildings and buildings at places where strong breeze blow throughout the year, since the door is so assembled that it excludes the wind drought. The door many consist of centrally placed mullion to which four radiating shutters are provided. The mullion or vertical timber is supported on ball bearings at the bottom and has bush bearing at the top so that it rotation is without any jerk, friction and noise. The shutters may be fully glazed, fully paneled or partially glazed and partially paralleled. The shutters and the mullion are enclosed in a vestibule. Vertical rubber piece are provided at the rubbing ends of shutters to prevent draught of air. The radiating shutter can be folded when traffic is more. The opening can also be closed.

Sliding Door (Fig 2) : In this type of door, the shutter slides on the side with help of runner and guide rails. The shutter may be of one or several leaves and can slide either on one side or both the sides. Cavities may be provided in the wall to receive the door in an open position or it may be simply lie touching the wall. As sliding door does not cause any obstruction during movement, it is used for entrance of godowns, sheds, shops, show rooms etc. It is provided with handles, locking arrangement, stopper etc.

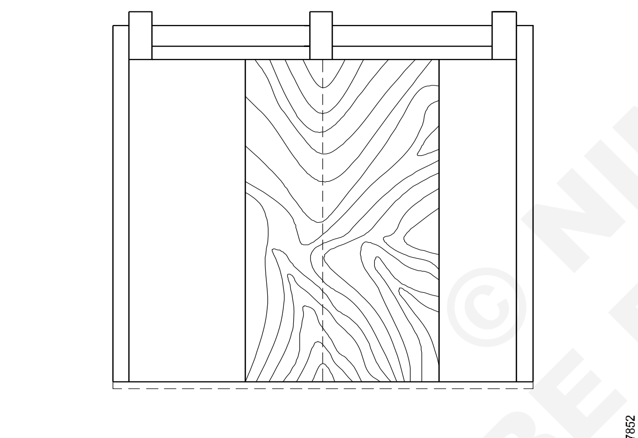
Swing Door (Fig 3) : A swing door has its shutter attached to the door frames by means of special double action spring hinges so that the shutter moves both inward and outward as desired. Generally such doors have single leaf, but two leaves can also be provided. Such doors are not rebated at the meeting styles. The closing edge of which should be segmental when the door is to be used, a sight push is made and the action of spring brings the shutter to closed position. The return of the shutter is with force and hence in order to avoid the accident, either the door should be fully glazed or a peep hole should be provided at the eyelevel as shown in figure 3.

Fig 1



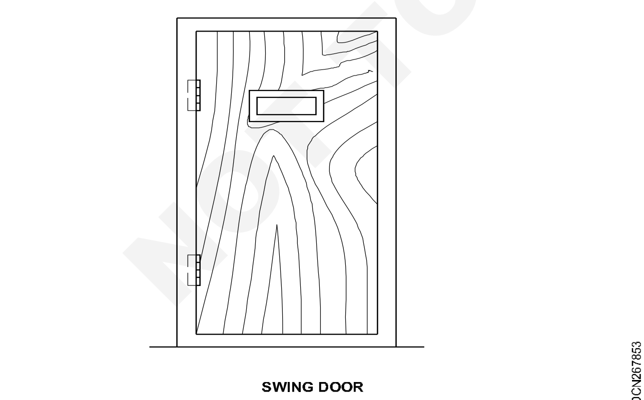
REVOLVING DOOR

Fig 2



SLIDING DOOR

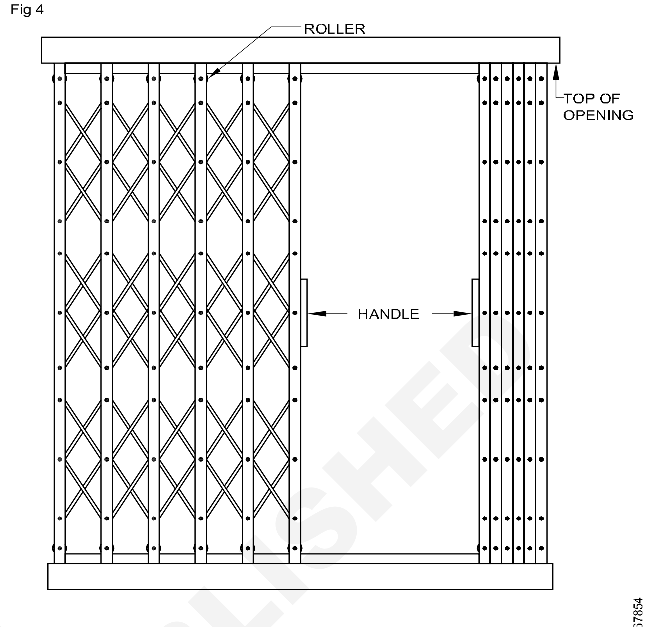
Fig 3



SWING DOOR

Collapsible Steel Door (Fig 4) : A collapsible door may consist of a mild steel frame. Two vertical pieces of mild steel channels about 15 to 20 mm wide are jointed together with the hollow portion of the channel insides; so that a vertical gap is created. Such channel units are spaced at 100-120 mm apart and are braced with flat iron diagonals 10-20mm wide and 5 mm thick. These diagonals allow the shutter to open out or get closed. The door can be opened or closed by a slight push or pull. A collapsible door thus work without hinges. It is used for compound gate, residential building, sheds, godown etc.

Fig 4



COLLAPSIBLE STEEL DOOR

Rolling Steel Shutter (Fig 5) : A rolling steel shutter may consist of a frame, a drum and a shutter of thin steel plate or iron sheet of thickness about 1mm. Grooves of about 25 mm thickness are left in the frame. A horizontal shaft and springs are provided in the drum at the top. The diameter of drum is about 20 cm – 30 cm. The shutters are usually rolled in turns. Thus a slight push or pull will open or closed the shutter.

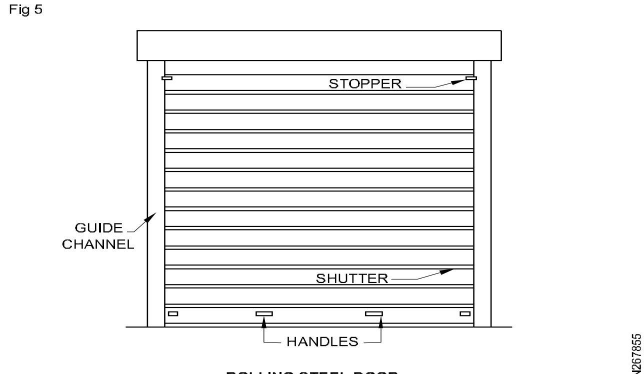
Rolling steel shutter doors are sufficiently strong and they can be easily rolled up or down. They cause no obstruction to the floor as well as openings. Rolled steel shutter door are usually provided for garages, showrooms, shops, godowns etc. They provide security against fire, but the appearance is not good. They cause noise in movement.

Rolling Shutters are two types:

i Pull push type rolling shutters provided for door opening area less than $10m^2$

ii Mechnical gear type rolling shutters provide for door opening are greater than 10 m^2

Fig 5



ROLLING STEEL DOOR

Windows and ventilators

Objectives: At the end of this lesson you shall be able to
- **enumerate factors for selection of size, location & no. of windows in a room**
- **describe Indian standard recommendations of windows**
- **explain different types of windows and ventilators.**

Introduction

Windows: Windows are necessary for ventilation and lighting. These are usually glazed with clear or opaque glasses. As already stated, not less than 10 t0 15 percent of the floor area of a room is given to windows opening to the outside. The smaller the floor area, the larger will be the percentage.

Ventilators

Ventilators are windows of small heights and they are fixed at the top of door or window. The ventilators are provided with glass panels and steel grill is fixed in ventilator for the purpose of safety.

Windows

The selection of size, shape location and no. of windows in a room depends upon the following factors.

1 Size of the room
2 Location of the room
3 Utility of the room
4 Direction of the wall
5 Direction of the wind
6 Climatic conditions such as humidity, temperature etc.
7 Requirement of exterior view
8 Architectural treatment to the exterior of the building.

Based on these factors the following thumb rules are in use.

1 Breath of window = 1/8 (Width of room + Height of room)
2 The total area of window opening normally varies from 10-12% of the floor areas of the room depending upon the climatic conditions.
3 The area of window opening should be at least 1 sq.m for every 30-40 cubic metre of the room volume.
4 In public buildings, the minimum area of window should be 20% of floor areas.
5 For sufficient natural light, the area of the glazed panels should at least be 8-10% of the floor area.

Indian standard recommends that the size of window frame. Should be derived after allowing a margin of 5 mm all round an opening for convenience of fixing. The width and height of an opening is indicated by a number of modules, where each module is of 100 mm. A designation 6ws 12 indicates a window opening with single shutter having width equal to 6 modules.

It, 6 x 100 = 600 mm

And height equal to 12 modules

It, 12 X 100 = 1200 mm

Indian standard recommendations for size of opening size of frame and size of window shutters are given below:

SI No	Designation	Size of Opening	Size of Window frame	Size of window shutters
1	6 WS 12	600 x 1200	590 x 1190	560 x 110
2	10 WT 12	1000 x 1200	990 x1190	460 x 1100
3	12 WT 12	1200 x 1200	1190 x 1190	560 x 1100
4	6 WS 13	600 x 1300	590 x 1290	560 x 1200
5	10 WT 13	1000 x 1300	990 x 1290	460 x 1200
6	12 WT 13	1200 x 1300	1190 x 1290	560 x 1200

Types of Windows

The Common Verities of windows used in building construction are as follows:

1 Fixed Window
2 Pivoted window
3 Double hung window
4 Casement window

5 Sliding window

6 Sash window

7 Louvered window

8 Metal window

9 Bay window

10 Clerestorey window

11 Dormer window

12 Corner window

13 Gable window

14 lantern window

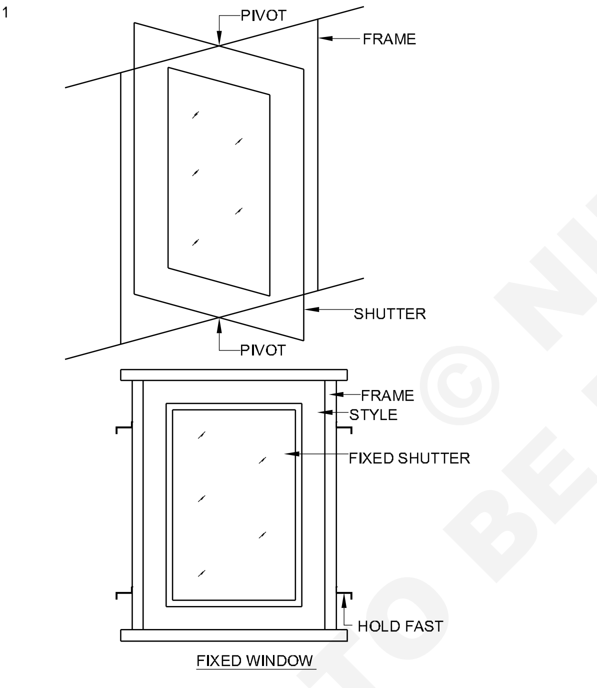
15 Sky lights

16 Ventilators

17 Combined windows and Ventilators.

Fixed Window (Fig 1)

Fig 1



FIXED WINDOW

PIVOTED WINDOW

These windows are provided for the only purpose of admitting light and providing vision in the room. This window may consist of a window frame to which shutters are fixed. No rebate are provided to the window frame. The shutters are fully glazed.

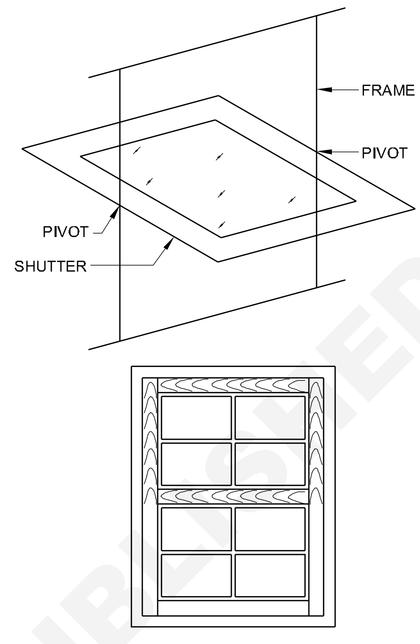
Pivoted window (Fig 1)

In this type of window the shutter is capable of rotating about a pivot fixed to window frame. The window frame has no rebate. The shutter can rotate horizontally or vertically depending upon the position of pivot.

Double – hung window (Fig 2)

This type of window consist of a pair of shutters arranged one above the other which can slide vertically within the grooves provided in the frame. A pair of metal weights connected by chain passing over pulleys, is provided for each shutter. By this arrangement the window can be opened at top or bottom to the desired extent by pulling the metal weight suitably. Thus in this type of window, it is possible to have controlled ventilation. In addition, the shutter can also be cleaned easily.

Fig 2

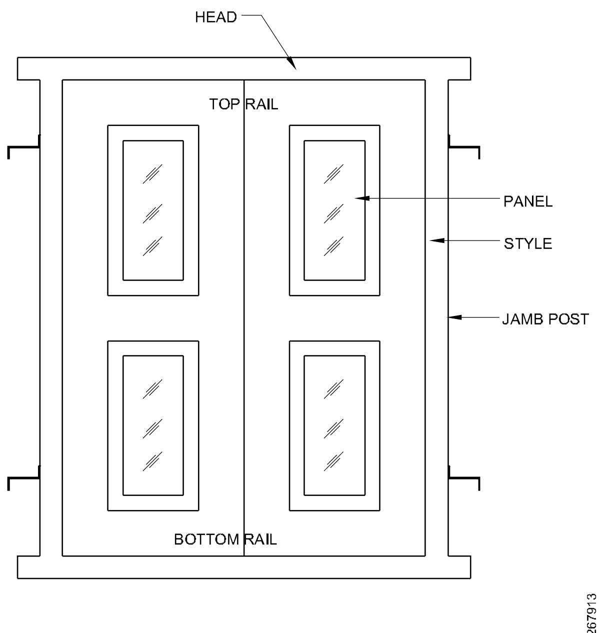


DOUBLE - HUNG WINDOW

PIVOTED WINDOW

Casement window (Fig 3)

Fig 3



CASEMENT WINDOW

Window where shutters open like door are called casement windows. The window has a frame which is rebated to receiving the shutters. The shutters consist of style, top rail, bottom rail and intermediate rail, thus dividing it into panels. The panel may be glazed or unglazed or partially unglazed. In case of windows with double shutters, the outer shutter may have wire-gauged panels.

Sliding Window

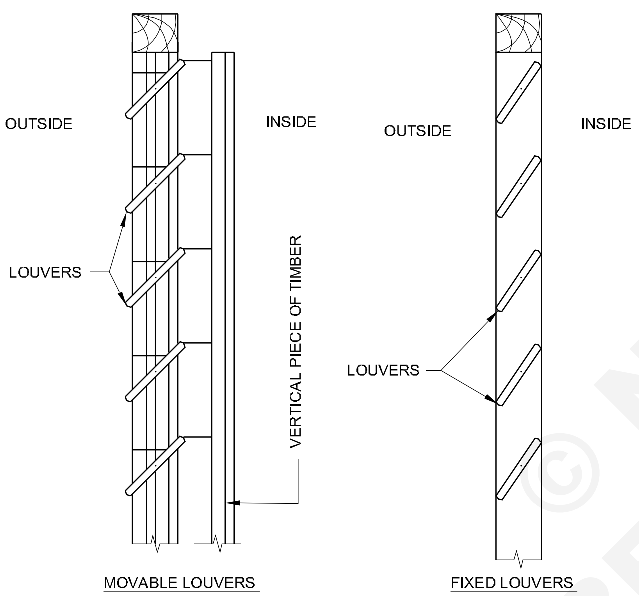
In this type of window the shutters move on roller and can slide horizontally or vertically similar to sliding door.

Sash or glazed window

In this case the window shutter consists two vertical styles, top and bottom rails. The panel space of window shutter between the style and rail is fixing divided by sash bars into panels of small size for fixing glass panels. The glass panels are secured in position either by putty or by fillets, known as glazing beads.

Louvered window (Venetian window) (Fig 4)

Fig 4



LOUVERED WINDOW (VENETIAN WINDOW)

In this type of windows the lowers are provided as in the case of louvered doors. They allow free passage or air when close and at the same time they maintain sufficient privacy. The shutter consists of top rail, bottom rail and two styles; which are grooved to receive the louvers. The economical angle of inclination of the louvers is 45^0 and they are generally fixed in position.

Metal window

These are now a day's widely used especially in public buildings. Windows are made of metals like mild steel, glavanised mild steel, aluminimum, bronze, stainless steel etc. Bronze, aluminium and stainless steel are considered to be the best as they process high degree of elegance, finishing, durability and are dust-proof as well. Mild steel being cheapest of the above metals, steel window works out to be the most economical. Hence steel windows are extensively used in all types of buildings.

Steel window can be fixed direct in the masonry opening in the wall or it may be fitted in a wooden frame fixed in a window opening in the wall. It should be ensured that no load of the wall etc, is transferred to the window frame. For this it is usual practice to keep the size of the window opening slightly more than that of window frame. Also the frame may be fixed in the opening after the masonry work is complete.

Method of fixing metal windows (Steel windows)

The prepared opening in which steel window frame is to be fixed is cleaned and exact position of the window frame is marked by drawing lines.

The distance of fixing holes on the frame are measured and these positions are marked on the chalk line drawn in the opening.

Holes are cut in brick masonry of size 5 m^2 and 5-10cm deep to accommodate hold fast or legs. In case of stone masonry or R.C.C work where it is difficult to cut holes for legs, wooden plugs are embedded at appropriate places during the construction itself. The window frame is then fixed to these plugs with the help of galvanized iron or wood screws.

The frame is placed in the opening and position is adjusted in correct alignment by striking wooden wedges in correct position. Since there is a little gap between the opening and window frame temporary wooden wedges can be easily driven after adjusting the window in correct alignment the legs are screwed light in the frame.

Legs are grouted into the holes with cement mortar. After grout has set, wooden wedges are removed and space between the opening and frame is filled with cement mortar.

Following precaution is to be taken in metal windows

The members of the frame and sash should be properly welded at corners.

Precaution should be taken to prevent the corrosion of metal windows.

Glasses panels should be properly fixed.

The metal frame should be embedded in cement or bituminous mastic to prevent the entry of moisture on rain water.

It is advisable to check and slightly adjust the movement of shutter before erecting the window in the opening.

The handles to the window should be fixed before doing the glazing work.

Scaffolding members or any other support should not be tilt down the metal windows. Otherwise the window will be damaged.

The masonry opening to receive the metal window should be prepared in proper level and plumb.

Following are the advantages of steel windows over wooden windows

The steel windows are factory made products and hence they possess greater precision as compared to the wooden windows.

The steel windows are not subjected to contraction and expansion due to whether effects as sin the case of wooden windows.

The steel windows exhibit elegant appearance.

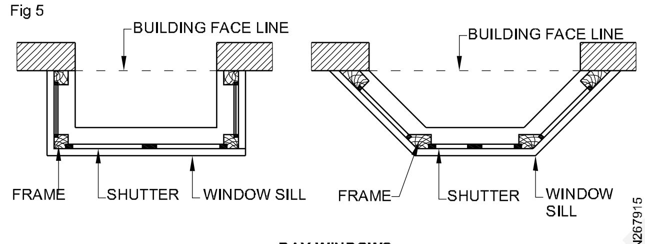
The members of steel windows are narrow and hence the steel windows admit more light and ventilation for the same area as compared to the wooden windows.

The steel windows are highly termite proof and fire proof.

Steel windows are more durable and stronger as compared to wooden windows.

Bay windows (Fig 5)

Fig 5

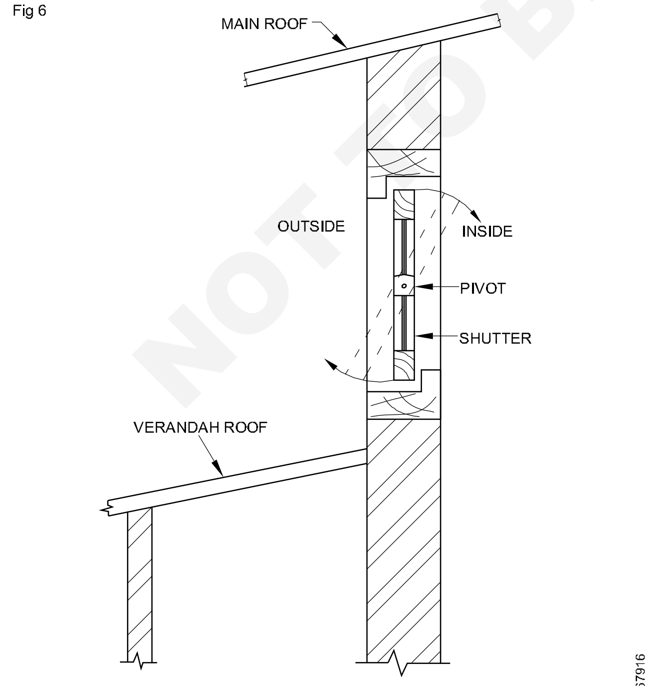


BAY WINDOWS

Bay windows project outside the external walls of a room. This projection may be triangular, circular, rectangular or polygonal in plan. Such a window is provided to get an increased area of opening for admitting more light and air. They also provide extra space in the room, and improved the overall appearance of the building.

Clere – storey window (Fig 6)

Fig 6



CLERESTOREY WINDOW

These windows are provided near the top of main roof. The pivoted windows are used for this purpose. The clere-storey windows provide ventilation to the inside of the room where the front is blocked by veranda and improved the appearance of the building.

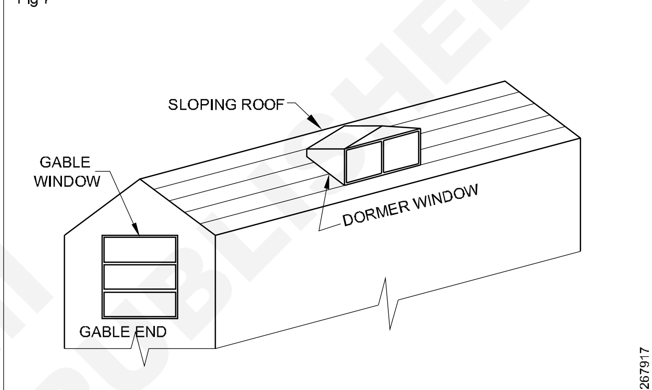
Dormer Window (Fig 7)

A dormer window is a vertical window built in the sloping side of the pitched roof. This window is provided to achieve proper ventilation and lighting of the enclosed spaces below the roof. Dormer window also serves as an architectural feature of the building.

Gable Window (Fig 7)

The windows provided a in the gable end of a pitched roof are known as a gable windows.

Fig 7

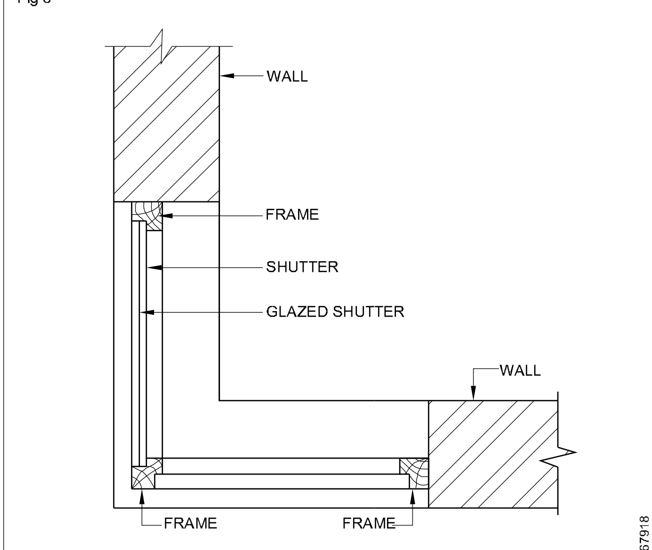


DORMER WINDOW

Corner window (Fig 8)

These windows are provided at the corner of the room and thus they have two faces and two directions. Due to this there is entry of light and air from two directions and in many cases the elevation of the building is also improved. However special lintel will have to be casted at the corner and jamb posts of the window at the corner will have to be made of heavy section.

Fig 8

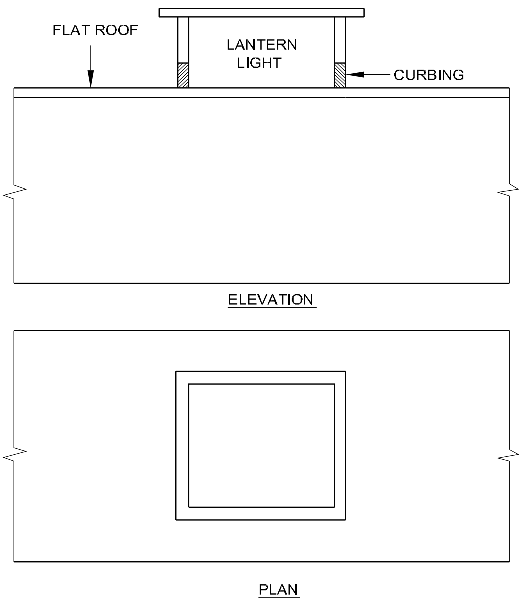


CORNER WINDOW

Lantern Window (Fig 9)

These are the windows which are fixed on flat roofs to provide light to the inner portion of the building where light coming from the windows in external wall is in sufficient. They may be square or rectangular or curved. Glass panels are generally fixed; but if ventilation is required in addition to light, then pivot window may be provided.

Fig 9



LANTERN WINDOW

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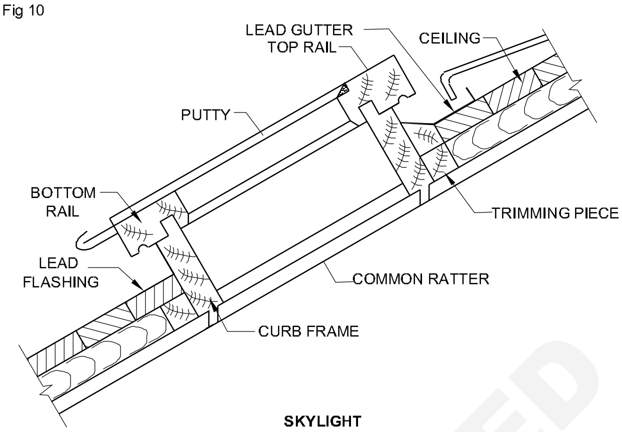
Sky light (Fig 10)

A sky light is provided on a sloping roof to admit light. The window project above the sloping surface and is parallel to the sloping roof surface. The sky light is provided with a view to permit the room below to be fully lighted with natural light. The opening for sky light is made by cutting the common rafters.

Fig 10



SKYLIGHT

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Ventilators

Ventilators are small windows fixed at a greater height than the window, generally about 30-50cm below the roof level. The ventilator has a frame and a shutter generally glazed and horizontally pivoted. The top edge of the shutter open inside the bottom edge open outside so that rain water is excluded.

Ventilators combined with window or door

Ventilators may be provided in continuation of a door or a window at its top. Such a ventilator is known as Fan-light. The construction of a fan light is similar to sash window. Such a ventilator is usually hinged at top and can open out. Alternatively, the ventilator shutter can he hinged at the bottom.

Fixtures and fastenings

Objective: At the end of this lesson you shall be able to
- **explain types of fixtures and fastenings.**

Introduction

Various types of fastenings are employed for connecting and maintaining the joints. The basic objects of different fastening and their important features are given below:

Fixtures and fastenings

The following types of fixtures and fastenings are required for doors, windows and ventilators.

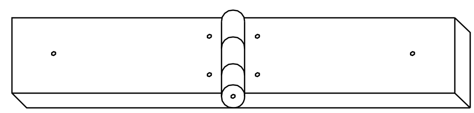
1 Hinges
2 Bolts
3 Handles
4 Locks.

1 Hinges

Following types of hinges are used for doors, windows and ventilators.

a Black flap hinge: These hinges are used where the shutters are thin. These are fixed on backside of the shutter and frame. (Fig 1)

Fig 1



BACK FLAP HINGE

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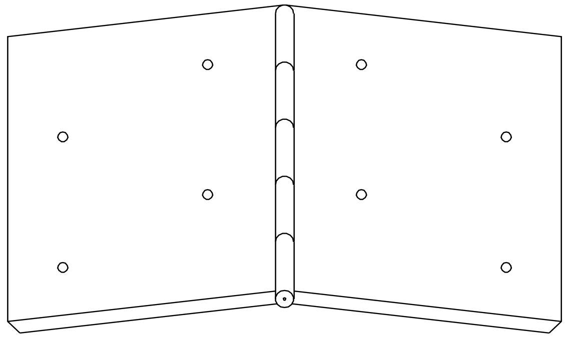
b Butt Hinge: These hinges are commonly used for fixing door and window shutters to the frame. (Fig 2)

c Counter-Flap hinge: This type of hinge has three parts and two centres. Provision of this type of hinge enable the shutter to be folded back to back (Fig 3)

d Garnet hinge: This type of hinge is also known as T-hinge and is commonly used for battened, ledged and braced doors. (Fig 4)

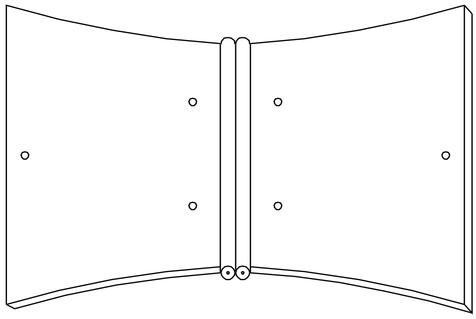
e Parliamentary Hinge: These hinges permit the door shutters, when open, the rest parallel to the wall. Hence these hinges are used where the opening is narrow and when it is required to keep the opening free from obstruction due to door shutters. (Fig 5)

Fig 2



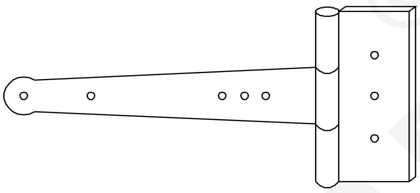
BUTT HINGE

Fig 3



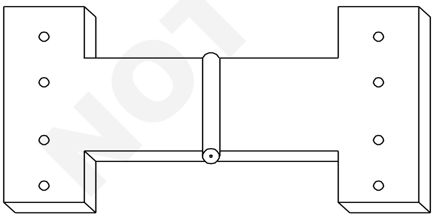
COUNTER - FLAP HINGE

Fig 4



GARNET HINGE

Fig 5

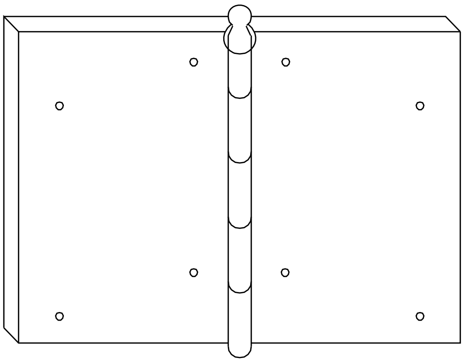


PARLIAMENTARY HINGE

f Pin hinge: This is used for heavy door shutters. The centre pin of the hinge can be removed and the two leaves or straps of the hinge can be fixed separately to the frame and the shutter. (Fig 6)

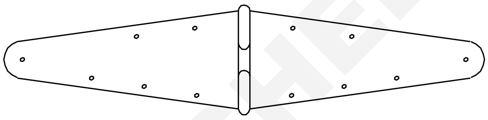
g Strap hinge: It is used for ledged and braced door and for heavy doors such as for garages, stables gate etc. (Fig 7)

Fig 6



PIN HINGE

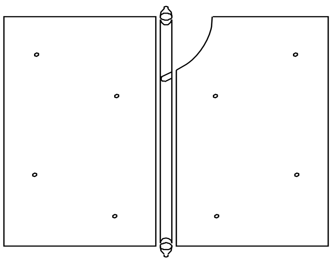
Fig 7



STRAP HINGE

h Spring hinges: Single acting or double acting hinges are used for swinging doors, single acting hinge is used when door shutter opens only in one direction while the double acting hinge is used when shutter swings in both the directions. The door closes automatically due to spring action (Fig 8)

Fig 8



SPRING HINGE

i Rising butt hinge: Such hinges are used for doors of rooms having carpet etc. They are used in place of ordinary butt hinges. The door is closed automatically, due to which the shutter is raised by 10 mm on being opened (Fig 9)

Bolts

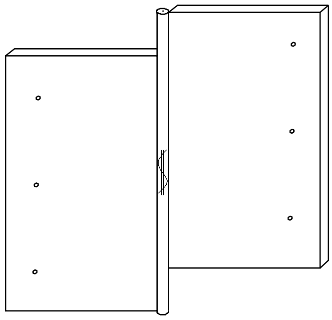
Following are the various type of bolts used for doors and windows:

a Aldrop: It is fixed on external doors where pad locks are to be used (Fig 10)

b Barrel bolt: It is used for fixing back faces of doors. The socket is fixed to the door frame while the plate is succeeded to the inside of the shutter (Fig 11)

c Tower bolt: This is similar to barrel bolt except that instead of barrel bolt are two or three staples (Fig 12)

Fig 9



RISING BUTT HINGE

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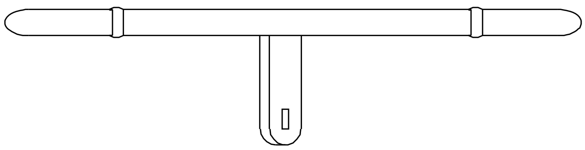
Fig 10



ALDROP

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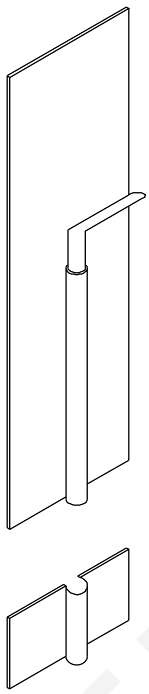
Fig 11



BARREL BOLT

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d **Flush bolt:** This bolt is used when it is desired to keep the bolt flush with the face of the door (Fig 13)

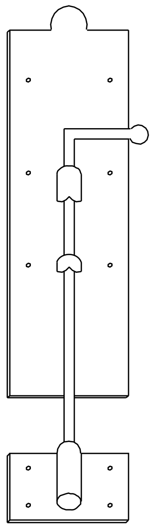
e **Hasp and Staple bolt:** This is used for external doors where padlock is to be used. The staple is fixed to the door frame while hasp is fixed to the shutter (Fig 14)

f **Latch :** This is made of iron, it consists of lever pivoted at one end. The Liver is secured in a hasp and staple. It is fixed to the inside face of the door (Fig 15)

Locks

a **Hook and Eye:** This is used for keeping the window shutter in position when the window is opened (Fig 16)

Fig 12



TOWER BOLT

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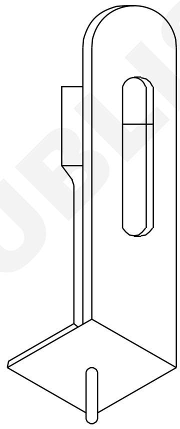
Fig 13



FLUSH BOLT

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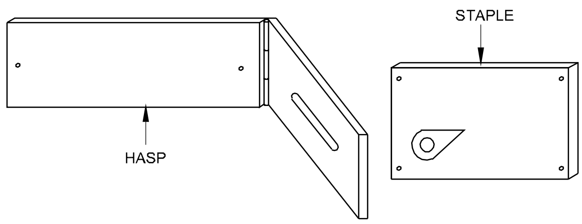
Fig 14



HASP AND STAPLE BOLT

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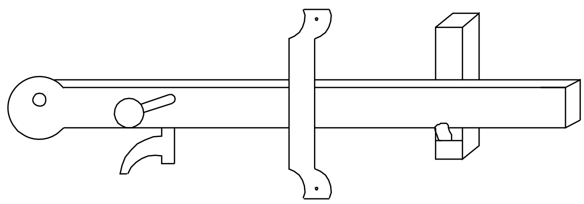
Fig 15



LATCH

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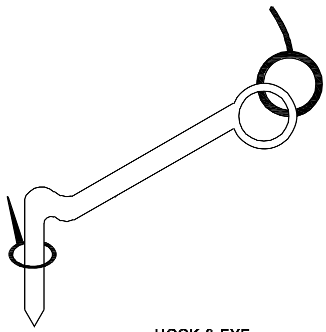
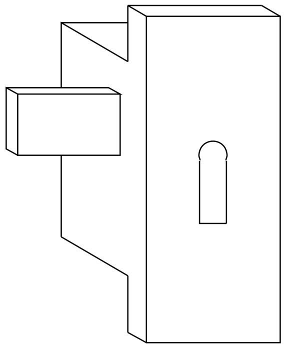
Fig 16



HOOK & EYE

b **Cup-board lock:** It is used to secure doors of minor importance (Fig 17)

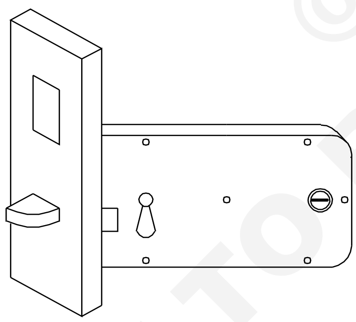
Fig 17



CUP - BOARD LOCK

c **Mortice lock**: It is fixed in mortice formed on the edge of a door (Fig 18)

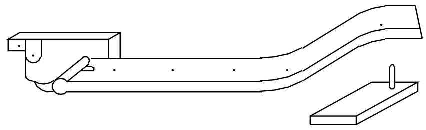
Fig 18



MORTICE LOCK

d **Peg Stay**: It is used for steel windows. The width of opening can be adjusted by holes which are provided in the peg stay (Fig 19)

Fig 19

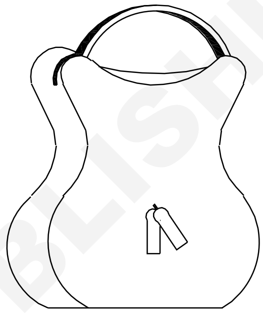


PEG STAY

e **Pad lock:** It is used for securing doors when all drop bolts and hasp and staple bolts are employed (Fig 20)

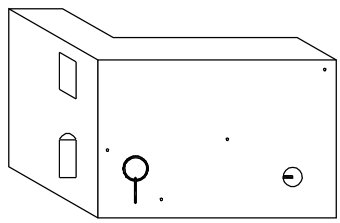
f **Rim Lock :** It is used for thin doors (Fig 21)

Fig 20



PAD LOCK

Fig 21



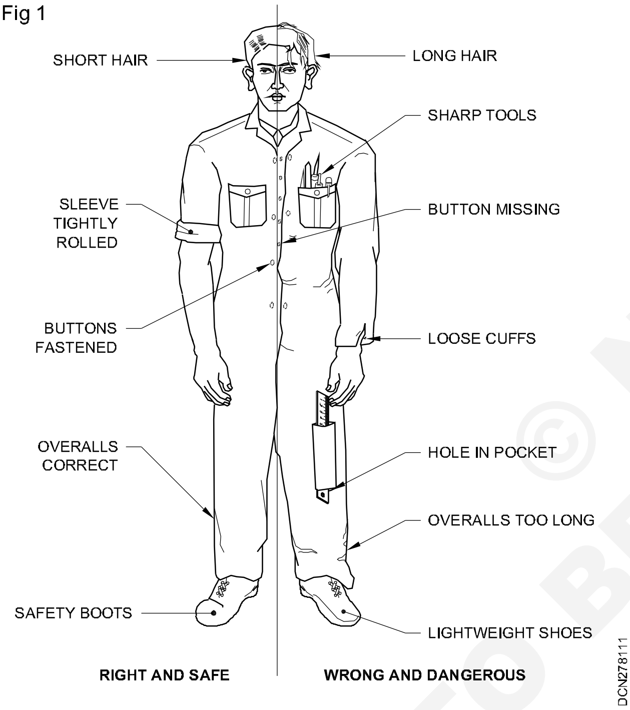
RIM LOCK

Safety Precaution

Objectives: At the end of this lesson you shall be able to
- **state the importance of safety**
- **list out the safety precautions to be observed in a machine shop**
- **list out the personal safety precautions to be observed**
- **list out the safety precautions to be observed while working on the machines.**

Generally accidents do not happen, they are caused. Most accident are avoidable. A good craftmans, having a knowledge of various safety precautions', can avoid accidents to himself and to his fellow workers and protect the equipment from any damage. To achieve this, it is essential that every person should follow safety procedure. (Fig 1)

Fig 1



Safety in a workshop can be broadly classified into 3 categories.

- **General Safety**
- **Personal Safety**
- **Machine Safety**

General Safety

Keep the floor and gangways clean and cleaner.

Move with care in the workshop, do not run.

Don't leave on the machine which is in motion.

Don't touch or handle any equipment / machine unless authorized to do so.

Don't walk under suspended loads.

Don't cut practical jokes while on work.

Use the correct tools for the job.

Keep the tools at their proper place.

Wipe out split oil immediately.

Replace worn out or damaged tools immediately.

Never direct compressed air at yourself or at your co-worker.

Ensure adequate light in the workshop.

Clean the machine only when it is not in motion.

Sweep away the metal cuttings.

Know everything about the machine before you start it.

Personal Safety

Wear a one piece overall or boiler suit.

Keep the overall buttons fastened.

Don't use ties and scarves

Roll up the sleeves tightly above the elbow.

Wear safety shoes or boots or chain.

Cut the hair short.

Don't wear a ring, watch or chain.

Never lean on the machine.

Don't clean hands in the coolant fluid.

Don't remove guards when the machine is in motion.

Don't use cracked or chipped tools.

Don't start the machine until.

- The work piece is securely mounted.
- The feed machinery is in the neutral.
- The work area is clear,

Don't adjust clamps or holding devices while the machine is in motion.

Never touch the electrical equipment with wet hands. Don't use any faulty electrical equipment.

Ensure that electrical connections are made by an authorized electrician only.

Concentrate on your work.

Have a calm attitude.

Do things in a methodical way.

Don't engage yourself in conversation with others while concentrating on your job.

Don't distract the attention of others.

Don't try to stop a running machine with hands.

Machine Safety

Switch off the machine immediately if something goes wrong.

Keep the machine clean.

Replace any worn out or damaged accessories, holding devices, nuts, bolt etc. as soon as possible.

Do not attempt operating the machine until you know how to operate it properly.

Do not adjust tool or the work piece unless the power is off.

Stop the machine before changing the speed.

Disengage the automatic feeds before switching off,.

Check the oil level before starting the machine.

Never start a machine unless all the safety guards are n position.

Take measurements only after stopping the machine.

Use wooden planks over the bed while loading and unloading heavy jobs.

Safety is a concept, understand it

Safety is a habit, Cultivate it.

Safety signs

Objectives: At the end of this lesson you shall be able to
- **list three kinds of road sign**
- **describe the marking on the road**
- **describe the various police traffic hand signal and light signal**
- **list the collision causes.**

In olden days road locomotive carrying a red flag by day and red lantern by night. Safety is the prime motive of every traffic.

Kinds of Road Signs

Mandatory

Cautionary and

Information.

Mandatory Sign (Fig 1)

Fig 1

DCN278121

Violation of mandatory sign can lead to penalties. Ex. stop, give way, limits prohibited, no parking are compulsory sign.

Cautionary Signs (Fig 2)

Cautionary /warning signs are especially safe. Do's and don'ts for pedestrians, cyclists, bus passengers and motorists.

Information signs (Fig 3)

Fig 2

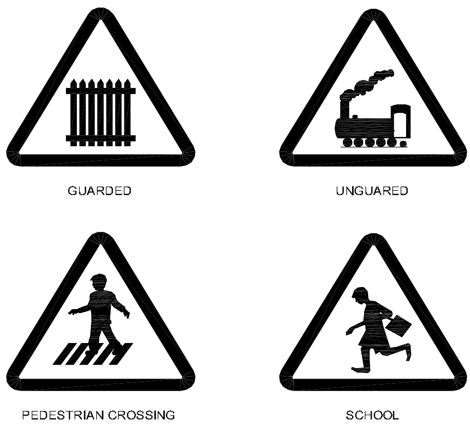


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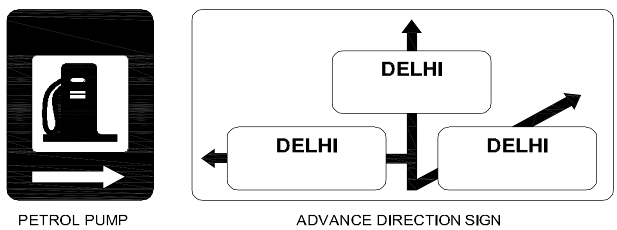
Fig 3



DCN278123

Elementry first aid refer Ex.No. 1.1.01 - 08

Elementary of electricity

Objectives: At the end of this lesson you shall be able to
- **define atom and electricity**
- **explain about the atomic structure**
- **define conductors, insulator and semiconductors.**

Introduction : Electricity is one of today's most useful sources of energy. Electricity is of utmost necessity in the modern world of sophisticated equipment and machinery.

Electricity in motion is called electric current. Whereas the electricity that does not move is called static electricity.

Example of Electric current

– Domestic electric supply, industrial electric supply.

Example of static electricity

Shock received from door knobs of carpeted room.

Attraction of paper to the comb.

Structure of Matter : To understand electricity, one must understand the structure of matter. Electricity is related to some of the most basic building blocks of matter that are atoms (electrons and portons). All matter is made of these electrical building blocks, and therefore, all matter is said to be 'electrical'.

Matter is defined as anything that has mass and occupies space. A matter is made of tiny, invisible particles called molecules. A molecule is the smallest particle of a substance that has the properties of the substance. Each molecule can be divided into simpler parts by chemical means. The simplest parts of a molecule are called atoms.

Basically, an atom contains three types of sub-atomic particles that are of relevance to electricity. They are the electrons, portons and neutrons. The protons and neutrons are located in the centre, or nucleus, of the atom, and the electrons travel around the nucleus in orbits.

Atomic Structure

The Nucleus : The nucleus is the central part of the atom. It contains the protons and neutrons of an atom as shown in Fig 1.

Protons : The proton has a positive electrical charge (Fig 1) It is almost 1840 times heavier than the electron and it is the permanent part of the nucleus; protons do not take an active part in the flow or transfer of electrical energy.

Electron : It is a small particle revolving round the nucleus of an atom (as shown in Fig 2). It has a negative electric charge. The electron is three times larger in diameter than the proton. In an atom the number of protons is equal to the number of electrons.

Neutron : A neutron is actually a particle by itself, and is electrically neutral. Since neutrons are electrically neutral, they are not too important to the electrical nature of atoms.

Fig 1

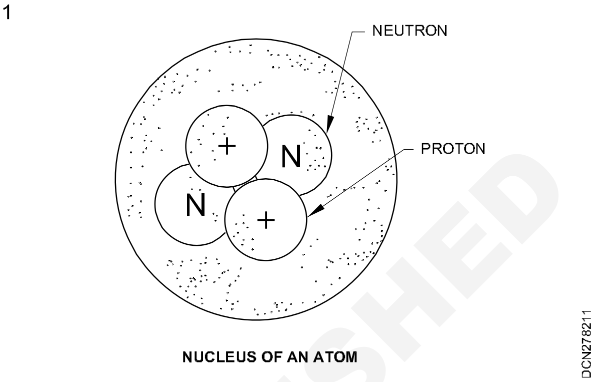
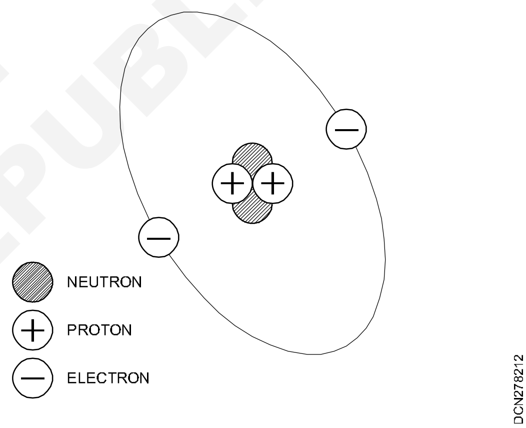


Fig 2



Energy Shells : In an atom, electrons are arranged in shells around the nucleus. A shell is an orbiting layer or energy level of one or more electrons. The major shell layers are identified by number or by letters starting with 'K' nearest the nucleus and continuing alphabetically outwards. There is a maximum number of electrons that can be contained in each shell. Fig 3 illustrates the relationship between the energy shell level and the maximum number of electrons it can contain.

If the total number of electrons for a given atom is known, the placement of electrons in each shell can easily determined. Each shell layer, beginning with the first, is filld with the maximum number of electrons in sequence. For example, a copper atom which has 29 electrons would have four shells with a number of electrons in each shell as shown in fig. 4

Similarly an aluminium atom which has 13 electrons has 3 shells as shown in Fig 5.

Electron Distribution : The chemical and electrical behavior of atoms depends on how completely the various shells and sub-shells are filled.

Fig 3

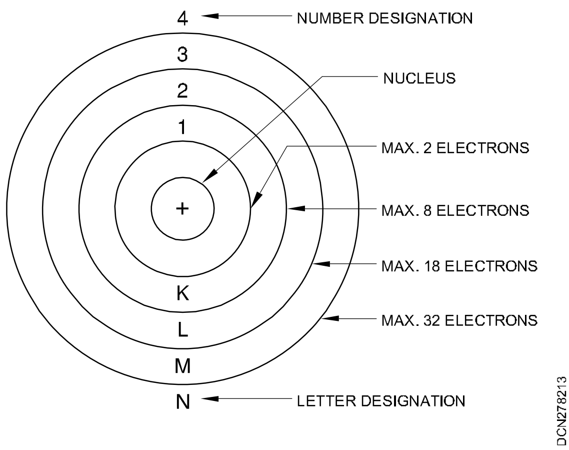
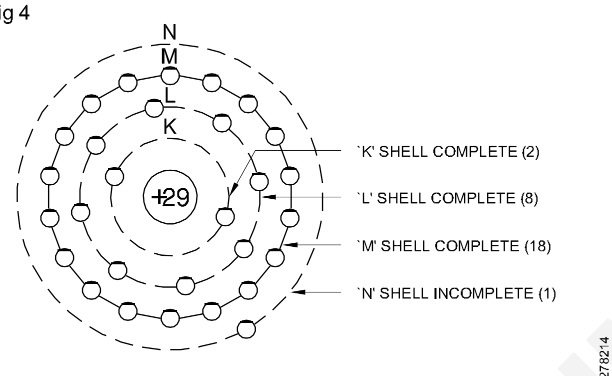


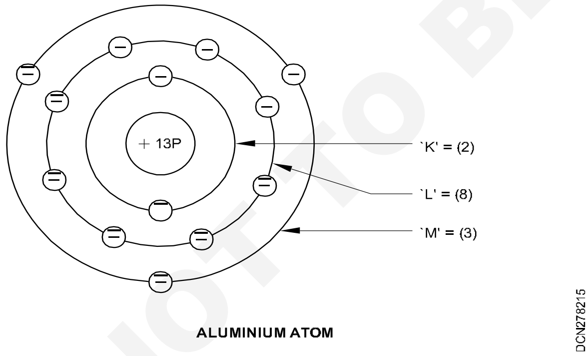
Fig 4



COPPER ATOM

Atoms that are chemically active have one electron more or one less than a completely filled shell. Atoms that have the outer shell exactly filled are chemically inactive. They are called inert elements. All inert elements are gases and do not combine chemically with other elements.

Fig 5



ALUMINIUM ATOM

Metals possess the following characteristics

- They are good electric conductors.
- Electrons in the outer shell and sub-shells can move more easily from one atom to another.
- They carry charge through the material.

The outer shell of the atom is called the valence shell and its electrons are called valence electrons. Because of their greater distance from the nucleus, and because of the partial blocking of the electric field by electrons in the inner shells, the attracting force exerted by nucleus on the valence electrons is less. Therefore, valence electrons can be set free most easily. Whenever a valence electrons is moved from its orbit it becomes a free electron. Electricity is commonly defined as the flow of these free electrons through a conductor. Though electrons flow from negative terminal to positive terminal, the conventional current flow is assumed as from positive to negative.

Conductors, Insulators and Semiconductors

Conductors : A conductor is a material that has many free electrons permitting electrons to move through it easily. Generally, conductors have incomplete valence shells of one, two or three electrons. Most metals are good conductors.

Some common good conductors are Copper, Aluminum, Zinc, Lead, Tin, Eureka, Nichrome, Silver and Gold.

Insulators : An insulator is a material that has few, if nay, frees electrons and resists the flow of electrons. Generally, insulators have full valence shells of five, six or seven electrons. Some common insulators are air glass, rubber, plastic, paper, porcelain, PVC, fibre, mica etc.

Semiconductors : A semiconductor is a material that has some of the characteristics of both the conductor and insulator. Semiconductors have valence shells containing four electrons.

Common examples of pure semiconductor materials are silicon and germanium. Specially treated semiconductor are used to produce modern electronic components such as diodes, transistors and integrated circuit chips.

Wiring - Electrical

Objectives: At the end of this lesson you shall be able to
- **explain the systems of wiring**
- **enlist the materials for wiring**
- **enlist the tools used dfor wiring**
- **explain the safety precautions.**

Introduction : Electricity is a sort of energy which can neither be seen nor touched but its presence can be experienced in its applications like electric bulb, heater, motar or an electric operated radio. Nowadays electricity is an unavoidable operated radio. Nowadays electricity is an unavoidable part of the life. We can't imagine the world without electricity. As a civil engineer we can make a lot of involvement in the generation of electricity as well as its distribution. In the least sense a new building is planned in the economical and satisfactory wiring and arrangements of fittings.

Systems of Wiring

1 Temporary wiring
- a Flexible wire wiring
- b Cleat wiring

2 Permanent wiring
- a Casing capping wiring
- b CTS/ TRS wiring
- c Lead sheathed wiring
- d Conduit pipe wiring
- e Duct wiring

Temporary wiring

1 Flexible wire wiring

In this type of wiring flexible PVC wires are used. The wiring may be utilized for one month or so. It is useful for the decoration purposes in the marriage, exhibitions etc. A common main switch is used.

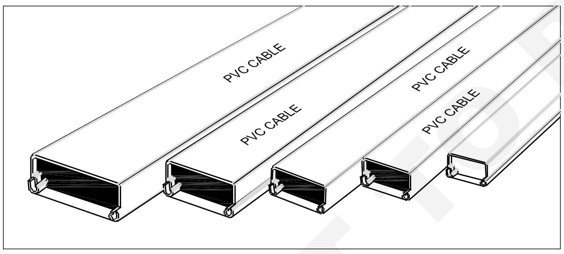
2 Cleat wiring

It is an open type wiring, which is done with VIR or PVC wires. The wiring may be utilized for a year or so. Porcelain cleats are used to support the wires.

Permanent wiring

1 **Casing caping wiring (Fig 1) :** The system of wiring is being used for the last more than 50 years, but is has become unpopular. The casing has two grooves to carry wires.

Fig 1



CASING CAPING WIRING

2 **CTS / TRS Wiring (Fig 2) :** This type of wiring is installed on wooden battens, and hence it is known as batten wiring also. Clips are used to hold the wires.

3 **Lead sheathed wiring** : This system is similar to batten wiring but lead sheathed wires are used instead of PVC wires. The lead covering provides protection to cable against mechanical injuries.

4 **Conduit pipe wiring (Fig 3) :** This system of wiring is suitable for single or three face wiring. The types of conduit pipes used area a) light gauge conduit pipes. b) heavy gauge conduit pipe. VIR or PVC wires are used for this wiring. This wiring is suitable for factories, godowns, workshops etc.

Fig 2

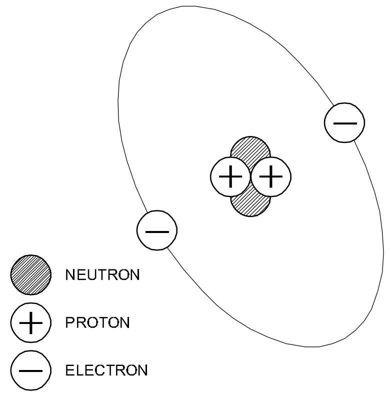
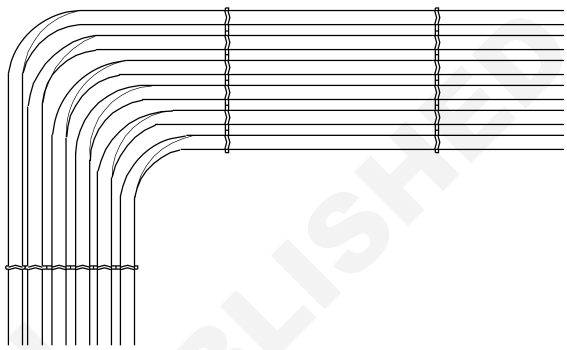


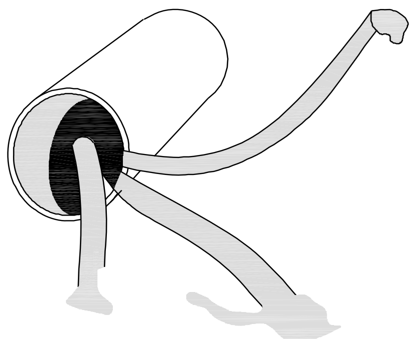
Fig 3



CONDUIT PIPE WIRING

5 **Duct wiring (Fig 4) :** It is also known as concealed wiring. For this wiring grooves are made in the wall and floor as per diagram and then conduit wiring is placed in the grooves. Finally the wiring is covered with cement plaster. Only inspection boxes, junction boxes, round blocks and switch boards remain in visible outside the walls and ceiling.

Fig 4



DUCT WIRING

Safety Precautions

1 No live naked wire or electric gear etc. should be touched because it will give electric shock.

2 Before working with the live wire, the supply should be switched off.

3 Neither the live wire be touched with hand nor the man working with the wire be touched.

4 Work on poles should not be done without using the safety belt.

5 It should be ensured before switching on the supply that no man is working with the wires.

6 No live wire should be earthed.

7 Before changing the fuse wire, the switch should be turned in off position.

8 All the appliances should be properly earthed because it ensures safety from electric shock.

9 No live wire should be without switches.

10 Plug from the socket should be removed by pulling the wire but should be done carefully and correctly.

11 The earthing plate should be embedded in the most earth at sufficient depth below ground level.

12 Water should never be thrown on the electric wires and live conductors in case of fire. The line should be first switched off and dry sand is used for extinguishing the fire. Fire extinguisher may be used to put off the fire.

13 While the electric appliances like table fan, electric iron, electric kettle or toaster are not in use, It is advisable to pull out the plug instead of switching off the switches

14 Proper electrical tools should only be used for doing jobs.

15 It is advisable to check the earth resistance at least once a year. If it is more than five ohms it should be reduced immediately.

16 A first aid box should always be kept in the shop.

17 In case of any accident, the victim should be given the facility of first and immediately before he is taken to the doctor.

Materials for Wiring

S .No.	Material	Description
1	Electrical Accessories	It includes the switches, holders, sockets fuse cut-outs, ceiling roses, etc.
2	Wires	Generally VIR and PVC wires are used for wiring, but TRS and weather proof wires are used as per requirements.
3	Wooden Screws	These are used for fixing the wooden boards, round blocks, etc. on the wooden plugs. Their size varies from 12 mm to 60 mm.
4	Porcelain and PVC pipes	These pipes are water resistant. These are used for passing the wiring across a wall or concealed wiring
5	Wooden boards and Plug	The switches and sockets etc. are fitted on rectangular boards of teak wood.
6	Distribution boards	It comprises the fuse cut-out for different circuits.
7	Main switch boards	It is fitted near the meter board. It includes main switch, fuse cut-out, neutral link and earthing terminals.
8	Meter board	It is fitted by the electric distribution department. It comprises an energy meter, fuse cut-out and neutral link. The meter is sealed.

Tools

S. No.	Name of tool	Use
1	Poker	To make pilot holes in the boards
2	Knife	To remove insulators
3	Nose pliers	To hold wires in narrow place, screw and unscrew small nuts, twist wires etc.
4	Adjustable pliers	To hold sheets and other articles
5	Combination pliers	For gripping, bending and cutting wires
6	Wrench	To screw and unscrew
7	Bench vice	To hold tools
8	Screw driver	To tighten and untighten screws

9	Cold chisel	To make holes in masonry
10	Wood chisel	To cut slots in wooden boards
11	Pipe vice	To hold G.I. pipes
12	Files	To sharpen knife
13	Taps	To make threads
14	Gauge	To measure the thickness of wire
15	Centre punch	To make mark before drilling
16	Plumb bob	To make vertical lines on walls for wiring
17	Key Hole screw	To make key holes, cut wood along curves
18	Tenon saw	To cut wooden wiring material like battens, casing, etc.
19	Hand drilling machine	To make holes
20	Hammer	For riveting, chipping. etc.
21	Ratchet brace	To make large diameter holes in wood
22	Stock and die	To make threads on conduits and G.I. pipes
23	Soldering iron	To solder the joints of wires
24	Neo tester	To test the presence of electricity

Trade hand tools - specification

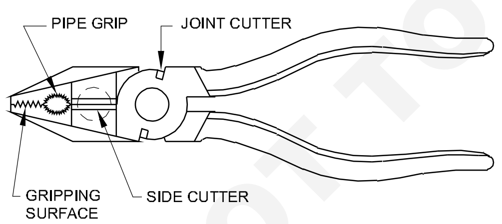
Objectives: At the end of this lesson you shall be able to
- **list the tools necessary for an electrician**
- **specify the tools and state the use of each tool**
- **explain the care and maintenance of electrician hand tools.**

Listed the most commonly used tools by wireman.

PLIERS : They are specified with their overall dimensions of length in mm. The pliers used for electrical work will be of insulated grip.

1 **Combination pliers with pipe grip, side cutter and insulated handle.** BIS 3650 (Fig 1)

Fig 1



COMBINATION SIDE CUTTING PLIERS
(ENGINEER'S PLIERS, COMBINATION PLIERS)

Size 150 mm, 200 mm etc.

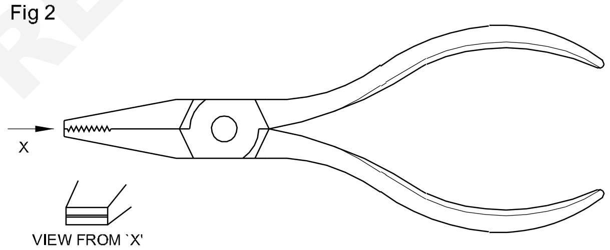
It is made of forged steel. It is used for cutting, twisting, pulling, holding and gripping small jobs in wiring assembly and repairing work. A non-insulated type is also avilable. Insulated piliers are used for work on live lines.

2 Flat nose pliers BIS 3552 (Fig 2)

Size 100 mm, 150 mm, 200 mm etc.

Flat nose pliers are used for holding flat objects like thin plates etc.

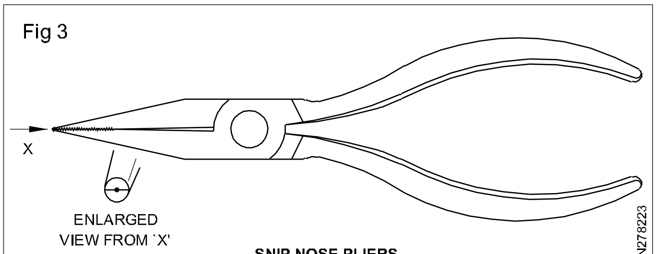
Fig 2



FLAT NOSE PLIERS

3 Long nose pliers or (snip nose pliers) with side cutter BIS.5658 (Fig 3)

Fig 3



SNIP NOSE PLIERS

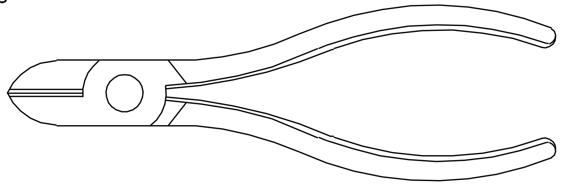
Size 100mm , 150 mm etc.

Long nose pliers are used for holding small objects in places where fingers cannot reach.

4 Side cutting pliers (Diagonal cutting pliers) BIS 4378 (Fig 4)

Size 100 mm, 150 mm etc.

Fig 4

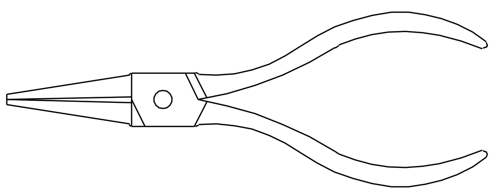


DIAGONAL CUTTING PLIERS/NIPPER

It is used for cutting copper and aluminium wires of smaller diameter (less than 4mm dia)

5 Round nose pliers BIS 3568 (Fig 5)

Fig 5



ROUND NOSE PLIERS

Size 100mm, 150mm etc.

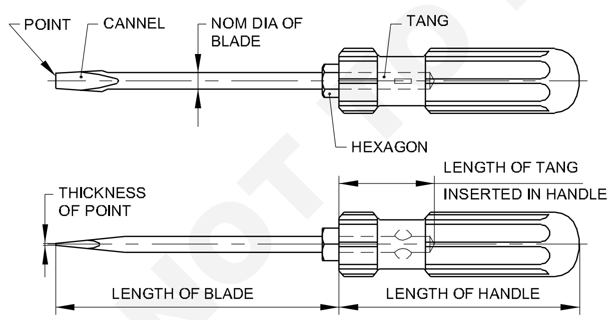
Wire hooks and loops could be made using the round nose pliers.

Care and maintenance of pliers:

- Do not use pliers as hammers.
- Do not use pliers to cut large sized copper or aluminium wires and hard steel wires of any size.
- While using the pliers avoid damages to the insulation of hand grips.
- Lubricate hinged portions.

6 Screwdriver BIS 844 (Fig 6)

Fig 6



NOMENCLATURE FOR SCREWDRIVERS

The Screwdrivers used for electrical works generally have plastic handles and the stem is covered with insulating sleeves. The size of the screw driver is specified by its blade length in mm and nominal screwdriver's point size (thickness of tip of blade) and by the diameter of the stem.

E.g. 75mm x 0.4 mm x 2.5 mm
150mm x 0.6mm x 4 mm
200mm x 0.8mm x 5.5 mm etc.

The handle of screwdrivers is either made of wood or cellulose acetate.

Screwdrivers are used for tightening or loosening screws. The screwdriver tip should snugly fir the grooves of the screw to have maximum efficiency and to avoid damage to the screw heads.

As the length of the screw driver is proportional to the turning force, for small work choose a suitable small sized screwdriver and vice versa.

Screwdriver – Philips

It is used for driving star headed screws.

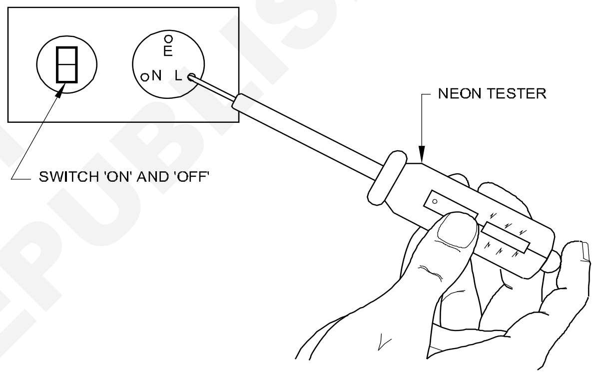
Care and maintenance

i Never use a screwdriver as a lever to apply force as this action will make the stem to bend and the use of the screw driver will be lost.

ii Keep the tip in correct shape and in rare cases it could be grinded to shape.

7 Neon tester BIS 5579 -1985 (Fig 7)

Fig 7



NEON TESTER

It is specified with its working voltage range 100 to 250 volts but rated to 500 V.

It consists of a glass tube filled with neon gas, and electrodes at the ends. To limit the current within 300 micro-amps at the maximum voltage, a high value resistance is connected in series with one of the one end. The presence of supply is indicated by the glow of the lamp when the tip like a probe or screwdriver at one end. The presence of supply is indicatedd by the glow of the lamp when the tip is touched on the live supply and the brass contact in the order of neon tester is touched by hand.

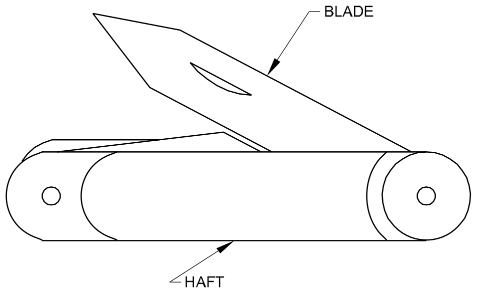
Care and maintenance

- Never use the neon tester for voltage higher than the specified range.
- While testing see the circuit is completed through the earthing o the body could be provided by touching the wall by one hand.
- Use the screwdriver tipped neon tester for light duty work only.

8 Electrician's Knife (Double blade) (Fig 8)

The size of the knife is specified by its largest blade length e.g 50 mm, 75mm.

Fig 8



ELECTRICIAN'S KNIFE

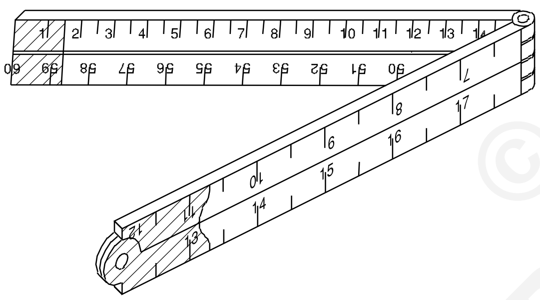
It is used for skinning the insulation of cables and cleaning the wire surface. One of the baldes which is sharp is used for skinning the cable and the rough edgedblade is used for cleaning the surface of the wires.

Care and maintenance

- Do not use the knife for cutting wires.
- Keep it free from rust.
- Keep one of the blades in a sharp condition.
- Fold the knife blade when not in use.

9 Four-fild box wood rule 600mm (Fig 9) : Used for measuring short lengths. To be kept in folded condition when not in use.

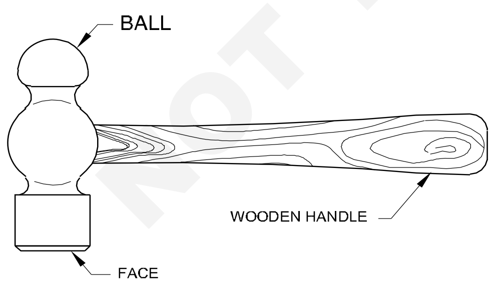
Fig 9



FOUR-FOLD BOX WOOD RULE

10 Hammer ball Pein (Fig 10) : The size of the hammer is expressed in weight of the metal head. Ex. 125 gms, 250 gms etc.

Fig 10



BALL PEIN HAMMER

The hammer is made out of special steel and the striking face is tempered. Used for nailing, straightening, and bending work. The handle is made of hard wood.

Care and maintenance

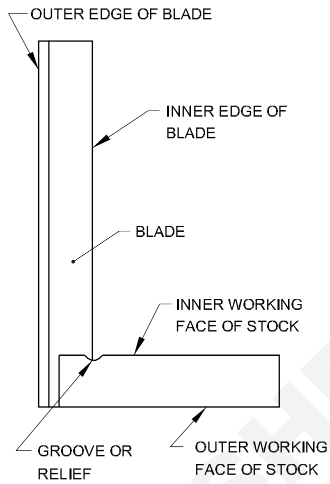
i Do not use a hammer must be free from oil, grease and mushroom.

ii The fce of the hammer must be free from oil, grease and mushrooms.

11 Try-square: (Engineer's square) (Fig 11) BIS 2103

This is specified by its blade length.

Fig 11



TRY-SQUARE

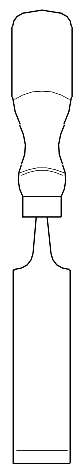
E.g. 5mm x 35mm
100mm x 70mm
100mm x 100mm etc.

There are two types; one is the beveled edge with stock and the other is the flat edge without stock. It is used to check whether the object is plane, perpendicular and at right angle. Two straight blades set at right angles to each other constitute the try square. The steel blade is riveted to the stock. The stock is made of cast iron. The stock should be set against the edge of the job.

Do not use it as s hammer

12 Firmer Chisel (Fig 12) : It has a wooden handle and a cast steel blade of 150mm length. Its size is measured according to the width of the blade eg. 6mm, 12mm, 18mm, 25mm. It is used for chipping, scraping and grooving in wood.

Fig 12



FIRMER CHISEL

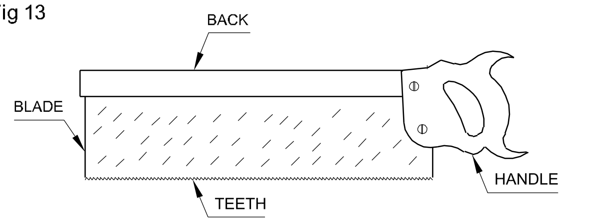
Care and maintenance

Do not use it for driving screws.

- Use mallet for chiseling
- Grind on a water stone and sharpen on an oil stone.
- Do not use it in places where nails are driven.

13 Tenon – saw (Fig 13) BIS 5123, BIS 5130, BIS 5031

Fig 13



TENON-SAW

Generally the length of the tenon-saw will be 250 or 300 mm and has 8 to 12 teeth per 25.4 mm and the blade width is 10 cm. It is used for cutting thin, wooden accessories like wooden batten, casing capping, boards and round blocks.

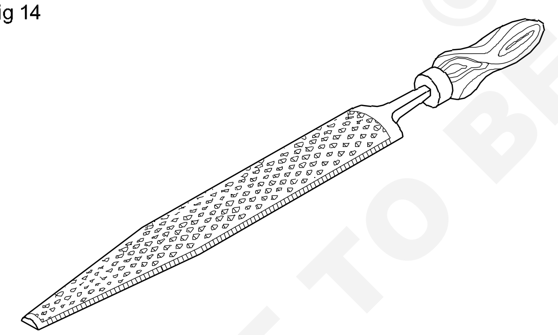
Care and maintenance

- Keep free from rust.
- Apply grease when not in use.

14 Wood rasp file (Fig 14) BIS 1931

It is used for filing wooden articles where finish is not important. Wood rasp files are of half round shape. They have sharp coarse single cut teeth.

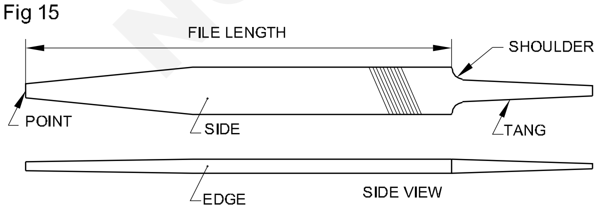
Fig 14



WOOD RASP FILE

15 Files (Fig 15) BIS 1931

Fig 15



FILE

These are specified by their nominal length.

Eg. 150 mm, 200 mm, 250 mm 300 mm etc.

These files have different numbers of teeth designed to cut only in the forward stroke. They are available in different lengths and sections (Ex. Flat, half round, round, square, triangular), grades like rough, bastard second cut and smooth and cuts like single and double cut.

These files are used to remove fine chips of material from metals. The body of the file is made of cast steel and hardened except the tang.

Care and maintenance

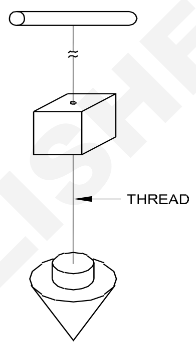
i Never use the file as a hammer.

ii Do not use the file without the handle.

iii Do not throw a file since the teeth get damaged.

16 Plumb bob (Fig 16) : It has a pointed tip with a centre hole at the top for attaching a string as shown in Fig 16. It is used for making vertical lines on the wall.

Fig 16



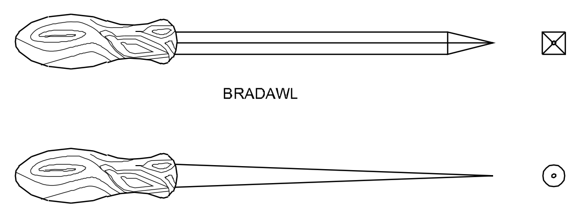
PLUMB BOB

Care and Maintenance

Do not drop to the ground.

17 Bradawl square pointed (or poker) (Fig 17) BIS 1035-1982

Fig 17



It is specified by its length and diameter eg. 150mm x 6mm.

It is a long sharp tool used for making pilot holes on wooden articles to fix screws.

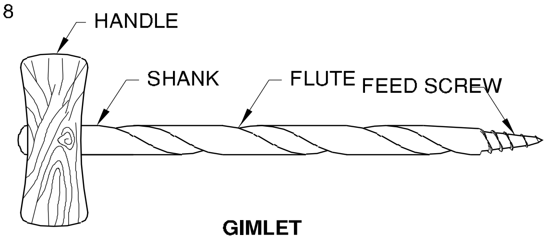
Care and maintenance:

- Do not use it on metals for making holes.
- Keep it in good sharpened condition.

18 Gimlet (Fig 18)

It is used for boring small holes on wooden articles. It has a wooden handle and a boring edge. The size of it depends upon its diameter. Ex. 3mm, 4 mm, 5 mm, 6 mm

Fig 18



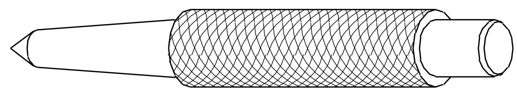
GIMLET

Care and maintenance

- Do not use it without the handle.
- Do not use it on nails.
- Keep it straight while making holes, otherwise the screwed portion can get damaged.

1**9 Centre Punch (Fig 19)** BIS 7177

Fig 19



CENTRE PUNCH

The size is given by its length and diameter of the body. E.g. 100mm x 8 mm. The angle of the tip of the centre punch is 90º.

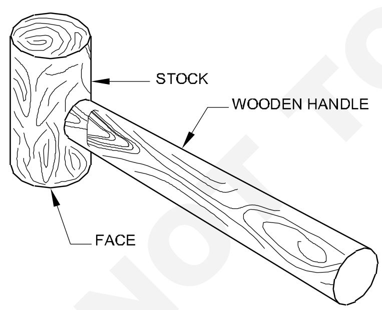
It is used or making and punching pilot holes on metals. It is made of tool steel and the ends are hardened and tempered.

Care and Maintenance

- Keep the tip sharp and at a proper angle.
- Avoid mushroom heads.

20 Mallet (Fig 20) : The mallet is specified by the diameter of the head or by the weight.

Fig 20



MALLET

E.g., 50 mm x 150 mm

75 mm x 150 mm or 500 gms 1 kg

It is made out of hard wood or nylon. It is used for driving the firmer chisel, and for straightening and bending of thin metallic sheets. Also it is used in motor assembly work.

Care and Maintenance

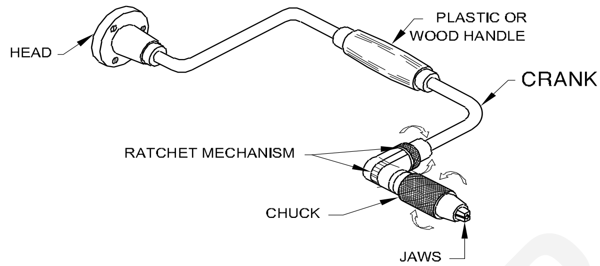
i Do not use it for fixing nail

ii Never use it on hard metal like steel and iron

1 Ratchet brace (Fig 21) BIS 7042

The size of a ratchet brace is given by the size of drill bit it can accommodate ie. 0-6 mm, 0-12mm. It is used to drill holes on wooden blocks.

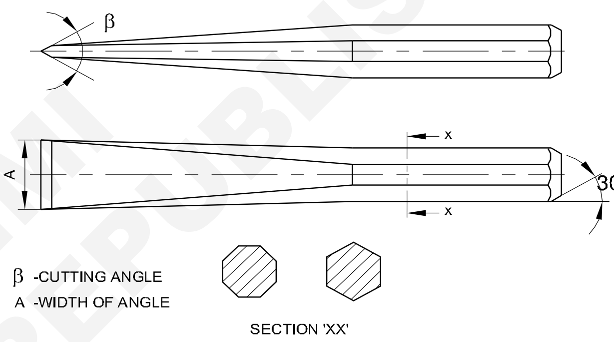
Fig 21



RATCHET BRACE

2 Flat cold chisel (Fig 22) BIS 402 : Its size is given by the nominal width and length.

Fig 22



COLD CHISEL

ie. 14 mm x 100 mm

15mm x 150 mm

20mm x 150mm

The body shape of a cold chisel may be round or hexagon.

The cold chisel is made out of high carbon steel. Its cutting edge angle varies from 35° to 45° . The cutting edge of the chisel is hardened and tempered. This chisel is used for making holes on wall etc.

Care and Maintenance

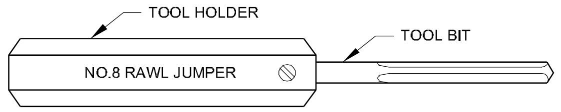
– The edge of a chisel must be maintained as per the required angle.

– While grinding a chisel apply a coolant frequently so that its temper may not be lost.

23 Rawl plug tool and bit (Fig 23) : Its size depends upon the number. As the number increases, the thicknesses of the bit as well as the plug also decrease. E.g. Nos.8, 10,12,14 etc.

A rawl plug tool has two parts, namely the tool bit and tool holder. The tool bit is made of tool steel and the holder is made of mild steel. It is used for making holes in bricks, concrete wall and ceiling. Rawl plugs are inserted in them to fix accessories.

Fig 23



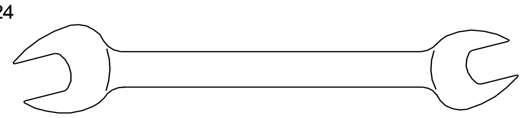
RAWL PLUG TOOL

Care and Maintenance

- Slightly rotate the holder after each hammering stroke.
- Hold the tool straight.
- Do not throw it on the ground.
- Keep its head fee from mushrooms.

24 Spanner: double ended (Fig 24) BIS 2028 : The size of a spanner is indicated so as to fit on the nuts. They are available in many sizes and shapes.

Fig 24



DOUBLE ENDED OPEN JAW SPANNER

The sizes, indicated in double –ended spanners are:

10-11 mm

12-13 mm

14-15 mm

16-17 mm

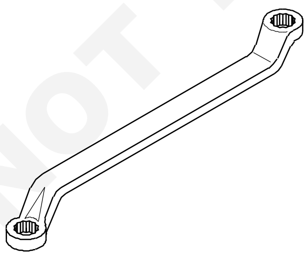
18-19 mm

20-22 mm

For loosening and tightening of nuts and bolts, spanner sets are used. It is made out of cast steel. They are available in many sizes and may have single or double ends.

25 Ring spanner set (Fig 25) BIS 2029 : The ring spanner is used in places where the space is restricted and where high leverage is required.

Fig 25

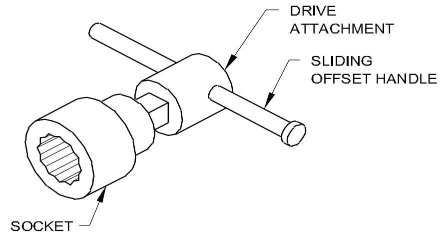


RING SPANNER

26 Socket (box) Spanner (Fig 26) BIS 7993, 7991, 6129: These spanners are useful at places where the nut or bolt is located in narrow space or at depth.

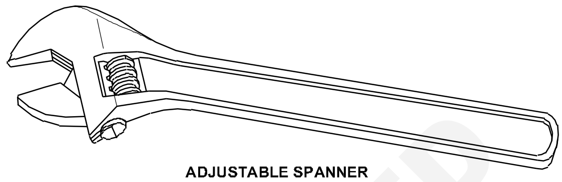
27 Single ended open jaw adjustable spanner (Fig 27) BIS 6149 : It saves time and working. The movable jaw is made adjustable by operating a screw. It is known as a monkey wrench also. Available in 150,200,250 mm etc.

Fig 26



SOCKET SPANNER

Fig 27



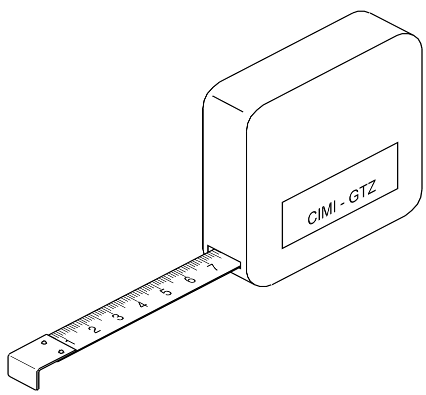
ADJUSTABLE SPANNER

Care and maintenance

- Use correct size spanner suitable to the size of nut and bolt.
- Do not use a spanner as a hammer.
- While using a spanner do not strike it with a hammer..
- Prevent the grease and oil traces on its jaws.

28 Measuring Steel tape (Fig 28) : The size will be the maximum length it can measure.

Fig 28



MEASURING STEEL TAPE

E.g. Blade 12 mm wide 2 metres long.

The measuring tape is made of thin steel blade, bearing dimensions on it.

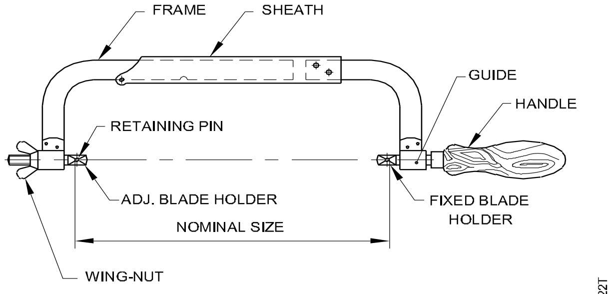
It is used for measuring the dimension of the wiring installation and general measurements.

Care and maintenance

- Handle with great care as carelessness may spoil the graduation.

29 Hacksaw (Fig 29) BIS 5169 – 1986 for frames BIS 2594 – 1977 for blades : It is made out of sturdy nickel plated steel frame. The frame can be adjusted for 250 mm to 300 mm blades. It should be fixed on the frame with its teeth pointing away from the handle in order to do the cutting in forward stroke. It is mainly used for cutting metals.

Fig 29



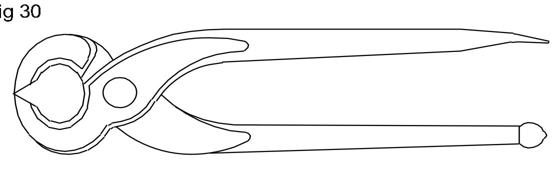
NOMENCLATURE FOR HACKSAW FRAME

Care and maintenance

- The blade should be properly tightened.
- Use a coolant while cutting.
- It should be straight during cutting.
- Lift the saw slightly on the return stroke.
- Do not attempt to saw too fast.

30 Pincers (Fig 30) BIS 4195 : The Size is given by its length. E.g. 100 mm, 150mm, 200 mm.

Fig 30



PINCERS

It is used for extracting nails from the wood.

Care and maintenance

- Do not use it as a hammer.

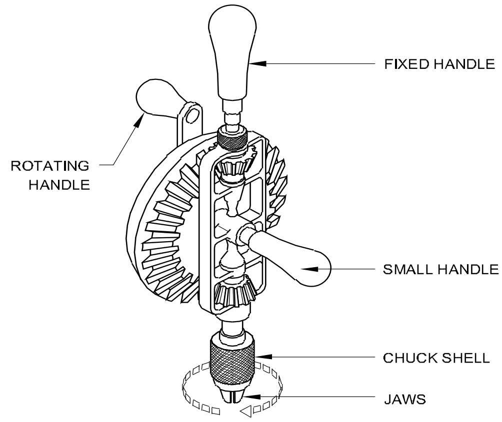
31 Hand drill (Fig 31) : The size is given by the twist drill bits which can be fitted in e.g 6 mm , 0-12 mm capacity.

A hand drill machine is used for making holes in thin metal sheets or wooden articles.

32 Portable Electric Drilling Machine (Fig 32)

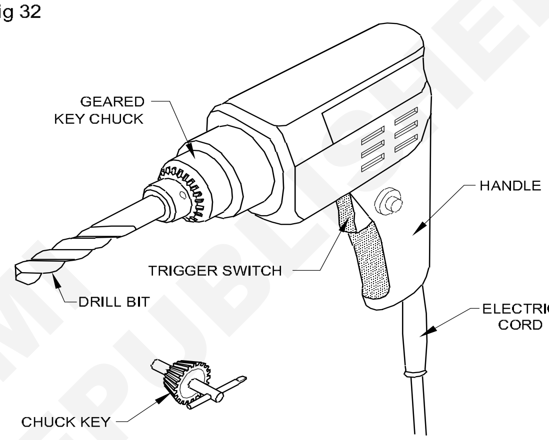
When power is available, a power drilling machine is a more convenient and accurate tool for drilling holes on wooden and metal articles.

Fig 31



HAND DRILL

Fig 32



ELECTRIC DRILLING MACHINE

Care and maintenance

- Lubricate all the moving parts of the machine.
- Fix the drill bit firmly in the jaws.
- Before drilling mark the job with a centre punch.
- For taking out the drill bit move the chuck in the reverse direction.
- Do not apply excess pressure on small bits.
- In the case of an electric drilling machine it must be properly earthed and the insulation should be sound.

Domestic wiring installation

Objectives: At the end of this lesson you shall be able to

- **explain the necessity of inspection and test for a domestic wiring installation and the items to be inspected**
- **explain the type of test to be carried out in wiring installations and their necessity**
- **explain the procedure of conducting the following tests:**
  - **– continuity test**
  - **– effectiveness of earth connection**
  - **– insulation test between conductors**
  - **– insulation test between conductors and earth**
  - **– polarity**
- **explain the necessity of installing correct rating fuses in a circuit taking into consideration the connected load and the circuit cable capacity.**

General requirement of inspection and tests (Ref: BIS 732 – (Part III) 1982) : Before a completed installation, or an addition to the existing installation, is put into service, inspection and existing shall be carried out in accordance with the Indian Electricity Rules, 1956. In the event of defects being found, these shall be rectified, as soon as practicable and the installation retested.

Periodic inspection and testing shall be carried out in order to maintain the installation in a sound condition after putting it into service.

Where an addition is to be made to the fixed wiring of an existing installation. The latter shall be examined for compliance with the recommendations of this code.

The individual equipment and materials which form part of the installation shall generally conform to the relevant Indian Standard specification wherever applicable. If there is no relevant Indian Standard specifications for any item, these shall be approved by the appropriate authority.

Specification of the installation

On Completion of wiring a general inspection shall be carried out by competent personnel in order to verify that the provisions of this code and those of Indian Electricity Rules, 1956 have been complied with. This, among other things, shall include checking whether all equipments, fittings, accessories, wires/cables, used in the installation are of adequate rating and quality to meet the requirement of the load; the layout and finish shall be examined for neatness that would facilitate easy identification of circuits of the system, adequacy of clearances, soundness of the termination with respect of tightness, contact pressure and contact area. A complete check shall also be made of all the protective devices, with respect to their ratings, range of settings and coordination between the various protective devices.

Items to be inspected in lighting circuit

Lighting Circuits – The lighting circuits shall be checked for the following.

1 Wooden boxes and panels are avoided in factories for mounting the lighting boards and switch controls etc.

2 Neutral links are provided in double- pole switch-fuses which are used for lighting control and no fuse is provided in the neutral.

3 The plug points in the lighting circuit are all 3-pin type, the third pin being suitably earthed.

4 Tamper – proof interlocked switch socket and plugs are used for locations easily accessible.

5 Lighting wiring in factory area is taken in enclosed conduit and the conduit properly earthed, or alternatively, armoured cable wiring is used.

6 A separate earth wire is run in the lighting installation to provide earthing for plug points, fixtures and equipments.

7 Proper connectors and junction boxes are used wherever joints are to be made in conductors or cross over of conductors takes place.

8 Cartridge fuse units are fitted with cartridge fuses only.

9 Clear and permanent identification marks are painted in all distribution boards, switchboards, sub-main boards and switches as necessary.

10 The polarity having been checked and all fuses and single –pole switches are connected on the phase conductor only and wiring is correctly connected to socket-outlets.

11 Spare knock-outs provided in distribution boards and switch fuses are blocked.

12 The ends of conduits enclosing the wiring leads are provided with ebonite or other suitable bushes.

13 The fittings and fixtures used for outdoor use are all of whether – proof construction, and similarly, fixtures, fittings and switchgears used in the hazardous area are of flame-proof application.

14 Proper terminal connectors are used for termination of wires (conductors and earth leads) and all strands are inserted in the terminals;

15 Flat ended screws are used for fixing conductors to the accessories.

16 Use of flat washers backed up by spring washer for making end connections is desirable and executed.

17 The number of wires in a conduit conforms to provisions of Part II of BIS 732.

Testing of Installation

After inspection, the following tests shall be carried out, before an installation or an addition to the existing installation is put into service. Any testing of the electrical installation shall commerce after obtaining a permit to work from the engineer-in-charge and after ensuring the safety provisions.

A test should be conduct with an insulation tester whose rated DC voltage is double the working volatage of the installations provided that it need not exceed 500 v for medium voltage circuit.

1 Continuity or open circuit test.

2 Effectiveness of earth connections.

3 Insulation test

- Between conductors
- Between conductors and earth

4 Polarity test.

Continuity or open circuit test

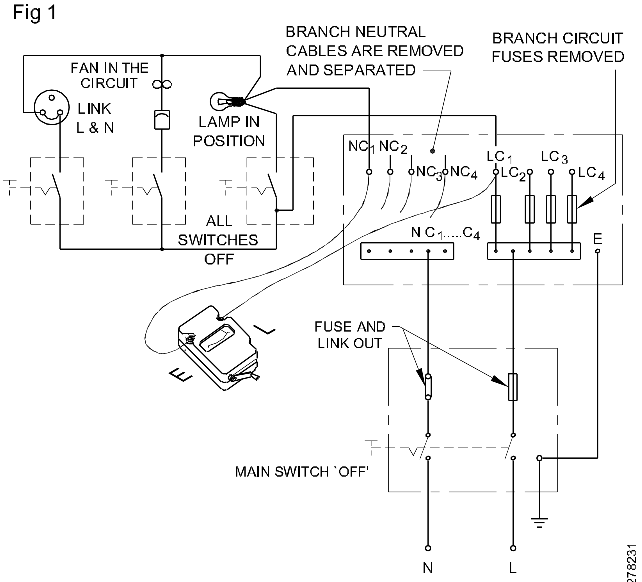
This is test is carried out to check the continuity of cables in the individual sub-circuits. Before conducting this test, the main and all distribution circuit fuse should be removed.

The phase and neutral of the individual circuits should be identified from the distribution board and segregated.

Place all bulbs in position, connect fans to the respective ceiling roses, regulators and switches, short all socket outlets by linking phase and neutral.

Connect the megger terminals E and L to the individual circuit phase and neutral as shown in Fig 1; rotate the megger.

Fig 1



CONTINUITY OR OPEN CIRCUIT TEST

By switching 'ON' and 'Off' the switches one by one, the Megger should show zero reading and infinity alternatively. Two-way switches may have to be operated alternatively to ensure the correct test results.

If the Megger shows no continuity in the 'ON' condition of the switch, then the particular circuit is deemed to be open. On the other hand, if the Megger shows continuity in both the 'ON' and 'OFF' positions of the switch, it indicates short in the particular circuit.

Remember to remove all the shorting links at the socket points and to connect phase to the fuse, and neutral to the link , before switching 'ON' the supply.

Testing the effectiveness of earth connection

For checking the efficiency of the earthing the following tests are done.

a Testing the continuity of earth continuity conductor (ECC) and measuring its resistance.

The earth continuity conductor resistance value should not be higher than 1 Ohm.

b The earth resistance of electrode shall be measured.

The value of earth electrode resistance should not exceed 5 ohms or a value such that the protective devices in the circuit efficiently operate in the case of earth faults in the circuit.

Insulation test in wiring installation (Ref: BIS732 Part II- 1982):

The following tests shall be done:

a The insulation resistance shall be measured by an insulation tester/Megger having a voltage rating twice the system voltage (for medium voltage systems 500 Megger is suitable) The Megger terminals should be connected between earth and the whole system of conductor or any section thereof with all fuses in place and all switches closed, and except in earthed concentric wiring, all lamps in position or both poles of installation. Otherwise electrically connected together, a DC voltage, of not less than twice the working voltage provided that it does not exceed 500 volts for medium voltage circuits. Where the supply is derived from three-wire (AC or DC) or poly-phase system, the neutral pole of which is connected to earth either direct or through added resistance, the working voltage shall be deemed to be that which is maintained between the outer or phase conductor and the neutral.

b The insulation resistance in megohms of an installation measured as in (a) shall not be less than 50 divided by the number of points on the circuit, provided that the whole installation need not be required to have an insulation resistance greater than one megohm.

c Control rheostats, heating and power appliances and electric signs, may , If desired , be disconnected from the circuit during the test, but in that event the insulation resistance between the case or framework, and all live parts of each rheostat, appliance and sign shall be not less that specified in the relevant Indian Standard specification, or where there is no such specification, shall be not less half a megohm.

d The insulation resistance shall also be measured between all conductors connected to one pole or phase conductor of the supply and all the conductors connected to the middle wire to the neutral on to the other pole of phase conductors of the supply. Such a test shall be made after removing all metallic connections between the two poles of the installation and in these circumstances the insulation resistance between conductors of the installation shall be not less than that specified in (b).

On completion of an electrical installation (or an extension to an installation) a certificate shall be furnished by the contractor, counter-signed by the authorised supervisor under whose direct supervision the installation was carried out. This certificate shall be in the prescribed form as required by the local electric supply authority.

Insulation resistance between conductors

For this test, switch off the mains and remove the fuse carriers.

Remove all lamps from their holders, disconnect all appliances, keep all switches in ON position.

Keep all the distribution fuses in position.

Connect one test prod of the Megger to the phase cable and the other to neutral as shown in Fig 2.

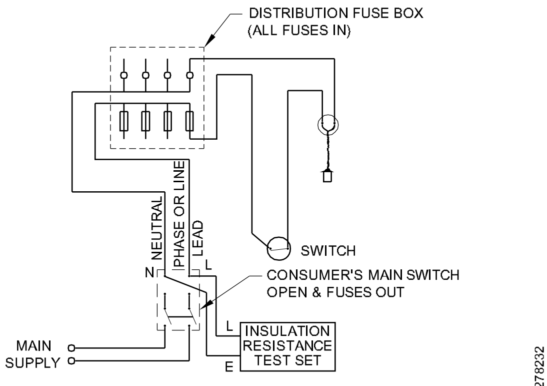
Rotate the Megger and measure the insulation resistance in megohms.

The reading in megohms should not be less than the lowest of the reading obtained in any one of the three methods stated under insulation resistance between conductors and earth.

Insulation resistance between conductors and earth

For this test, put 'OFF' the main switch and remove the main fuse carrier. All distribution fuses should be 'IN' , lamps should be in their holders and all switches for fan and light should be in the 'IN' position. Unplug all the appliances from the socket and short the phase and neutral of sockets with a jumper wire.

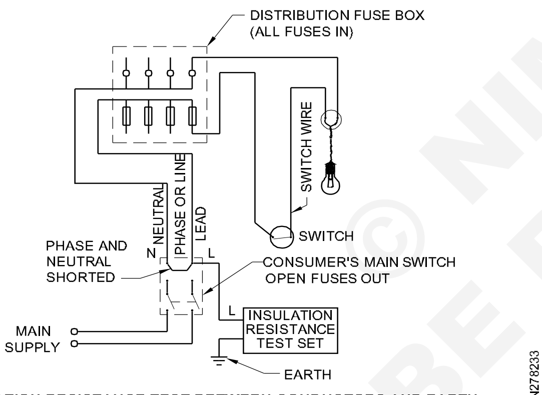
Fig 2



INSULATION RESISTANCE TEST BETWEEN CONDUCTORS

Connect the phase and neutral cables at the outgoing terminals of the main switch together and connect the lead of the Megger terminal to this shorted cable as shown in Fig 3. Connect the other lead of the Megger to the earth connection and rotate the Megger at its rated speed.

Fig 3



INSULATION RESISTANCE TEST BETWEEN CONDUCTORS AND EARTH

The reading thus obtained should not be lower than the lowest of the values obtained in the following three methods.

METHOD 1 **Standard value as per B I S**

$$\begin{pmatrix}\text{Standard value of} \\ \text{insulation} \\ \text{resistance}\end{pmatrix} = \frac{50}{\text{No. of points in the circuit}}\ \text{m}\Omega$$

where the switch, lamp-holder and socket are taken as individual points.

METHOD 2

IE rules states that the leakage current in an installation should not exceed 1/5000th part of the full load current of the installation.

Applying this, the value of insulation resistance

$$= \frac{\text{Supply voltage in Volts}}{\text{Leakage Current}}\ \Omega$$

since leakage current

$$= \frac{\text{Supply voltage in Volts}}{\text{Leakage Current}}\ \Omega$$

$$= \frac{\text{Full load current of installation}}{5000}$$

$$= \frac{\text{Supply voltage in volts x 5000}}{\text{Full load current of the installation}}\ \Omega$$

$$= \frac{\text{Supply voltage in volts x 5000 x } 10^{-6}}{\text{Full load current of installation}}\ \text{m}\Omega$$

METHOD 3 **Thumb rule**

The measured insulation resistance of an installation should not be less than one megohm.

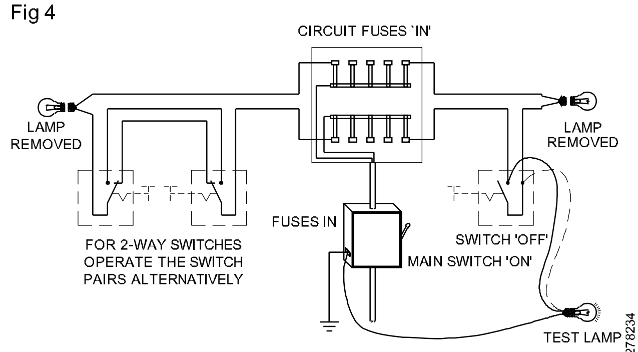
Polarity test

This test is conducted to check whether switches are connected in phase/live cable or not.

For conducting this test the lamps are removed from the lamp- holders, the fan regulators are kept in the 'OFF' position and the fuses in the main and distribution boards are inserted.

Remove the switch covers and switch 'ON' the supply. Connect one end of the test lamp to the earth continuity conductor and the other end of the test lamp to the switch terminals alternatively as shown in Fig 4.

Fig 4



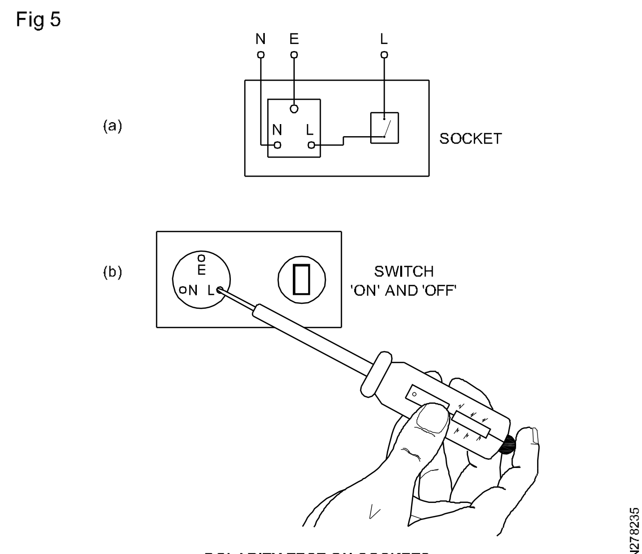
POLARITY TEST

Lighting of the test lamp indicates that the phase or live cable is controlled by the switch.

Further polarity test should be done on the sockets to verify whether

- the phase wire is connected to the right side hole of the socket as shown in Fig 5
- the switch controls the phase wire.

For this test, the neon tester could be inserted in the right side hole of the socket as shown in Fig 5 and the control switch is switched 'ON'. Lighting of the neon tester when the switch is 'ON' and no light when the switch is 'OFF' indicates correct polarity. This test is a must in all old or new wiring installations as a safety measure.



POLARITY TEST ON SOCKETS

Necessity of correct rating fuse in a circuit

The prime use of a fuse in a circuit is to protect the circuit from excess current. The reasons for excess current in a circuit may be overload, earth fault or short circuit. In such cases of current more than normal, the fuse melts and opens the circuit.

The fuse rating is normally decided by the load or by the capacity of the circuit cable whichever has a lower rating. If the load requires 10 amps and the cable capacity is only 5 amps, then the fuse should be restricted to 5 amps only. On the other hand such a situation is practically impossible as the fuse will blow soon after the load is switched on. On the contrary if a 10 amps fuse is placed in the circuit, the under-rated cables will get overheated and cause fire hazards.

But in a circuit, there is a possibility that the circuit cables may be of a higher capacity but the connected load may be less than the cable capacity. In such cases, it is advisable to use a fuse of the load rating. In the event of earth fault or short circuit, the fuse will blow and open the circuit eliminating chances of shock or fire hazards in the equipment. On the other hand in the above case, the fuse rated for the cable capacity will end in shock or fire hazard.

Hence, it is utmost necessary to place the correct capacity fuse in the circuit. As rewirable fuses cannot be readily identified, in case of doubt, it is better to replace the correct fuse wires taken from well marked stock.

Floor (Ground)

Objectives: At the end of this lesson you shall be able to
- **define the floor**
- **purpose of the floor**
- **flooring materials & factors affecting the choice of flooring material**
- **components of a floor**
- **types of floors.**

Introduction

In order to sub-divide the portion between the plinth level or basement level and roof level, solid constructions are carried out. These constructions are known as floors and exposed top surface of floors are termed as floorings. Ground floors or basement floors are termed as flooring. Ground floor or basement floors, which directly kept on the ground, do not require the provision of a floor. But they are provided with suitable type of flooring. In addition to that measures should be taken to prevent the entry at dampers and for giving thermal insulation.

Definition

It is a horizontal element of a building structure, which divide the building into different levels, for the purpose of creating more accommodation within a restricted space, one above the other and provide support for the occupants, furniture and equipment of a building.

Purpose

The purpose of floor is to creating more accommodation within a restricted space, one above the other and provide support for the occupants, furniture and equipment of a building.

Flooring Materials

For giving pleasing appearance to the upper surface of the floor, various materials are used. The common materials used as flooring are:

1 Mud
2 Muram
3 Bricks
4 Flag Stones
5 Concrete
6 Terrazzo
7 Mosaic
8 Tiles
9 Marble
10 Granolithic Finish
11 Wood or timber
12 Asphalt
13 Rubber
14 Linoleum
15 Cork

Factors affecting the selection of flooring materials

1 Appearance: The material should give pleasing appearance and if should produce the colour effect with the use of building.
2 Cleanliness: It should be such that it can be cleaned easily and effectively and has resistance against oil, grease etc.
3 Comfort: It should possess good thermal insulation to give comfort for the residents.
4 Cost: Cost should be reasonable.
5 Damp resistance: The material should offer sufficient resistance against dampness.
6 Durability: Resistance to wear, tear and chemical action.
7 Fire resistant
8 Easy to give maintenance
9 Noiseless while Len which using the floor.
10 Non slippery surface but smooth enough to clean easily.

Components of Floor

Floor is composed of two essential components.

1 Sub floor – base course or floor base.
2 Floor covering, or simply flooring.

Sub Floor: It provides proper support to floor covering and the super imposed load are carried by it.

Floor covering: It provides a smooth, clean, impervious and durable surface.

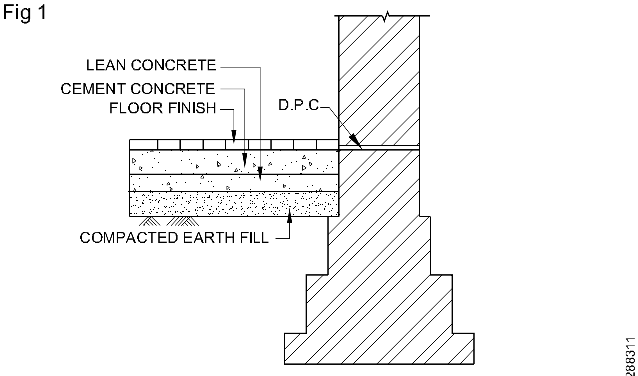
Types of floor

The floor is mainly divided in to two:

1 Ground Floor
2 Upper floor

Ground floor (basement floor) (Fig 1)

Fig 1



SOLID GROUND FLOOR

The floors resting directly on the ground surface are known as ground floors. They do not require provision of a floor. The major problems of a ground floor are damp exclusion and thermal insulation. For this purpose it is usually provided a bedding concrete of 1:4:8.

Material used for ground floor

Mud floors

1 Such flooring is cheap, hard and fairly impervious.

2 Easy to construct and easy to maintain.

3 It has good thermal insulation property.

4 Over a well-prepared ground, a 25 cm thick selected moist earth (mostly impervious) is spread and is then rammed well to get a compacted thickness of 15 cm.

5 In order to prevent cracks due to drying, small quantity of chopped straw is mixed in the moist earth, before ramming.

6 Sometimes, cow-dung is mixed with earth and a thin layer of this mix is spread over the compacted layer.

7 Sometimes, a thin paint of cement – cow – dung (1:2 to 1:3) is applied.

Muram floors

1 Muram is a form of disintegrated rock with binding material.

2 To construct such a floor, a 15 cm thick layer of muram is laid over prepared sub grade.

3 Over it, a 2.5 cm thick layer of powdered muram (Fine muram) is spread and water is sprinkled over it.

4 The surface is then rammed well.

5 After ramming, the surface is saturated with a 6 mm thin film of water

6 The surface well - trampled under the feet of workmen till the cream of muram rises to the top.

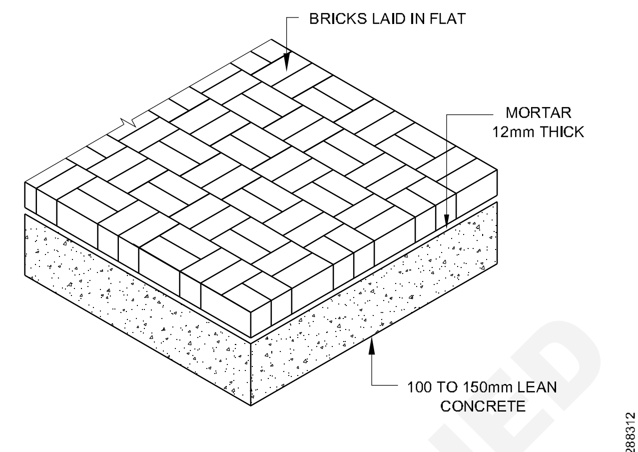
7 The surface is levelled and then kept in that state for a day, and then rammed again with wooden rammers.

8 The surface is then smeared or rubbed with thin paste of cow dung and rammed again for two days, during morning hours.

9 Finally, a coating of mud - cow dung mix is applied over the surface.

Brick floors (Fig 2)

Fig 2



BRICK FLOOR

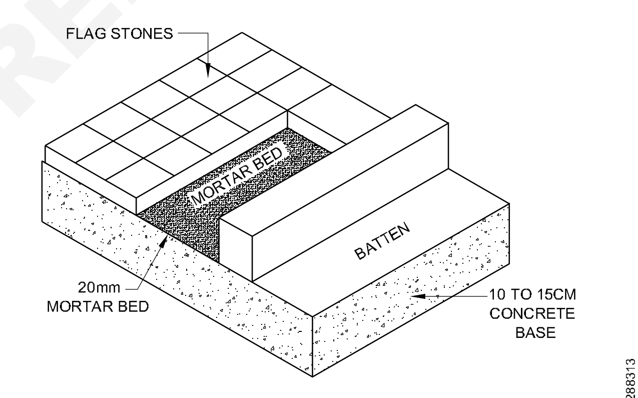
1 These floors are used in cheap type of construction such as stores, godowns, Warehouses etc.

2 The brick to be used should be of uniform shape and colour and good quality.

3 It consists of layer of brick (Flat or on edge) laid over 10 to 15 cm thick P.C.C of 1:8:16

Flag Stone Floor (Fig 3)

Fig 3



FLAG STONES FLOOR

1 Flagstone is any laminated sand stone available in 2cm to 4 cm thickness.

2 The stone slabs are laid on concrete base.

3 The sub soil is properly compacted, over which 10 to 15 cm thick lime concrete or lean cement concrete is laid.

4 The Flagstones (Stone slabs) are then laid over 20 to 25 mm thick layer of bed mortar.

5 In laying the slabs, work is started from two diagonally opposite corners and brought up from both sides.

6 A strings is stretched between two corner slabs first to correct level.

7 Other slabs are then so laid that their tops touch the string.

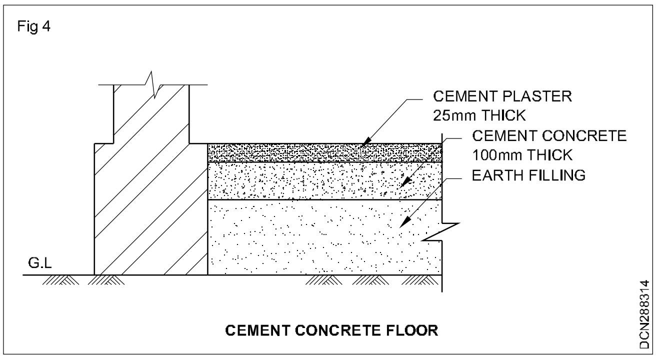
8 If any particular slab falls lower than the string level, it is re-laid by putting fresh layer of stiff mortar.

9 When the stone slabs are properly set, mortar in the joints is raked out to a depth of about 15 to 20 mm and then flush pointed with 1:3 cement mortars.

10 Proper slope is given to the surface for drainage.

11 The work is properly cured.

Cement Concrete floor (Fig 4)



CEMENT CONCRETE FLOOR

1 This is commonly used for residential, commercial and even industrial buildings.

2 It is moderately cheap, quite durable and easy to construct.

3 The floor consists of two components (1) base concrete, and (2) topping or wearing surface.

4 The base course may be 7.5 to 10 cm thick, either in lean cement concrete (1:3:6 to 1:5:10) or line concrete containing 40% mortar of 1:2 line – sand (or 1 lime: 1Surkhi: 1 sand) and 60% coarse aggregate of 40mm nominal size.

5 The base course is laid over well compacted soil, and leveled to rough surface.

6 It is properly cured.

7 When the base concrete has hardened, its surface is brushed with stiff broom and cleaned thoroughly.

8 It is wetted the previous right of laying topping and excess water is drained.

9 The topping is then laid in square or rectangular panels, by use of either glass or plain asbestos strips or by use of wooden battens set on mortar bed.

10 The topping consists of 1:2:4 cement concrete laid to the desired thickness (usually 4 cm) in one single operation. in the panel.

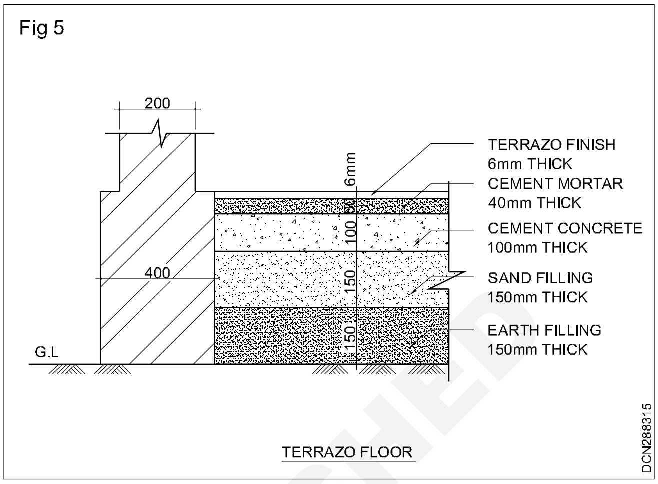
11 Topping concrete is spread evenly with the help of a straight edge, and its surface is thoroughly tamped and floated with wooden floats till the cream of concrete comes at the top.

12 Steel trowel is used for smoothening and finishing the top surface.

13 The prepared surface is protected from sunlight, rain, and other damages for 12 to 20 hours.

14 The surface is then properly cured for a period of 7 to 14 days.

Terazzo floor (Fig 5)



TERRAZO FLOOR

1 In this floor, marble chips of various shades are used as aggregate.

2 The proportion of terrazzo mix is generally 1:2 to 1:3 i.e, one part of cement to two to three parts of marble chips by volume.

3 Prepare base concrete surface of 75cm thick.

4 Over this cement mortar 1:3 of 34 mm thick is laid, and zigzag line are market on it. Surface is cured for effect

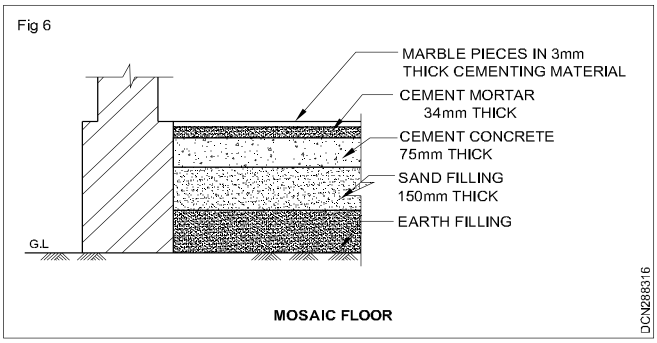
5 The cement and marble chips are thoroughly mixed wet and laid for a thickness 20 mm.

6 The first coat of polishing is done by a coarse carborandom stone, second coat is done by finely grained carborandom stone.

7 Wax is applied as a final coat of polishing to get glossy surface

8 This floor in generally used for residential buildings, bath room, Clock rooms, etc.

Mosaic floor (Fig 6)



MOSAIC FLOOR

1 Mosaic flooring is made of small pieces of broken tiles of china glazed or of cement, or of marble, arranged in different pattern.

2 These pieces are cut to desired shapes and sizes.

3 A concrete base is prepared as in the case of concrete flooring, and over it 5 to 8 cm lime – surkhi mortar is spread and levelled.

4 On this, a 3 mm thick cementing material, in the form of pate comparising two parts of slaked lime, one part of powered marble and one part of puzzolana material, is spread and is left dry for about 4 hours.

5 Small pieces of broken tiles or marble pieces of different colours are arranged in definite patterns and hammered into the cementing layer.

6 The surface is gently rolled by a stone roller.

7 Sprinkle water over the surface.

8 Surface is allowed to dry for 1 day, and is thereafter, rubbed with a pumice stone.

9 The surface is polished smooth.

10 The floor is allowed to dry for two weeks before use.

Tiled floors

1 Firstly, levelled hard bed or 15 cm thick P.C.C is prepared.

2 Over this bed, a thin layer of cement mortr 1:1 is laid.

3 Then pre cast tiles of cement concrete or pottery are laid over it carefully, filling the joints with mortar, which are generally paper thick.

4 Extra cement is wiped off and joints cleaned with saw dust. After curing the surface is rubbed and polished.

Marble

1 It is a superior type of flooring, used in residential buildings, hospitals, sanatoriums, temples etc. Where extra cleanliness is an essential requirement.

2 Marble slab may be laid in different sizes, usually in rectangular or square shapes.

3 The base concrete is prepared in the same manner as that for concrete flooring.

4 Over the base concrete, 20 mm thick bedding mortar of either 1:4 cement sand mix or (lime putty): 1 (surkhi):1 (coarse sand) mix is spread under the area of each individual slab.

5 The marble slab is then lifted up, and fresh mortar is added to the hollows of the bedding mortar.

6 The mortar is allowed to harden slightly, cement slurry is spread over it, the edges of already laid slabs are smeared with cement slurry paste, and then the marble slab is placed in position.

7 It is gently pushed with wooden mallet so that cement pastes oozes out. This is cleaned with cloth.

8 The paved area is properly cured for about a week.

Granolithic floors

1 It is a finished coat, which is provided over a concrete surface.

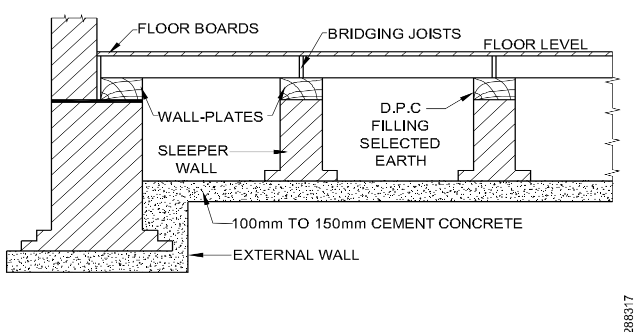
2 The concrete mix used is 1:1:2 or 1:1:3. And aggregate used may be basalt, lime stone or quartz silt.

3 The granolithic layer of concrete is laid before the base concrete is set to get a monolithic construction.

4 The minimum thickness of finishing should be 12 mm.

Wooden floors (Fig 7)

Fig 7



BASEMENT OR GROUND FLOOR OF TIMBER

1 In hilly areas where the wood is available in a large quantity and on the other hand, the climate is damp, wooden floors are used.

2 These are also used in dancing halls, auditoriums, etc.

3 The timber to be used for flooring should be of the best quality, well – seasoned and free from cracks, knots, flaws and other defects.

Asphalt floor

1 The asphalt flooring can be carried out in a variety of colours and in different forms.

2 The asphalt tiles, which are produced from natural asphalt, bitumen, asbestos fiber and mineral pigments are available in different sizes and in a variety of colours.

3 The asphalt terrazzo is formed by the combination of black or coloured asphalt with marble chips.

4 This terrazzo is laid hot and the surface is made smooth by a trowel.

5 The asphalt flooring is water-proof (no space), vermin proof, dustless and joint less.

6 It is used for surface subjected to heavy wear as incase of dairies, breweries, hospitals, shops, restaurants, loading platforms, swimming pools, terrace etc.

Rubber floor

1 It consists of sheets or tiles of rubber, in a variety of patterns and colours.

2 The sheet or tile is manufactured by mixing pure rubber with fillers such as cotton fibre, granulated cork or asbestos fibre.

3 The sheets or tiles are fixed to concrete base or wood by means of appropriate adhesive.

4 Rubber flooring is resilient and noise proof.

5 However, they are costly.

6 They are used only in office or public building.

Linoleum floor

1 It is a covering which is available in rolls, and which is spread directly on concrete or wooden flooring.

2 Linoleum sheet is manufactured by mixing oxidized linseed oil in gum, resins, pigments, wood flour, cork dust and other filler materials.

3 The sheets are either plain or printed, and are available in 2 to 6 mm thickness, and 2 to 4 m width.

4 Linoleum tiles are also available, which can be fixed (or glued) to concrete base or wood floor, in different patterns.

5 Linoleum sheet is either spread as such, or also may be glued to the base by inserting a layer of saturated felt.

6 Linoleum coverings are attractive, resilient, durable and cheap, and can be cleared very easily.

7 However, it is subjected to rotting when kept wet or moist for some time.

8 It cannot, therefore, be used for bath room, kitchens etc.

Cork floor

1 This type of flooring is perfectly noiseless, and is used in libraries, theatres, art galleries, broadcasting station etc.

2 Cork which is the outer bark of cork oak tree, is available in the form of cork carpet and cork tiles.

3 It is fixed to concrete base by inserting a layer of saturated felt.

4 Cork Carpet is manufactured by heating granules of cork with linseed oil and compressing it by rolling on canvas.

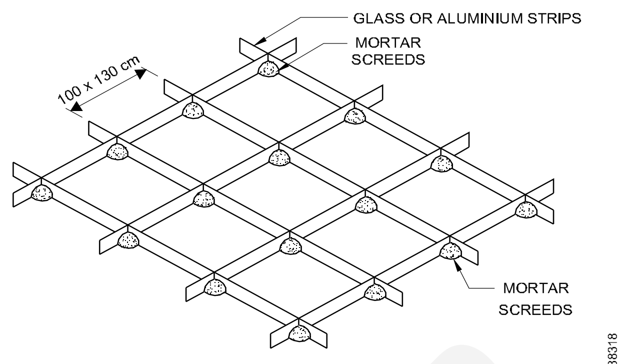
5 Cork tiles are manufactured from high grade cork or shearing compressed in module to a thickness of 12mm and baked subsequently.

Glass floor (Fig 8)

1 This is special purpose flooring, used in circumstances where it is desired to transmit light from upper floor to lower floor, and specially to admit light at the basement from the upper floor.

2 Structural glass is available in the form of tiles or slabs, in thickness varying from 12 to 30 mm.

Fig 8



METHOD OF FIXING GLASS STRIPS FOR CONCRETE FLOOR

3 These are fixed in closely spaced frames so that glass and the frame can sustain anticipated loads.

4 Glass flooring is very costly, and is not commonly used.

Plastic or PVC floor

1 It is made of plastic material, called Poly Vinyl Chloride (P.V.C), fabricated in the form of tiles of different sizes and different colour shades.

2 These tiles are now widely used in all residential as well as non –residential buildings.

3 The tiles are laid on concrete base.

4 Adhesive of specified make is applied on the base as well as on the back of P.V.C tile with the help of a notched trowel.

5 The tile is laid when the adhesive has set sufficiently (say within 30 minutes of its application); it is gently pressed with the help of a 5 kg weight wooden roller and the oozing out adhesive is wiped off.

6 The floor is washed with warm soap water before use. P.V.C tile flooring is resilient, smooth, good looking and can be easily cleaned.

7 However, it is costly and slippery, and can be damaged very easily when in contract with burning objects.

Upper floors

Objectives: At the end of this lesson you shall be able to
- **define the upper floor**
- **purpose of the upper floor**
- **types of upper floors**
- **choice of floor.**

Introduction : An upper floor is basically a principal structural element, and the general structural design of a building will greatly influence the choice of the type of floor. Upper floors are supported either on the walls or on columns; they have, therefore, the major problems of strength and stability.

The structural design of upper floors has to be such as to support the loads set up by the use of the building, in addition to the self weight and the weight of partitions etc. However, the flooring materials are practically the same as used for ground floor.

Definition : The floors constructed above the ground floor are known as upper floors.

Purpose : To create more accommodation with in a restricted space, one above the other and to provide support for the occupants, furniture and equipment of a building.

Types of floor : Floors are classified based on types of materials and construction as below.

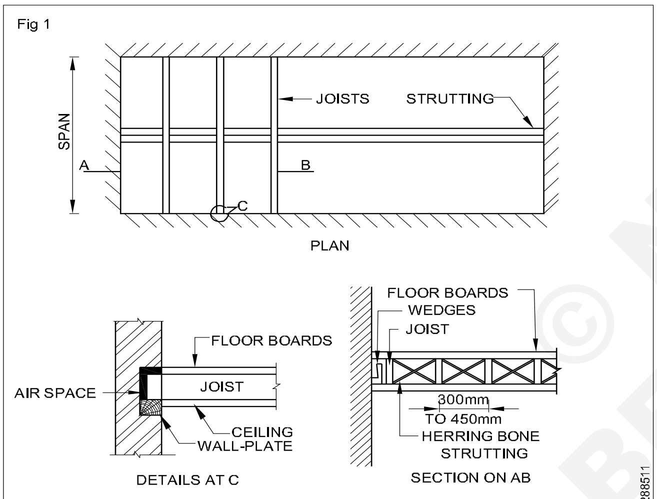
Timber Floor : This type of floor is preferred in hilly areas where timber is easily available, normally it is used in auditoriums where dances or dramas are performed…

Floors

- **Timber floors**
  - Single joint floor
  - Double joint timber floor
  - Framed or triple joist floor
- **Composite floors**
  - Double flange stone floor
  - Filler joist floor
  - jack arch floor
  - R.C.C floor
  - Hollow block or rib floor
  - Pre- cast concrete floor

A Single joist timber floor (Fig 1)

Fig 1



DETAILS OF SINGLE JOIST TIMBER FLOORS

- It is adopted for maximum span of 3.6 m
- These floors consist of single joists which are place below the floor boards.
- The joists are usually at a centre to centre distance of 300 mm to 450 mm.
- The joists are supported on wall – plates at their ends.
- When the span of joist exceeds about 2.4m, herring bone strutting are provided.
- Ends of this struts are nailed to the joists.
- At the end, the wedges are provided between the wall and the joist.

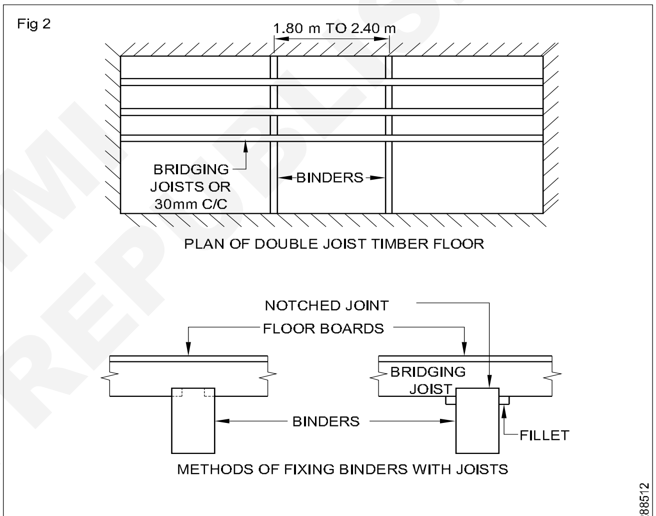
B Double joist timber floor (Fig 2)

1 It is stronger than single joist timber floor. Span is up to 7.5m

2 In this type of floor, the intermediate supports, known as the binders, are provided for the bridging joists.

3 The end of binders rest on wooden stone blocks.

Fig 2



DOUBLE JOIST TIMBER FLOOR

C Framed or triple joist timber floor (Fig 3)

1 It is suitable for span greater than 7.5 m

2 In this type of floors, the intermediate support, known as the girders, are provided to support the binders.

3 The girders are placed at a centre to centre distance of 3 m.

4 The ends of binders are supported on iron stirrups which are fixed to the girders.

5 The ends of girders rest in walls on stone or concrete templates.

Composite floor : If floors are composed of more than one material, then they are known as composite floors. It is more fire resistant and sound proof than timber floor. It can be easily cleaned and possesses better hygienic property. It can be adopted for long spans.

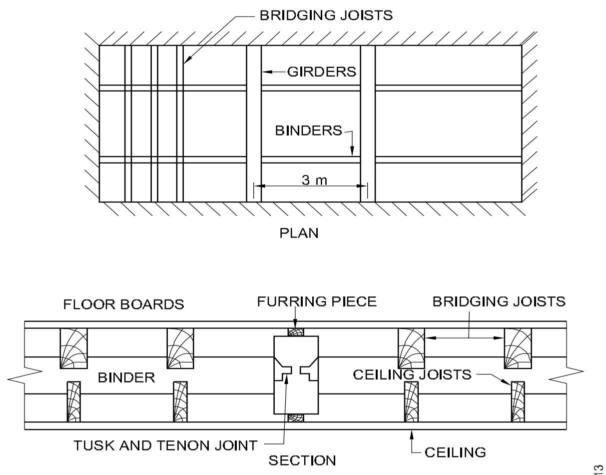
A – Double flagstone floor (Fig 4)

1 Flagstones of two layers are used.

2 If span is about 4 m only steel joists are provided.

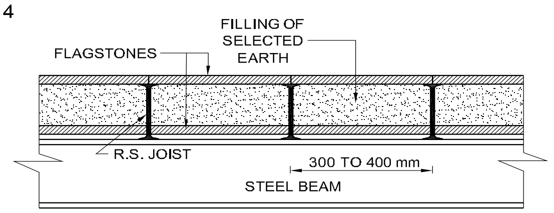
3 Top layer of flag stone is finished.

Fig 3



DETAILS OF FRAMED TIMBER FLOORS

Fig 4



DOUBLE FLAGSTONE FLOOR

B – Filler joist floor (Fig 5)

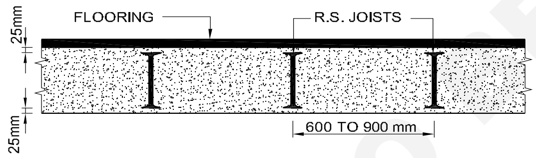
1 Small sections of R S J are placed in concrete.

2 The joists may either rest on wall or on steel beams.

3 The joists act as reinforcement.

4 The concrete should completely surround the joist.

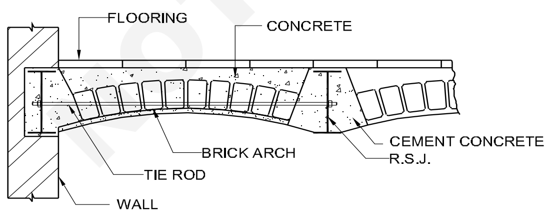
Fig 5



FILLER JOIST FLOOR

C – Jack arch floor (Fig 6)

Fig 6



BRICK JACK ARCH FLOOR

1 Brick or concrete arches are constructed and they rest on the lower flange of mild steel joist.

2 The joists are placed at a distance of about 800 mm to 1200 mm centre to centre.

3 Rise of arch should be 100 mm to 200 mm.

4 The minimum depth of concrete at the crown should be 150mm.

D – R.C.C floor

1 Steel bars and concrete are used to form a floor. Beams and slabs are designed as per load on floor.

2 For R.C.C slab, the thickness varies from 80 mm to 150 mm and the main reinforcement is generally in the form of mild steel bars of diameter varying from 9mm to 12 mm.

3 R.C.C beams are to be provided when the span of slab exceeds 4 m or so.

4 The location, spacing and bending of steel bars are to be decided carefully.

5 RCC work may be cast –in-situ or pre-cast, the former being very common.

6 Suitable flooring can be provided on the surface of an R C.C floor.

7 The R.C.C floors are less costly, durable, and easy to construct and fire proof.

8 However, they are likely to transmit sound.

9 In any case, the R.C.C. floors are fast replacing other types of floors.

10 The reinforcement in the flat slab can be arranged either in two-way system or four-way system.

11 For ordinary loading conditions, the two-way system of reinforcement is generally preferred.

Hallow block or rib floor

1 Hollow blocks of clay or concrete are used to reduce self weight of floor.

2 This type of floor is economical, fire-proof, sound-proof and light in weight.

3 Plumbing and electrical installations can be conveniently carried through the hollow blocks without affecting the appearance.

4 These floors are widely used for building like hospitals, hotels, schools, offices, etc.

E-Pre-cast concrete floor

1 With the development of pre-cast concrete construction technique, it is possible to prepare the pre-cast unit for the floor.

2 These pre-cast units are available in suitable size and can be conveniently handled, transported and fixed.

3 They may be supported either on walls or on rolled steel joists.

4 The sides of each unit contain grooves which are used to connect the adjacent units.

5 The members are light in weight and hence the cost proves to be economical.

6 They are fire-proof and sound-proof.

7 They do not require formwork during construction.

8 They have good thermal insulation.

Choice of floor

Choice of floor depends upon,

1 Span

2 Maximum load on the floor

3 Type of construction

4 Material and labour available

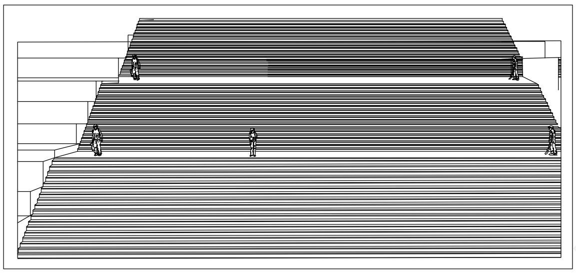
5 Purpose or use of building.

Vertical transportation

Objectives: At the end of this lesson you shall be able to
- **enlist the different means of vertical transportation**
- **define ramp**
- **explain the features of ramp**
- **state the materials used and purpose of ramp**
- **express the pitcher of ladder, stair & ramp.**

Introduction : Vertical transportation is a phrase used to describe the various means of travelling between floors in a building. All buildings with more than one storey have at least one means of vertical transportation. The provision and position of vertical transportation is a very important consideration while designing buildings in order to ensure all the occupants of the building can escape safely in the event of a fire.

Fig 1



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Types of vertical transportation used in different buildings

- **Ramps**
- **Ladder**
- **Stair**
- **Lifts (Elevators)**
- **Escalators**

Among these stairs are most commonly used for vertical transportation in residential buildings, lifts in workshops are lifts & escalators in commercial buildings.

Ramps

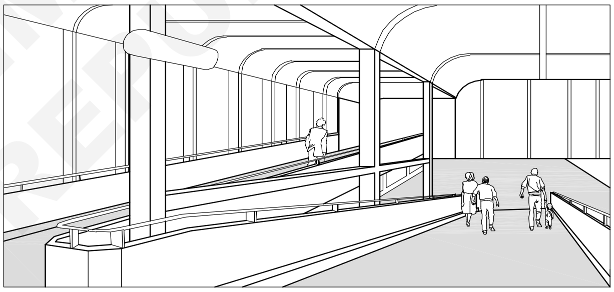
Definition

A ramp is a sloping surface and it is adopted as a substitute for stair for easy connection between the floors. They are especially useful when large numbers of people or vehicles are to be moved from floor to floor.

The important features of the ramps are as follows

- Minimum slope is 1 in 10, maximum slope is 1 in 15
- Shape need not be straight
- Provided with hand rail on both sides
- Minimum width of ramp for hospital should be 2.25m

Fig 3



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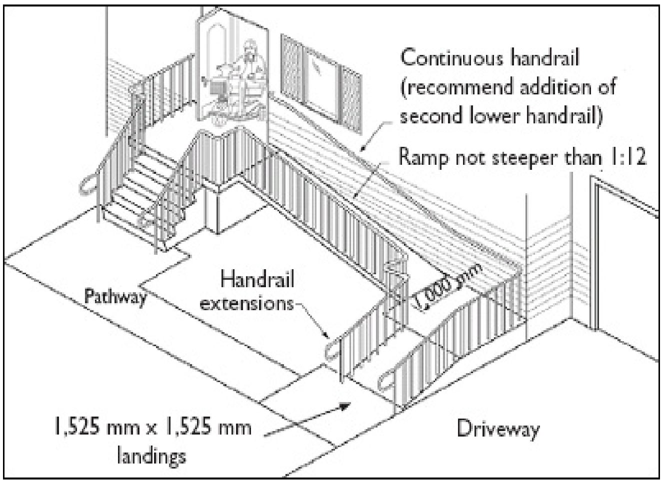


- Ramp leads directly from open space on ground level to upper floor levels.
- Used in garages, railway stations, stadium, town hall, hospital etc.

Materials : The materials used for ramp construction are rock or stone, brick, timber, steel, plain concrete, reinforced concrete etc.

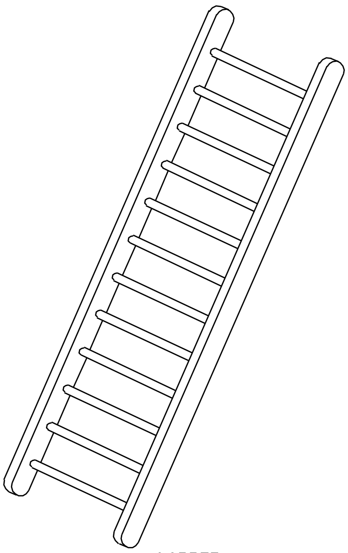
Purpose : Communication between different levels of building.

Easy and comfort transportation for vehicles, disable persons etc.

Improves aesthetic views for large buildings.

Ladder (Fig 1) : A structure of wood, metal, or rope, commonly consisting of two sidepieces between which a series of bars or rungs are set as suitable distances, forming a means of climbing up or down.

Fig 1



LADDER

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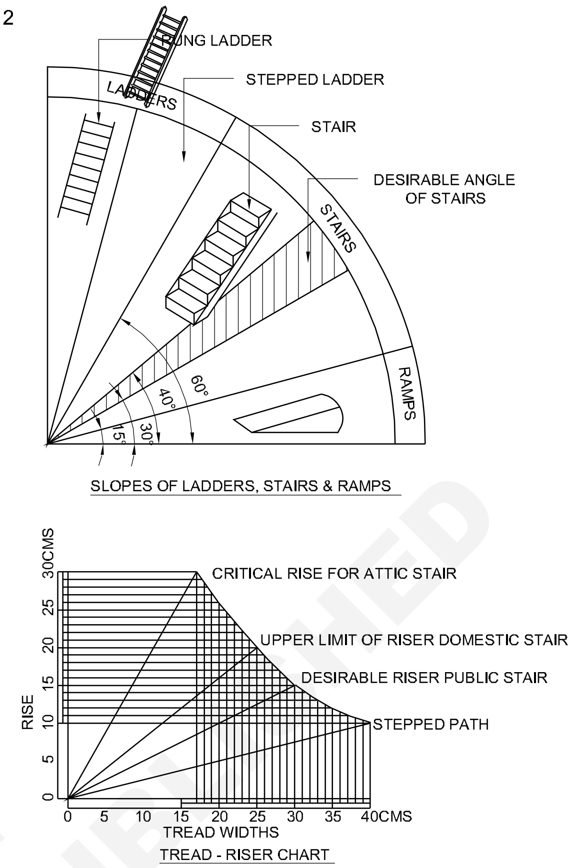
Fig 2



RAMPS, STAIRS, LADDERS

DCN298522

Stairs

Objectives : At the end of this lesson, you shall be able to,
- **define stair, stair case**
- **enlist the technical terms**
- **define the different types of slip.**

Introduction : A stair is a convenient means of access between the floors of a building. It is constructed to provide ready, easy, comfortable and safe ascent/descent with series of steps that are neither laborious nor difficult to climb within an enclosure called stairwell (Staircase).

Definition : A stair is defined as a series of steps suitably arranged for the purpose of connecting different floors of a building. It is provided to afford the means of ascending and descending between floors and landing. The room or enclosure of a building in which the stair is located is known as stair case. The opening or space occupied by the stair is known as stair way. It should be suitably located to provide easy access to all the rooms.

The definitions of technical terms used in connection with the stair are:- (Fig 1&2)

Sl.No	Terms	Definition
1	Tread	The horizontal upper portion of step
2	Going	Horizontal distance between faces of two consecutive risers.
3	Riser	The vertical front member of step
4	Rise	Vertical distance between two successive treads
5	Flight	Series of step between landings
6	Nosing	The projecting part of the tread beyond the face of riser
7	Scotia	Additional moulding provided under the nosing to improve the elevation of step and to provide extra strength to nosing end
8	Walking Line	The approximate line of movement of people on a stair. It may be 45 cm from the centre of handrail.

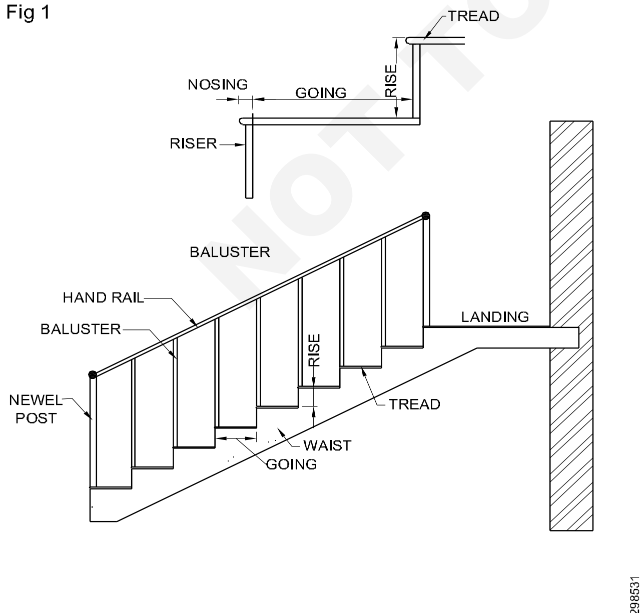
9	Head room	The vertical distance between the nosing of one flight and the bottom of the flight immediately above.
10	Run	Total length of stair in a horizontal plane. It includes the lengths of landings also. (Fig 2)
11	Soffit	The under surface of stair
12	Waist	The thickness if structural slab in case of RCC stair
13	Stringers	Inclined member in wooden stairs acting as wooden beams to support the steps.
14	String	The inclined member of a stair which supports the ends of step is known as string.
	a Cut or open string.	In the cut or open string, the upper edge is cut away to receives the ends of steps as shown in Fig 3.
	b A closed or housed string.	In the closed or housed string, the ends of steps are housed between straight parallel edges of the string as shown in fig 3.
15	Pitch	The angle of inclination of stair with the floor.
16	Landing	Horizontal platform between two flights to change of direction and to take rest for users.
17	Baluster	The vertical member fixed between string and hand rail to give support to hand rail
18	Handrail	The inclined rail over the string
19	Newel post	Vertical member placed at the end of flights to connect the ends of string and handrail.
20	Balustrade or Barrister	The combined frame work of hand rail and baluster.

STEPS: It is a portion of stairs which permits ascent or decent it comprises of a tread and riser. A stair is composed of a set of steps.

Types of steps (Fig 4)

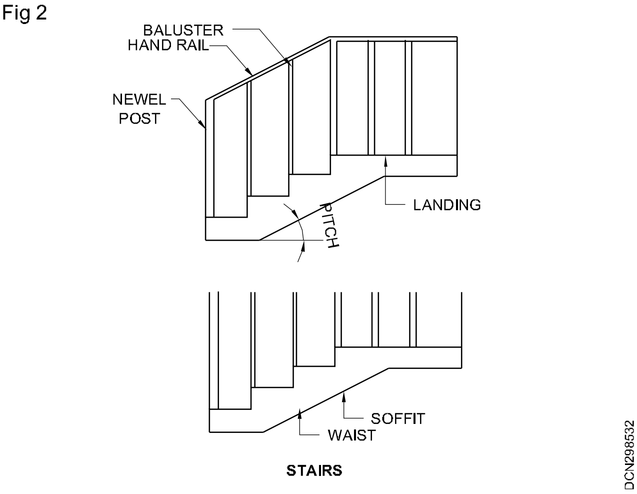
Sl. no	Terms	Definition
1	Flier	Ordinary step of rectangular shape in plan
2	Bull nose step	It forms a circular quadrant in plan and provided at the bottom of flight
3	Commode step	This step has a curved rise and tread
4	Dancing step	Step do not radiate from common centre
5	Round ended step	Similar to bull nose step except that its ends are semicircular in plan
6	Splayed step	One end or both ends splayed in plan.
7	Winder	Tapering step and used to change the direction of flight

Fig 1



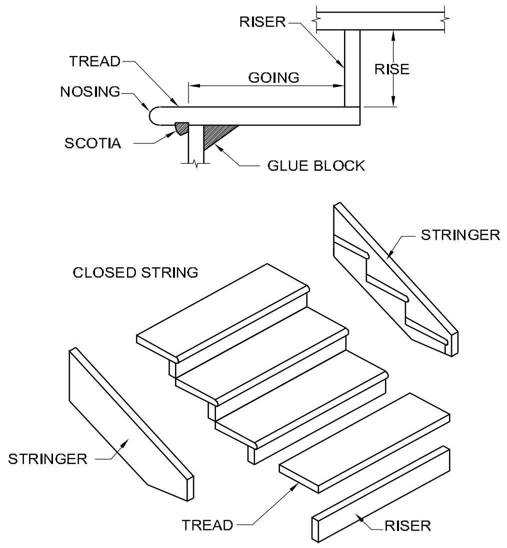
STAIRS

Fig 2



STAIRS

Fig 3



STAIRS

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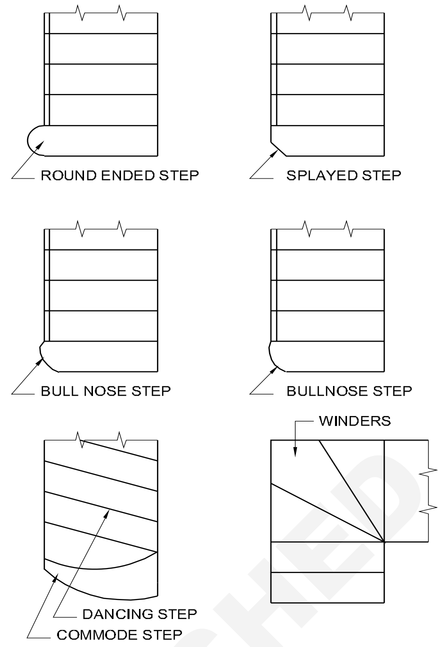
Fig 4



TYPES OF STEPS

DCN298534

Classification of stairs according to shape

Objectives : At the end of this lesson, you shall be able to
- **classify the means of vertical transportation**
- **explain types of stairs according to shape.**

Stair

Types of stairs

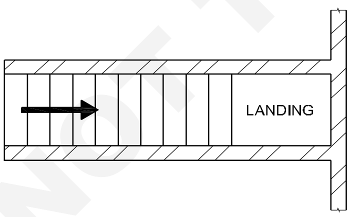
Stairs are classified as follows.

A Straight stair B Turning stair

C Circular or spiral stair D Geometrical stair

A Straight stair : In case of straight stair all steps leads in one direction only. This type of stair may consist of one or more flights and they are used when space available for staircase is long but narrow in shape. (Fig 1)

Fig 1



STRAIGHT STAIR

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B Turning stair : In case of turning stair the flights takes turn.

The usual type of turning stair are described below.

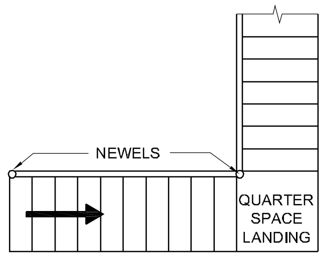
1 Quarter-turn stair

i Biffurcated stair ii Half-turn stair

iii 3-Quarter-turn stair

i Quarter-turn stair (Fig 2) : A stair turning through one right angle is known as a quarter-turn stair.

Fig 2



QUARTER - TURN STAIR

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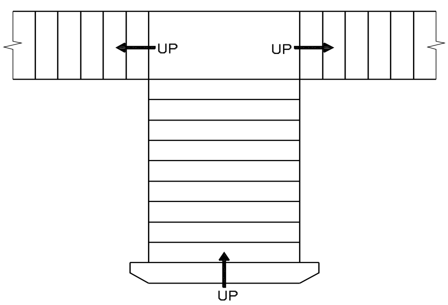
Biffurcated stair (Fig 3) : If a quarter turn stair is branched into two flights. At a landing as shown in figure is known as buffercated stair.

Fig 3



BIFURCATED STAIR

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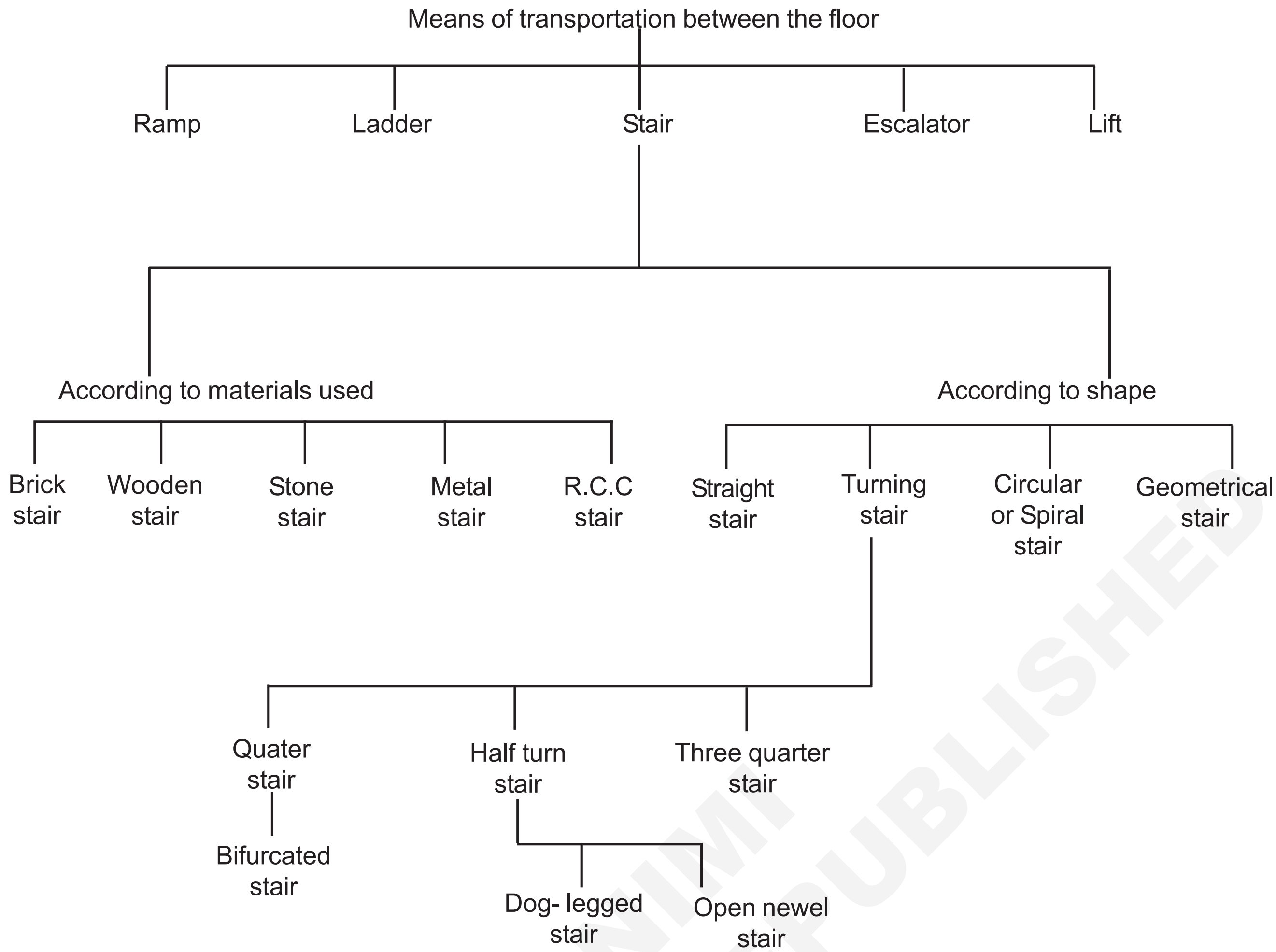
ii Half-turn stair : A stair turning through two right angle is known is a half-turn stair. A half-turn stair may be dog legged stair, and open newel stair.

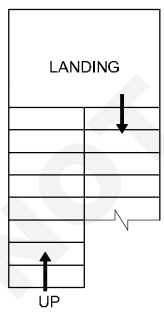


a Dog-legged stair

b Open-newel stair

a Dog-legged stair (Fig 4) : The stair its flights run in opposite directions and there is no space between them in space plan. The stair are useful where total width of space available for stair case is equal to twice the width of step.

Fig 4



DOG LEGGED STAIR

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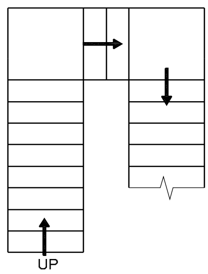
b Open newel stair (Fig 5) : In case of an open newel stair there is a well or opening between the flights in plan. This well may be rectangular or any geometrical shape and it can be used for fixing lift. These stair are useful where the total width of the space available for staircase has width greater than twice the width of the step.

Fig 5



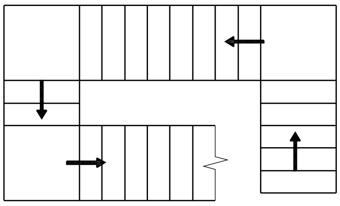
OPEN NEWEL STAIR

DCN298615

iii Three quarter turn stair (Fig 6) : A stair turning through three right angles is known as three quarter-turn stair as shown in figure. In this case an open well is formed.

C Circular helical or spiral stair (Fig 7) : In this type of stair, the steps are radiate from the centre. The flights consist of winders only and they may be continued through any desired number of turns. Spiral stair may be constructed of cast-Iron, Mild steel, concrete. Usually the structural design and construction of spiral stair are complicated in nature. For concrete spiral stair, steel reinforcement is heavy and framework is complicated so it is expensive. Spiral stair is useful where space available is limited and where traffic is less.

Fig 6



THREE QUARTER-TURN STAIR

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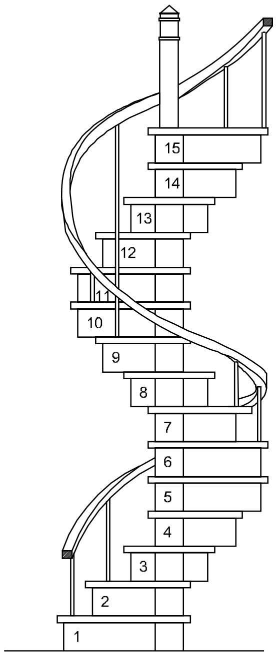
Fig 7



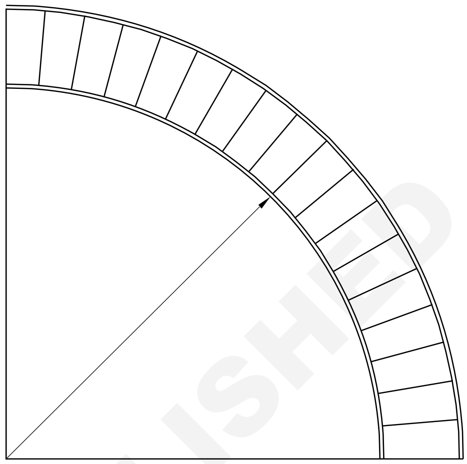
CIRCULAR OR HELICAL OR SPIRAL STAIR

DCN298617

D Geometric Stair (Fig 8)

These stairs have any geometrical shape and they do not require newel post. The handrail of a geometrical stair continuous without interruption and without any angular turns. Considerable skill is required for the construction of a geometrical stair and it is found that a geometrical stair is weaker than corresponding open-newel stair.

Fig 8



GEOMETRICAL STAIR

DCN298618

Classifications stair according to material and requirements of good stair

Objectives : At the end of this lesson, you shall be able to,
- **classify the stair according to materials**
- **explain the requirements of a good stairs**
- **design the stair case as per the given data.**

Introduction : Any well planned stair should meet the following criteria for easy, quick and safe ascent/decent.

Classification of stair according to materials used

Following are the materials which are commonly used in the construction of a stair

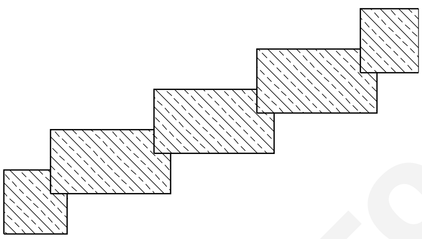
1 Stone stair
2 Wooden stair
3 Brick stair
4 Metal stair
5 R.C.C stair

Stone Stair : The stone to be used for the construction of stair should be hard, non-absorbent and they should possess enough resistance to the action of fire. These stairs are used for ware houses, work shopes etc.

Construction : A stone step may be constructed in any one of the following ways.

a Rectangular step (Fig 1)

Fig 1



RECTANGULAR STEP

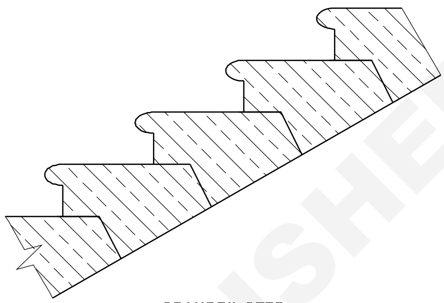
In case of a rectangular step the arrangement is made of as shown in figure. The overlap is about 25 mm to 40 mm. This arrangement results in considerable saving in labour of cutting and dressing stone.

b Spandril step (Fig 2)

In this arrangement the steps are cut in such a way so as to obtain a Plane soffit as shown in figure. This arrangement is used where head room is desired. The soffit affords a nice appearance and weight of step is also reduced the ends of spandrel step which are built into the wall should be square so as to provides a horizontal seating or bearing. The soffit can also be made broken or moulded.

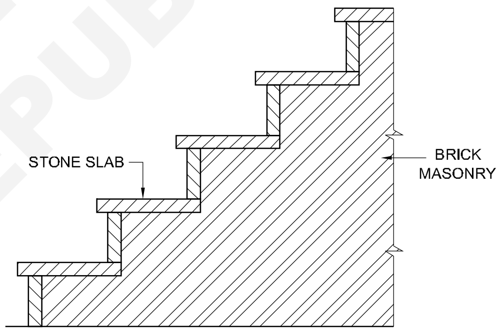
c Build up step (Fig 3) : These steps used as treads and risers in the form of thin sawn stone or marble stone, placed over brick or concrete step. The thickness of stone slab may vary from 2-5 cm.

Fig 2



SPANDRIL STEP

Fig 3



BUILT-UP STEP

Support and fixing : A stone may be supported and fixed in any one of the following four ways.

1 The step may be supported and fixed at the both ends in a wall. The bearing in wall should be at least 10cm for stairs up to 1.2m width and 20 cm for stairs having width greater than 1.2m.

2 The step may be supported at one end in a wall and the other end may be left unsupported, such a cantilever step should not have length more than 1.2m.

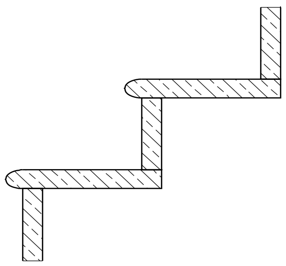
3 The step may be supported at one end in a wall and other end, it may be supported by a steel work.

4 The step may be supported both end on a steel work.

d Tread and Riser step (Fig 4) : In this arrangement the treads and risers of stones are provided as in case of timber steps. The stone slab treads and risers are connected by dowels as shown in figure.

e Cantilever tread-slab step (Fig 5) : In this arrangement the steps are formed of treads only. For this purpose only this slab stones are used without any riser. The steps may either be rectangular or triangular.

Fig 4



TREAD AND RISER STEP

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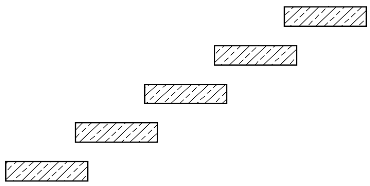
Fig 5



CANTILEVER TREAD-SLAB STEP

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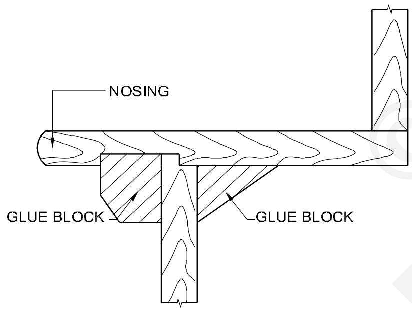
2 Wooden Stair (Timber stair) (Fig 6)

Fig 6



WOODEN STAIR

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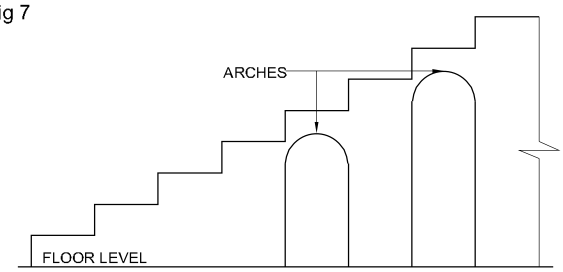
As wooden stairs are light in weight they are mostly used for residential building. But they have very poor fire resistance. They are un suitable for high raise residential building and for public building. Sometimes hard building wood such as (Mahogany, out etc) of paper thickness may be used. The timber used for the construction should be free from fungal decay and insect attack, and should be usual traded before use. In timber stair the strings are the support for the stair and act as inclined beam spanning between the floor and the landing. For additional support, a bearer or a carriage may be place under the treads.

The thickness of tread of a timber stair should not be less than 32mm (1/1/2 inch) and that of riser 25 mm. The nosing of the step should not project beyond the face of the riser for not more than the thickness of the treads. The thickness of the stinger should be 30-50 mm and 25-40 cm deep. Landing is constructed of tongued and grooved boarding on timber joist which are supported on walls.

3 Brick Stair (Fig 7)

Fig 7



BRICK STAIR

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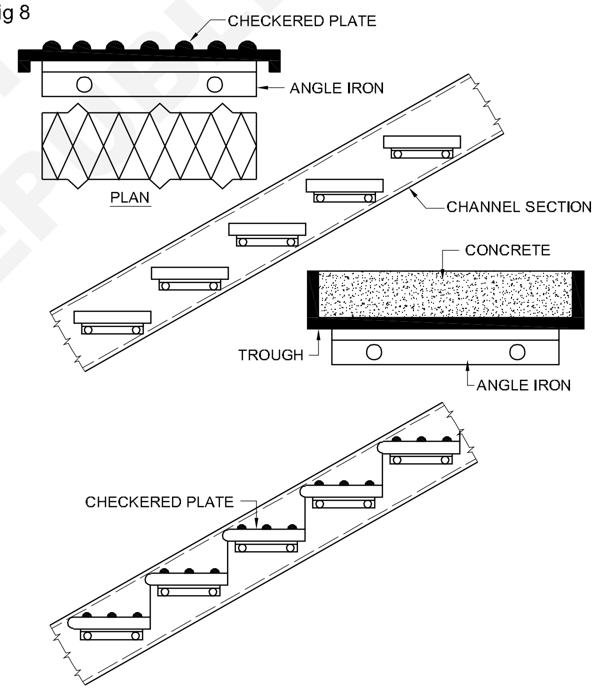
These stair are now not frequently used. A brick stair may be made of solid construction or arches may be provided as shown in figure. This arch reduces the quantity of brickwork and gives additional space which can be used for making cupboards. In case of brick stair the treads and risers are generally made equal to the length of 1 ½ bricks and height of two layer of brick respectively. The treads and risers of brick stair are finished with suitable flooring materials.

4 Metal Stair (Fig 8)

Fig 8



METAL STAIR

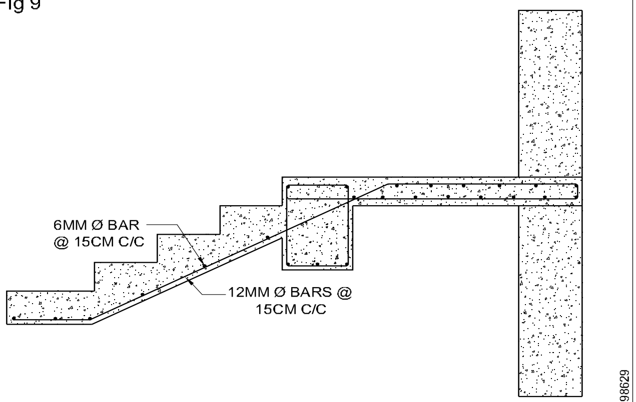
DCN298628

The External fire - escape stairs are generally made of metal. The common metal used for the construction of stairs is cast-Iron, bronze, mild steel. Metal stairs are generally is used in factories, workshop, godowns etc. In metal stairs the stringers are usually of channel sections and treads and risers are supported on angles, which are connected to the stringers. Tread and riser of a step may be of one unit or separate unit. For metal stair metal baluster with handrail of pipe are used.

R.C.C Stair (Fig 9)

These stairs are new commonly used in all types of construction. They are found to resist wear and fire better than any other material and can be moulded to the desired shape. The step can be provided with suitable finishing material such as marbles, tiles etc. These stairs can be easily maintained clean and they are strong, durable and pleasing in appearance. A typical R.C.C stair is shown in figure 9. The details and placing of reinforcement will naturally depend on design of R.C.C stair. The steps may be cast-in-sites or pre - cast.

Fig 9



R.C.C. STAIR

Requirements of a good stairs

A well designed stair should fullfill the following requirements.

i **Design of layout** : The height of floor is generally known procedure for determining the no. of treads and risers is as follows.

a The position of 1st and last risers are determined with regard to the position of doors, windows, verandas etc.

b A convenient height of riser is assumed.

c No. of risers equal to total height of floor divided by height of risers.

$$\text{i.e. no.of risers} = \frac{\text{Total height of floor}}{\text{Height of riser}}$$

d No. of treads = no. of riser -1

This is due to the fact that the surface of the upper floor forms the tread for the top step.

E.g:- For instance let us assume that height of floor is 3.8 m assume the rise of 14 cm.

$$\text{No. of treads} = \frac{3.50}{0.14} = 25 \text{ nos}$$

No. of treads in single flight = 25-1=24 Nos.

No. of treads in double flight = 25-2=23 Nos

Depending upon the space available for staircase the type of stair is selected.

Tread and Riser

In - order to make the ascend and descend easy the tread and risers of a stair should be proportional following rules of thumb are commonly used for obtaining a satisfactory proportion of the tread and riser of a step.

i Rise in cm X going in cm = 40 to 45

ii Rise in cm X going in cm = 426 (approximately)

iii 2 rise in cm X going in cm = 60 (approximately)

Take rise equal to 14 cm and going would be 30 cm as standard.

Other combination of rise and going would be 15 X 28 cm, 16 X 26 cm, 17 X 24 cm.

5 Materials and workman ship

The stair should be constructed of sound material and good workman ship so as to impart durability and strength to the stair.

6 Width

The width of stair should be sufficient for 2 persons to pass on it simultaneously and for furniture. The minimum width of stair is taken as about 80 cm.

7 Pitch

The inclination of a stair to the horizontal should be limited to 30°- 45°.

8 Head room

It should preferable not less than 2m.

9 Flight

It is not desirable to provide a flight with more than 12 or at most 15 steps and not less than 3 steps. Suitable landing should be provided to give comfort and safety to the users of the stair.

10 Winders

These are to be avoided as far as possible. However if winders are un- avoidable they should be place at the bottom rather than at the top of the flight.

11 Hand rail

When a flight consists of more than 3 steps a hand rail at least on one side is considered to be necessity.

12 Location

The stair should be suitably located in the building and they are well lighted, well ventilated and have convenient approches.

Problem (Fig 10 & 11)

1 The inside dimension of a stair case in a residential building are 2m X 4.6m. The height of floor is 3.3 m and the roof consist of R.C.C slab of 12 cm thickness. Design a proper layout of R.C.C slab stair for this building.

Section

Adopt a dog - legged stair

Assume a convenient height of riser say = 18 cm

$$\text{Then the no of raiser} = \frac{\text{Total hight of floor}}{\text{Height of risen}}$$

Total height = 3.30 + 0.12 = 3.42 m

Height of riser = 18 cm

$$Number of risers = \frac{3.42}{0.18}$$

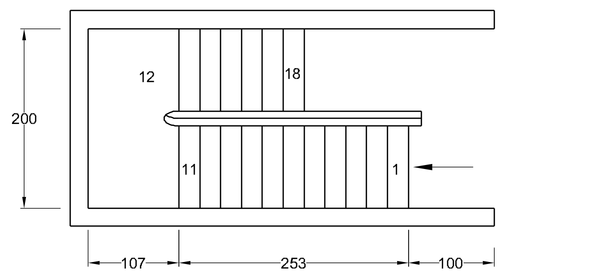
Split the number of risers into two flights conveniently say 12nos in first flight and 7 nos in second flight.

No of steps in 1st flight = 12-1 = 11 nos

No. of steps in 2nd flight = 7-1 = 6 nos

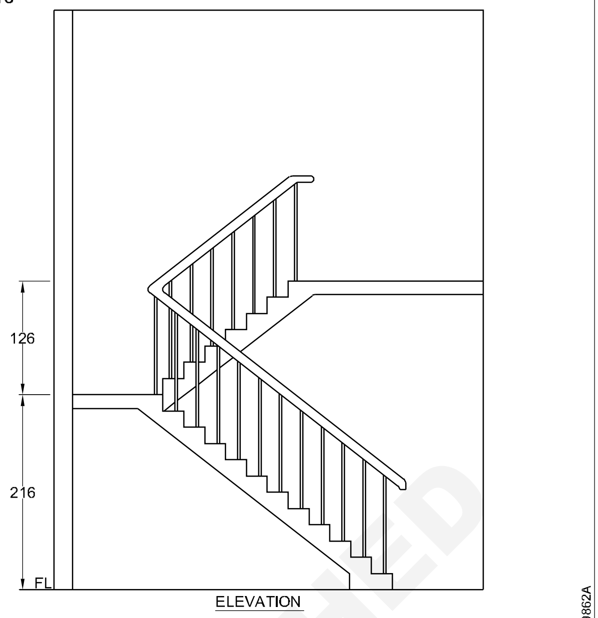
Draw the plan and sectional elevation of the dog legged stair case according the disigned values.

Fig 11



PROBLEM

Fig 10



PROBLEM

Lift or elevators

Objectives : At the end of this lesson, you shall be able to
- **introduction of lift or elevators**
- **materials needed for lift or elevators**
- **purpose of lift or elevators**
- **construction of lift or elevators.**

Introduction of lift or elevators

Lift is typically used for two purposes - passengers and goods. Passenger lifts, as the name suggests, are designed primarily for moving people although they are often used for moving small hand trolleys, persons in wheelchairs and sometimes prams/pushchairs. Passenger lifts in hospitals are often large enough to accommodate a hospital bed.

Passenger lifts usually have sliding automatic doors although in smaller building, they may have a hinged door. In both cases, a safety interlock is fitted that prevents the lift from moving while the doors are open.

In most medium sized office buildings, separate good 5 lifts are not required as most goods are small enough to fit in passenger lifts, however, industrial buildings, shopping malls and large retail stores often have a need for separate goods lifts.

Smallest goods lifts typically utilize automatic sliding doors in the same manner as passenger lifts. However larger lifts often utilize sliding concertina doors that must be opened and closed by the operator but like the passenger lift, there is usually a safety interlock to prevent the lift from moving unless the doors are closed. Similarly, the door is locked while the lift is moving for the safety of the occupants.

Definition of lift or elevator (Fig 1)

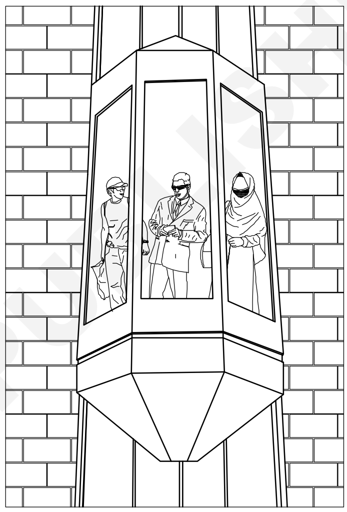
Lift/elevation is a type of vertical transportation equipment that efficiently moves people or goods between floors of buildings.

They are generally powered by electrical motors that either drive traction cables or counter weight system like a hoist, or pump hydraulic fluid to raise a cylindrical piston like a jack.

The type, size and number of elevators required is determined by:

- The type and tempo of traffic carried
- The total Vertical distance travelled: (The number of floors served and the floor to floor height)
- The average round trip time and elevator speed desired.

Fig 1



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Factors to consider in planning for elevators in a building include:

- Size, material and structural equipments for the elevator shaft
- Structural support requirements for the elevator and its hasting equipment
- Space and enclosure requirements for the elevators hosting and control equipment
- Electric power and control equipment required
- Lobby space requirements for banks of elevators.

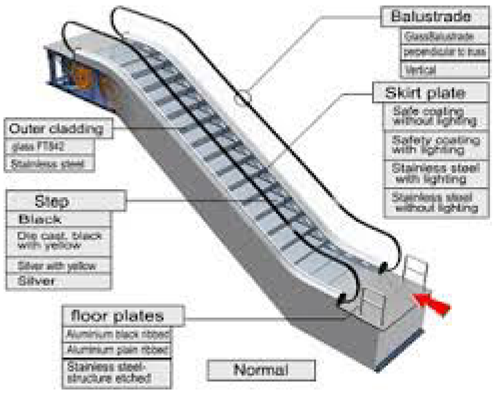
Moving stairs (escalator)

Objectives : At the end of this lesson, you shall be able to

- **definition of moving stairs (Escalators)**
- **features of the escalators**
- **constructionof the escalators.**

Definition of moving stairs (escalators) (Fig 1)

Fig 1



These stairs are known as the escalators or ever-moving flights of electrically operated stairs. These escalators are kept in motion by a revolving drum. A few steps at top and bottom are kept level though moving individually. The only thing a person has to do is to occupy a step of the escalator for his upward or downward motion.

Feature of escalators

The important features of the escalators are as follows.

Essential parts

An escalator consists essentially of the three parts: steel trussed framework handrails and an endless belt with steps. The accurately prepared tracks are attached to the steel trusses and the steps move on these tracks.

Speed and slope

The used accepted speed of the moving stair is 450 mm per second. A moving stair is in the form of an inclined bridge between two successive floors and its pitch or inclination to the horizontal is kept 30 degree.

Design

The various components of a moving stair should be carefully designed for the loads likely to come over them. The important factor affecting the design is the floor to floor height. The stairway should be kept independent by providing a structural frame around the stair well. This structural frame takes the load of floor handrail, etc.

Location

Before the position of a moving stair in a building is decided, a careful study of flow of traffic should be made or if it is a new structure, the moving stairs should be located at points where the traffic is likely to be the heaviest.

Installation

The various parts of a moving stair are prepared in the workshop and they are then brought on site for installation. The process of installation should be carefully done so as to fit each part of the stair in its proper position. This arrangement will ensure smooth working of the stair. Moreover the escalators are arranged in pairs: (Fig 2)

Fig 2

i upward movement and

ii downward movement.

The units may be placed parallel to each other.

Advantages

The moving stairs consume less power, possess large capacity and they have continuous operation without the help of operators. They are used for commercial buildings, railways, airports, etc.

Roofs

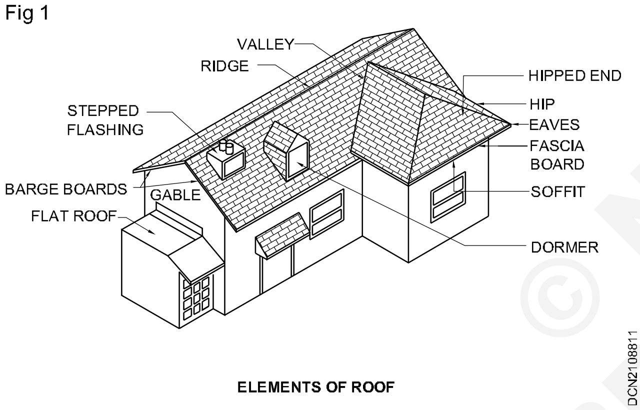
Objectives : At the end of this lesson, you shall be able to
- **define Roof**
- **identify the components of roof**
- **classify the roof**
- **forms of pitched roof**
- **explain the pitched roof.**

Introduction : Roof is the uppermost part of the building, which is supported on structural members and covered with a roofing material. Basically roof consists of trusses, portals, beams, slabs, and domes. The roof covering may be AC sheet, G I sheet, Wooden shingles, tiles etc.

Definition : A topmost covered structure provided over a building to protect from rain, snow, sun, and wind is called Roof.

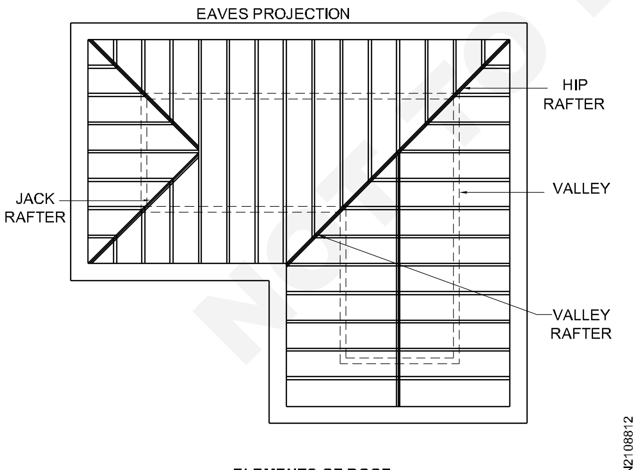
Elements of roof (Figs 1 & 2)

Fig 1



ELEMENTS OF ROOF

Fig 2



ELEMENTS OF ROOF

Span: Horizontal distance between internal faces of wall

Rise: The vertical distance between top of ridge piece and wall plate

Ridge: Wooden member provided in ridge line

Rafters: Members which support extend from eaves to ridge

Common Rafter : Rafter which supports roofs covering and extend from eaves to ridge

Principal rafter: Rafter which supports purlins

Jack rafter: Rafters shorter than common rafter

Hip rafter: Rafter provided on the junction of two slopes

Batten: Wooden plank on which roof covering is fixed

Cleat: Small wooden blocks fixed on principal rafter to prevent purlin from sliding.

Pitch: The inclination of roof

Purlin: The member fixed on principal rafter along the length of roof to carry common rafter or roof covering

Eave Board: Projection of roof beyond the surface of wall is eave and the wooden board which covers the ends of common rafters.

Valley: When two slopes meet together makes an internal angle

Wall plate: A long wooden member embedded on top of wall to receive common rafter

Barge board: The wooden planks or boards which are on the gable end of a roof

Verge: The edge of a roof running between the eaves and ridge

Gable: The triangular upper part of a wall formed at the end of a pitched roof.

Template : This is a square or rectangular block of stone or concrete placed under beam or truss, to spread the load over a large area of the wall.

Cleat : These are shorter section of wood or steel (angle Iron) which are fixed on the principal rafters of trusses to support the purlin.

Classification of Roofs

The roofs are classified into the following three categories.

i Pitched roof

ii Flat roof or terraced roof

iii Curved roof

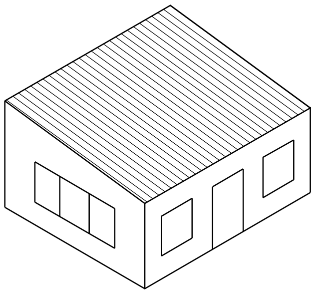
i Pitched roof

A sloping roof is known as pitched roof.

Pitched roofs are basically of following forms:-

1 Lean to roof : This is the simplest type of steps roof provided either for a room of small span or for verandah. It has slope only one side a shown in figure. (Fig 3)

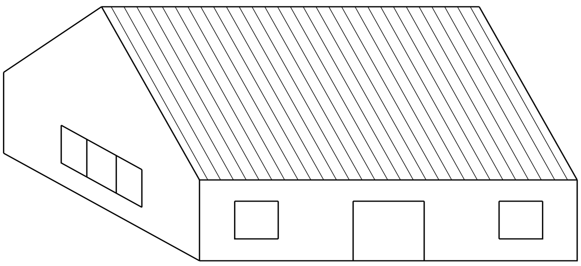
Fig 3



LEAN TO ROOF

2 Gable roof : This is the common type of sloping roof which slope in two directions. The two slopes meet at the ridge. At the end face a vertical triangle is formed. (Fig 4)

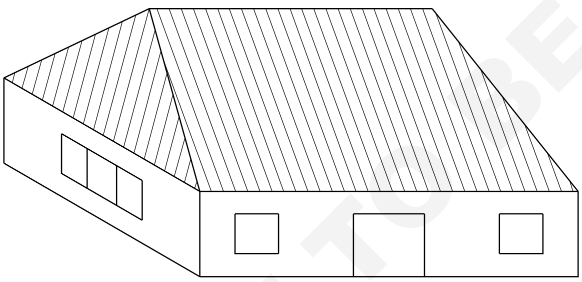
Fig 4



GABLE ROOF

3 Hip roof : This roof is formed by four sloping surface is four directions. At the end faces sloping triangle are formed. (Fig 5)

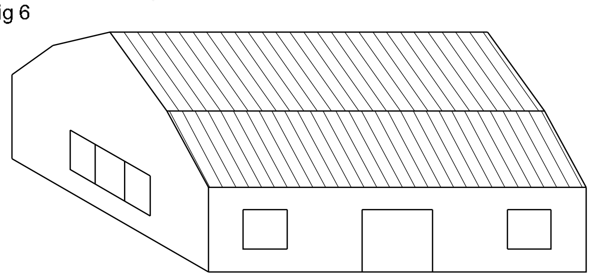
Fig 5



HIP ROOF

4 Gambrel roof : This roof is like a gable roof, slopes in two directions. But there is a break in each slope shown in figure. (Fig 6)

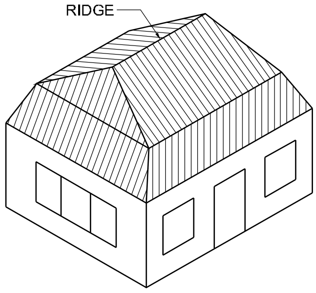
Fig 6



GAMBREL ROOF

5 Mansard roof or curved roof : Mansard roof like a hip roof slopes in four directions but each slopes have a break thus sloping are formed. (Fig 7)

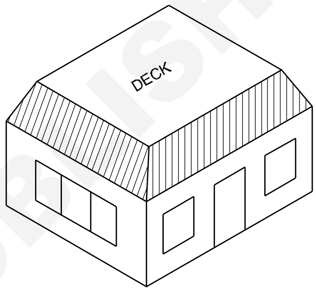
Fig 7



MASARD ROOF

6 Deck roof : A deck roof has slope in all four directions like a hip roof. But deck or plane surface is formed at the top. (Fig 8)

Fig 8



DECK ROOF

Definition

A pitched roof is one where the slope in any plane exceeds 10° to the horizontal.

Types of pitched roof

Pitched roof may be broadly classified into following

1 Single roof

2 Double roof (Purlin roof)

3 Trussed roof (Frame roof)

1 Single roof

Single roof are those which consist only the rafters which are supported at the ridge and at the cases. And such roofs are used only span is limited to 5m otherwise the size of rafters will be uneconomical the maximum span of the rafter taken as 2.5 m.

Single roofs are of four types.

a Lean to roof or verandah roof or shed roof

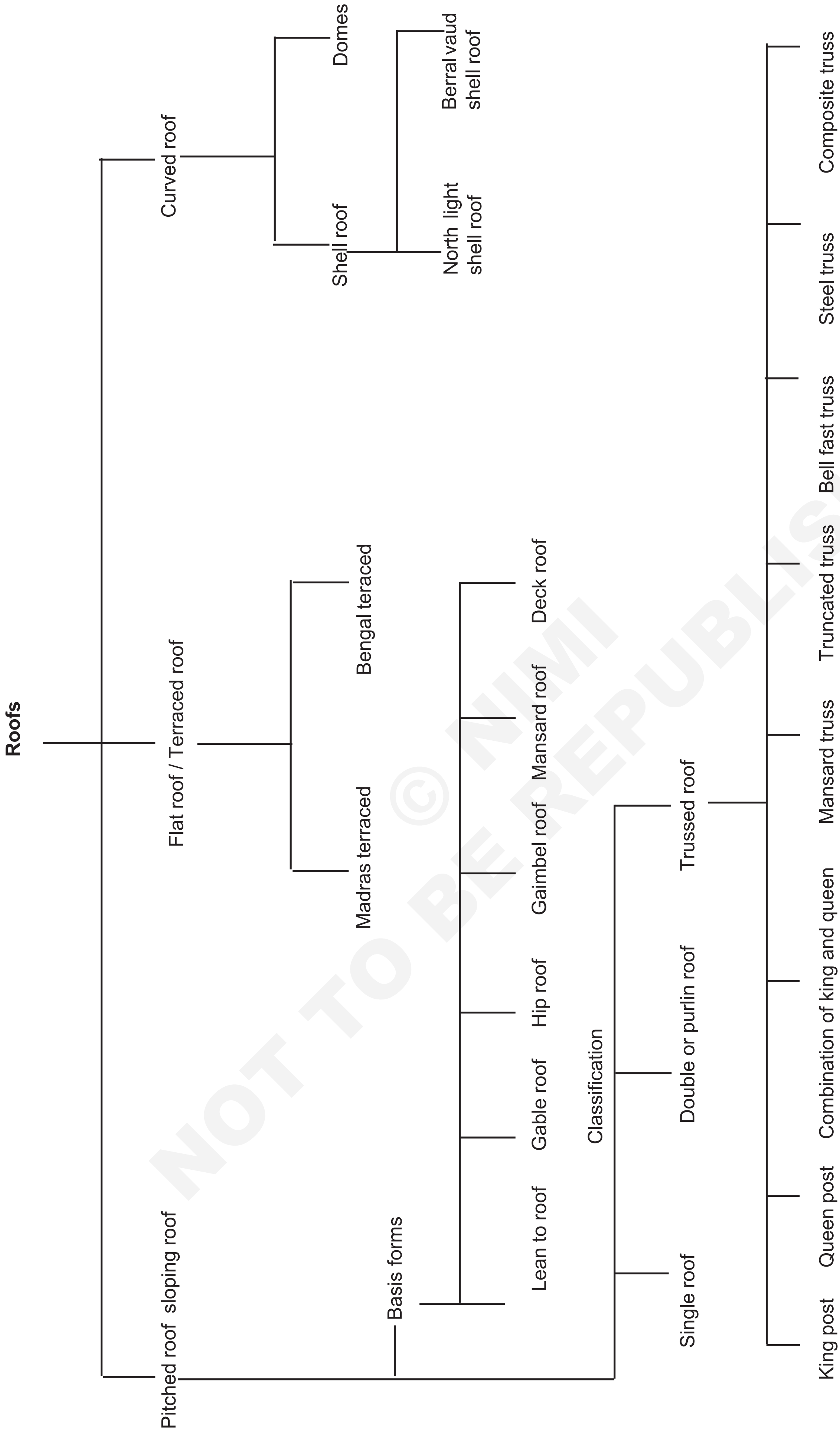
b Couple roof

c Couple close roof

d Collar beam roof

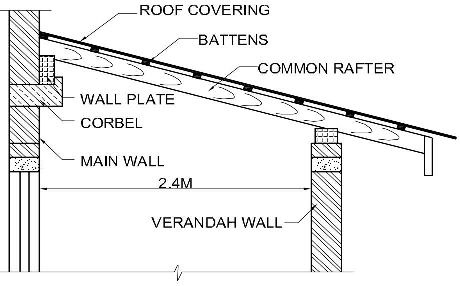
a Lean to roof (Fig 9)

This is the simplest form of sloping roof in which rafters slope to one side only. The wall to one side of the room or veranda is taken higher than wall or pillars to other side. A wooden wall plate is supported either on a steel corbel or stone corbel or a wooden corbel which are provided at 1 m centre to centre. The usual slope of this


Roofs
Curved roof
Domes
Shell roof
North light shell roof
Berral vaud shell roof
Flat roof / Terraced roof
Madras terraced
Bengal teraced
Pitched roof sloping roof
Basis forms
Lean to roof
Gable roof
Hip roof
Gaimbel roof
Mansard roof
Deck roof
Classification
Single roof
Double or purlin roof
Trussed roof
King post
Queen post
Combination of king and queen
Mansard truss
Truncated truss
Bell fast truss
Steel truss
Composite truss

roof is 30°. The rafters are suitably secured on the wall plate and ever boards, battens and roof covering are provided as shown in figure. A lean to roof is generally used for sheds, out- houses attached to main building, verandas etc. It is suitable for a maximum span of 2.4 m.

Fig 9



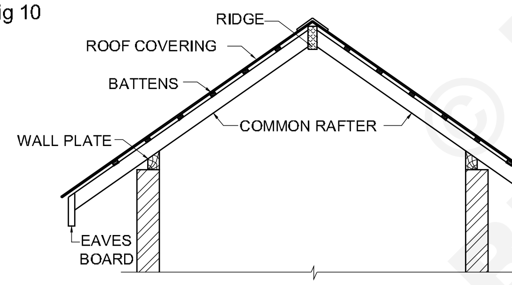
LEAN TO ROOF

b Couple Roof (Fig 10)

In this type of roof the common rulers slope upwards from the opposite walls and they meet on a ridge in the middle as shown in figure. The common rafters are firmly secured in positions at the both ends, the one end being on the ridge piece and other on the wall plate. Such a roof is not very much favoured because it has the tendency to spread out at the feet, it usual plate level and it push out with a force the wall supporting the wall plate. A couple roof is suitable for span up to about 3.6 m.

c Couple close Roof (Fig 11)

Fig 10



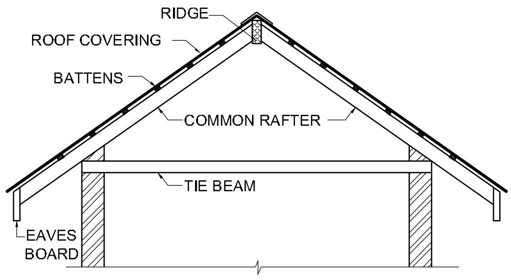
COUPLE ROOF

This roof is just III rd to a couple roof except that the legs of the common rafters are concealed by a tie beam as shown in figure. The tie beam by a tie beam as shown in figure. The tie beam position tendency of rafters to spread out and thus the danger of overturning of the walls is avoided. The tie beam can also be used as a ceiling joist when required. A close roof can be adopted economically up to span of 4.2. For increased span for load the rafters may have tendency to say in the middle. This can be checked by providing a central vertical rod, called king rod, or king boll which connect the ridge beam and tie beam is shown in figure.

d Collar beam roof (Fig 12)

When span increase or when the load is more the rafters of the couple close roof have the tendency to bend. This is avoided by rising the tie beam and fixing it 1/3 or 1 ½ of the vertical height from the wall plate to the ridge. This rised beam is known as the collar beam or collar tie. This roof is suitable for span up to 5m. A lower collar position gives stronger roof. A collar beam provides roof greater height of the room. If two collar beam crossing each other are provided to give the appearance of scissors, it is known as collar and scissors roof.

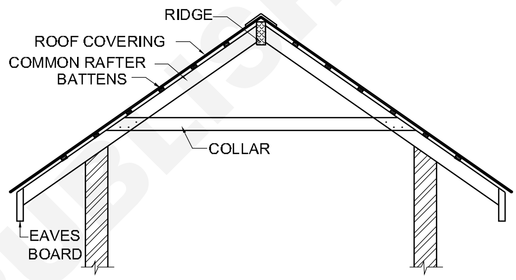
Fig 11



COUPLE CLOSE ROOF

(II) Double (Purlin) Roof (Fig 13)

Fig 12



COLLAR BEAM ROOF

These roof have two basic elements

i Rafter

ii Purlin

The purlins give intermediate support to the rafters and are supported on end walls. The intermediate supports so provided in the form of purlins, reduce the size of the rafters to the economical range. Such a roof is also known as rafter and purlin roof. The rafters are provided foreclose (42-60 cm c-c). Each rafters is thus supported at 3 points.

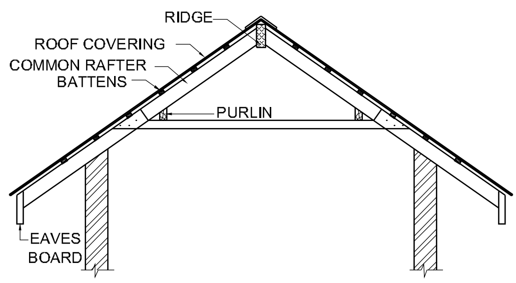
i At the bottom on wall plate

ii At the lop by the ridge

iii At the centre by a purlin

For large roof 2 or more purlins may be provided to support each rafter.

Fig 13



DOUBLE (PURLIN) ROOF

Trussed roof

Objectives : At the end of this lesson, you shall be able to,

- **define roof trussed**
- **sketch the basic types of trussed roofs**
- **explain the features & uses of basic forms trussed roofs.**

Definition

Trussed roof is used when the span exceeds 4.8m and there are no inside supporting walls or partitions for the purlins then the framed structure which are used to support the root is called truss.

Trussed roof

When span of the roof exceeds 5 m and there are no inside wall to support the purlins, framed structure known as trusses are provided at suitable interval along the length of the room. Spanning is generally limited to 3 m for wooden trusses. The roof may be consist of 3 elements.

a Rafters : Supporting the roofing elements

b Purlins : To provide intermediate support to rafters.

c Truss: To provide support to the end of purlin. The trusses span in the same direction in which the couple of rafters run. The truss also support the ridge piece or ridge beam.

The different type of trusses are as follows:-

1 King post truss

2 Queen post truss

3 Combination of king post and queen post truss

4 Mansard truss

5 Truncated truss

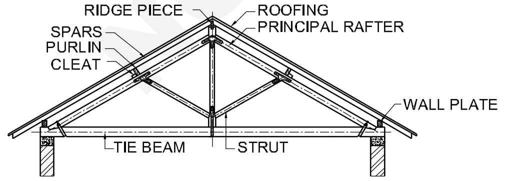
6 Bel - fast truss

7 Steel truss

8 Composite truss

1 King post truss (Fig 1)

Fig 1



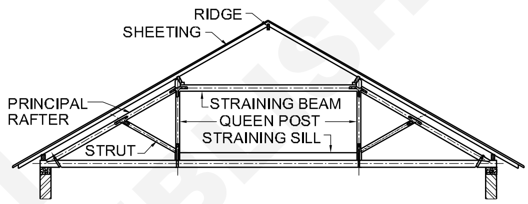
KING POST TRUSS

In this type of truss the central post known as king post forms a support for the tie beam. The inclined member known as struts prevent the principal rafter from bending in the middle. A king post truss is suitable for roof of span varying from 5-8 m.

Suitable joints are provided between the rafter and tie beams, between the principal rafter and king post, between king post and tie beam and at the end of strut. The joints are further strengthened by straps, bots as shown in figure. King post trusses are placed at centre to centre distance of 3m.

2 Queen post truss (Fig 2)

Fig 2



QUEEN POST TRUSS

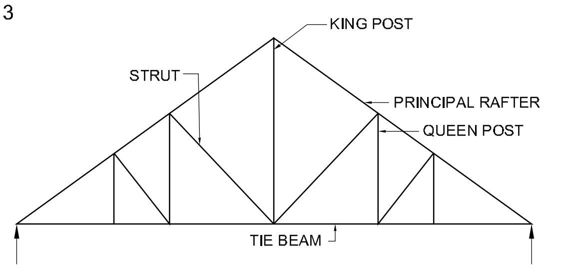
This truss differs from a king post truss in having two vertical posts, known as the queen post. The upper end of a queen post are kept in position by means of horizontal member known as a straining beam. A straining sill is introduced on the tie beam between the queen post to counteract the trust of struts. The additional purline are supported on the queen post as shown in figure.

A queen post truss in suitable for roof of span varying from 8-12m. Suitable joints should be provided at all the connections. The queen post trusses are space at a centre to centre distance of 3m.

3 Combination of king post and queen post

A convenient combination of the king post and queen post truss can be made to increase the suitability of queen post truss up to a span of 18m. For this purpose, the queen post truss is strengthened by one more up right member known as the princess post on either side as shown in figure 3.

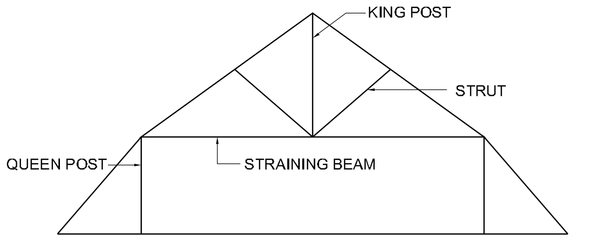
Fig 3



COMBINATION OF KING POST AND QUEEN POST TRUSS

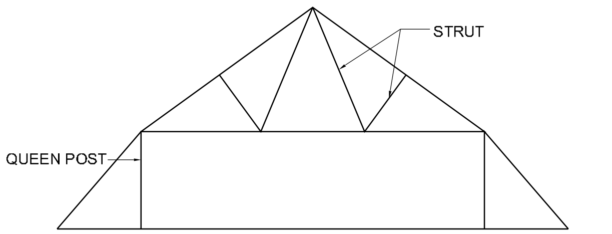
4 Mansard Truss (Fig 4 & 5)

Fig 4



MANSARD TRUSS

Fig 5



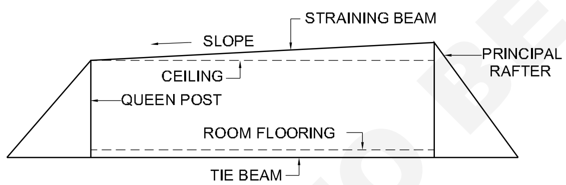
MANSARD TRUSS

Mansard truss a two- storey truss with upper portion consisting of the king post truss a lower portion of queen post truss. It is thus a combination of the king post truss and queen post truss.

The mansand truss has two pitches. The upper pitch (King post truss) varies from 30° - 40° and lower pitch (Queen post truss) Varies from 60°-70°.

5 Truncated truss (Fig 6)

Fig 6



TRUNCATED TRUSS

This truss is just similar to the mansard truss except that the top is finished flat with a gentle slope to one side as shown in figure. It is used when a room is required in the roof.

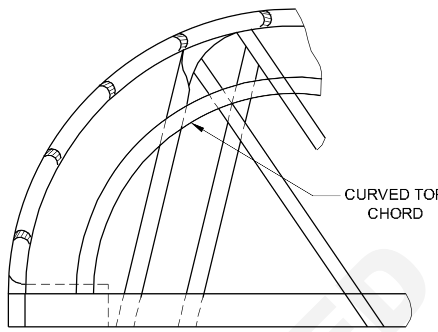
6 Bel fast truss (Fig 7)

This truss is in the form of a bow. Which consist of thin sections of timber which its top chord curved. If the roof covering is light roof truss can be used up to 30 m span. The roof truss is also known as latticed roof truss.

7 Steel roof truss (Figs 8 & 9)

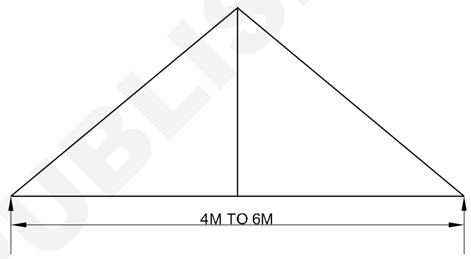
When the span exceeds 10m, timber truss becomes heavy and uneconomical. Steel trusser are more economical for large span. The mild steel is easily available in rolled section of standard shape and size such as channels T- sections and plate. Most of the roof trusser are fabricated from angle sections because they can resist effectively both tensions as well as compression and their jointing is easy. The arrangement and size of various member of a steel truss depend on the span, loading and wind pressure.

Fig 7



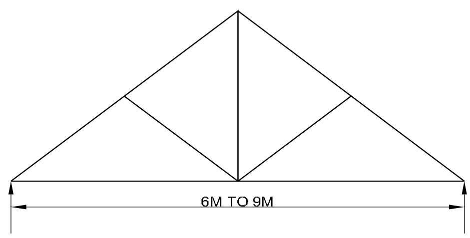
BET - FAST TRUSS

Fig 8



KING POST STEEL TRUSS

Fig 9



KING POST STEEL TRUSS

The various type of steel truss along with their suitability for different span ranges are shown in figure. (Figs 10 to 18)

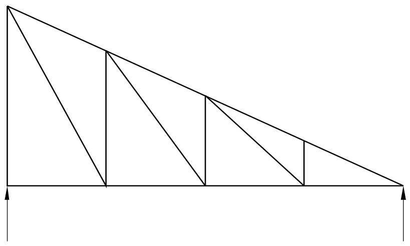
8 Composite truss (Fig 18)

These trusses are composed of wooden member and steel or wrought - iron member. The steel is used for member which have to resist tensile stresses. A composite truss is light in weight and economical.

Following are the advantages of steel trusses over timber trusses:-

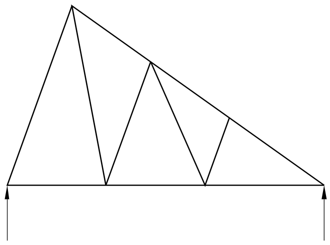
1 The components of steel trusses can be easily obtained in required dimensions and it result into the minimum wastage of material.

Fig 10



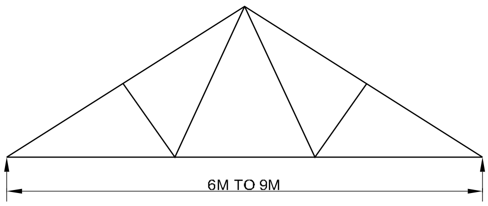
NORTH-LIGHT STEEL TRUSS

Fig 11



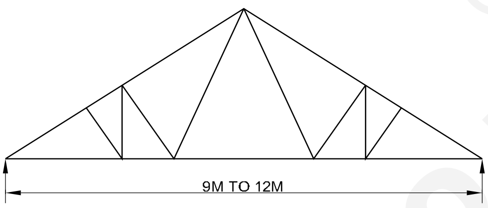
NORTH-LIGHT STEEL TRUSS

Fig 12



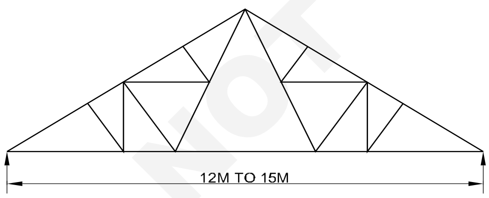
SIMPLE FINK STEEL TRUSS

Fig 13



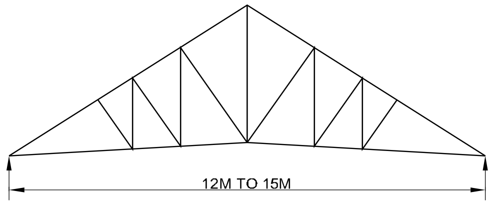
HOUSE STEEL TRUSS

Fig 14



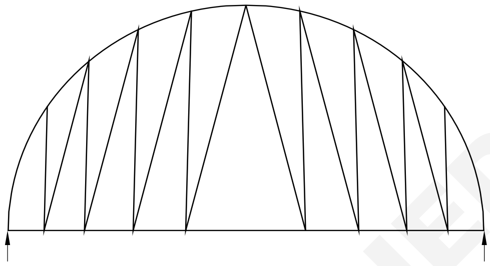
COMPOUND FINK STEEL TRUSS

Fig 15



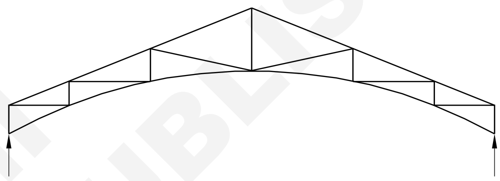
COMPOUND HOUSE STEEL TRUSS WITH KING POST STEEL RAISED CHORD

Fig 16



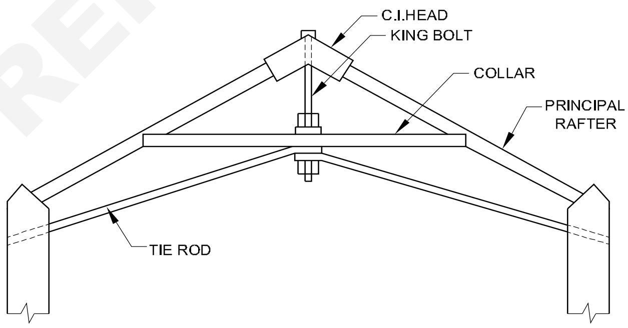
BOW-STRING STEEL TRUSS

Fig 19



ARCH - STEEL TRUSS

Fig 18



COMPOSITE TRUSS

2 They are fire proof and termite proof.

3 They are light in weight and can be fabricated in any shape.

4 They are strong and more durable as compared to the timber truss.

5 They can be easily and speedily installed because of their correction techniques.

Flat roof

Objectives : At the end of this lesson, you shall be able to,

- **definitions, advantages and disadvantages of flat Roof**
- **explain types of flat roof construction**
- **state the methods of drainage of flat roof and pitched roof**

Flat roof or terraced Roof : A roof which is nearly flat is known as the flat roof. It should be noted that no roof can be laid perfectly level. The roof must slope in one direction to drain off rain water rapidly and easily to the upper floor, the flat roof can be constructed on flag stones, RSJ and flag stones, R.C.C reinforced brickwork, Jack arch roof and pre-cast cement concrete unit. A flat roof is one where the slope in any plane does not exceed 10° to the horizontal.

Advantages of Flat roof

1 The roof can be used as terrace for playing, gardening, sleeping and for celebrating functions.
2 Construction and maintenance is easier.
3 They can be easily made fire proof in comparison to pitched roof.
4 They are more stable against high wind.
5 They do not require false ceiling which is essential in pitched roof.
6 The construction of upper floor can be easily done over flat roof, if so require in future.

Disadvantages

1 A flat roof cannot be used for long span without the introduction of intermediate pillars and beams.
2 Packets of water are formed on the surface of the roof it slope is not sufficient.
3 Cracks are developed on the surface of the roof when variation in temperature in ligh.

Type of flat roof construction : Flat roofs are constructed in similar way as the floors except that the roof surface is required to be protected against weather elements such as rain, heat, snow etc. For this purpose, the top surface of roof is given necessary slopes, either two-way or four-way, and also treated with damp-proofing materials to safeguard against the effects of rain and snow. In addition, the flat roofs are either provided with the insulation layer or treated by insulating material to counteract the effects of heat due to temperature variations.

1 Mud Terrace Roof,
2 Brick- Concrete Terrace Roofs (Including Madras Terrace Roof)
3 Jack Arch Flat Roofs,
4 R.C.C or Reinforced Brick Slab Roofs, and
5 Bengal Terrace Roofs.

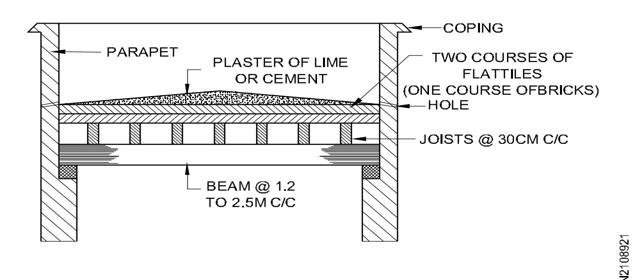
1 Mud Terrace Roofs : This type of roof, which is the cheaper and fairly water-tight, is extensively used at places of light rainfall. This mud terrace is constructed out of good white earth, containing a large percentage of sodium salts.

2 Brick - Concrete Terrace Roofs (Fig 1) : In places where the rain fall is heavy and the mud terrace roofs do not provide a satisfactory water-tight surface, one of the following methods of roof construction can be adopted:

In one method, as illustrated in Fig 1 the beams or girders of adequate sizes are placed, spanning across the room over the wall on girders or plates of wood or stone at regular intervals of 1.2 to 2.5 m.

Above these, the joists are placed at right angles to beams, etc. At spacing of 30cm centre -to -centre. Over the joists, either two courses of flat tiles or one course of bricks are laid and set in lime or cement mortar.

Fig 1

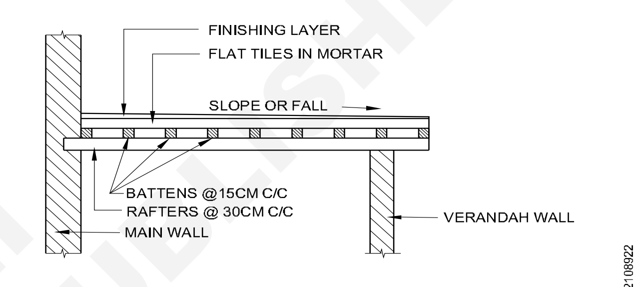


BRICK-CONCRETE TERRACE ROOFS

This is finally covered with a 7.5 to 10 cm thick plaster of lime or cement and rubbed to a polished surface.

II Bangal terraced roof (Fig 2) : The procedure of construction is as follows

Fig 2



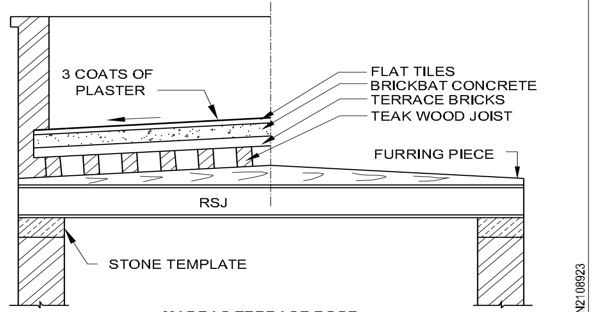
BANGAL TERRACED ROOF

1 The rafters are placed with slight inclination at 13-15 cm. One end of the rafter is inserted into the main wall to a depth of 20 cm and its other end is supported on a veranda wall or a bressumer. A bressumer is a beam on lintel or which is provided to support a wall over an opening.
2 Battens are provided at right angle to the rafter at a centre distance of about 15 cm.
3 A course of flat tiles are then lard in mortar over the battens.
4 Finally, the surface of the roof is finished in any one of the following methods.
   a Two or more causer of flat tiles may be lard and then the surface of roof is rubbed or polished with 2 or 3 coat of plaster.
   b A layer of fine jelly concrete may be laid over the first courses of flat tiles. The thickness of layer of concrete may be 40 mm.
5 As this type of roof is generally used in Bengal state to cover verandah it is known as Bengal terrace roof.

I Madras terrace roof (Fig 3) : The procedure of construction is as follows

i Teakwood joists are placed on rolled steel joist with a furring piece between the joists and rolled steel Joists. The furring is placed sloping and it gives necessary slope to the flat roof.
ii A course of specially prepared terrace bricks is laid diagonally across joist. The size of brick is generally 15cm X 75cmX 25cm and they are placed on edge in lime mortar.

Fig 3



MADRAS TERRACE ROOF

iii After the brick course has set, a course of brick bat concrete is laid. The thickness of this course is about 75 mm and it consist of 3 part of brickbat, 1 part of gravel and sand and 50% of lime mortar by volume.

iv The concrete is well rammed for 3 days and allowed to set

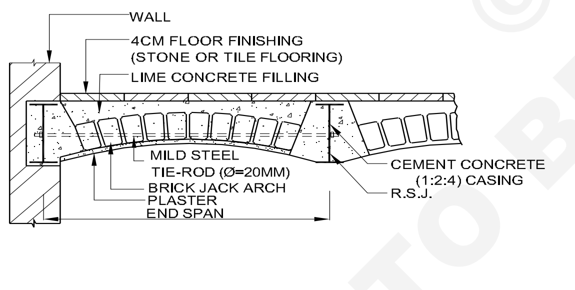
v Flat tiles are then laid over the layer of concrete. The tiles are laid in two courses of 50 mm thickness.

vi Finally the surface of the roof is finished with 3 coat of plaster as shown in figures, with a given slope of 1 is 30

vii As this type of flat roof construction is widely used in madras state (Tamil Nadu). It is known as madras terrace roof.

3 Jack Arch Flat Roofs (Fig 4) : These roofs are constructed in a similar way as the Jack Arch Floors (already described in Under Article 02.01.02) except they are provided with a protective layer at the top to safeguard against weather elements.

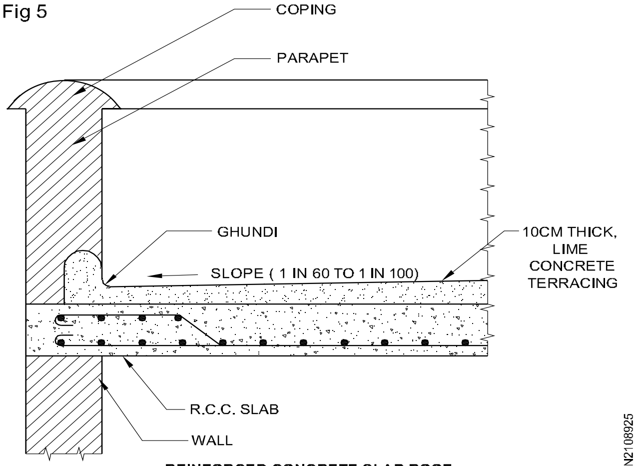
Fig 4



JACK ARCH FLAT ROOF

4 Reinforced Concrete or Reinforced Brick Flat Roofs (Fig 5) : These R.C.C or R.B. flat roofs are constructed in a similar way as R.C.C or R.B. floors (already described under Article 02.01.02) except that they are required to be protected against weather elements, i.e, rain, snow, heat, etc. A protective covering, consisting of 10 cm thick layer of lime concrete terracing with some waterproofing compound, is provided over the R.C.C or R.B. slab. This layer makes the roof leak- proof. The layer of lime concrete is thoroughly beaten by hand beaters to make it hard, impervious and compact. At the junction of wall, the lime concrete terracing is taken inside the wall for a depth of 10-15 cm and the corner is given a round smooth finish. This is done to prevent the accumulation and leakage of water at junctions. The construction details are illustrated in Fig 5.

Fig 5



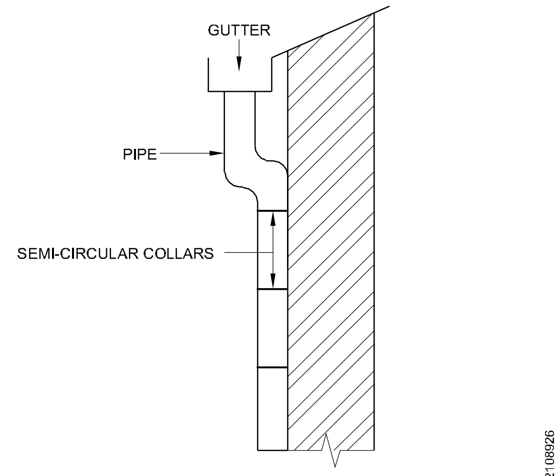
REINFORCED CONCRETE SLAB ROOF

The lime terracing is provided with a little slope, usually 1 in 60 to 1 in 100, to drain off the rain water rapidly and easily.

Drainage of pitched and flat roofs (Figs 6 & 7) : It is necessary to dispose off the rain water that falls on a pitched roof or a flat roof. In case of a pitched roof, a trough known as a gutter, is provided at the end of slope as shown in fig 6. This gutter extends for the full length of the roof at suitable points along the length of gutter, the outlet points are provided and in these outlet points, the ends of rain water pipes are fitted.

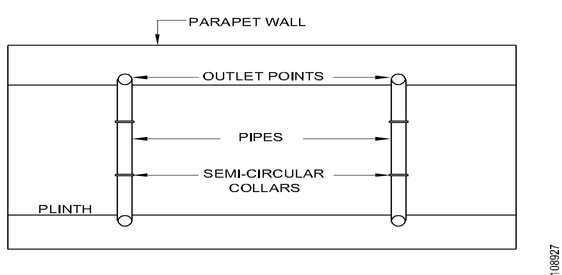
In case of flat roofs, no gutters are provided and the roof is provided with such a slope that the rain water is guided to the outlet points as shown in fig 7. The rain water thus collected is led through the pipes to the ground level.

Fig 6



DRAINAGE OF A PITCHED ROOF

Fig 7



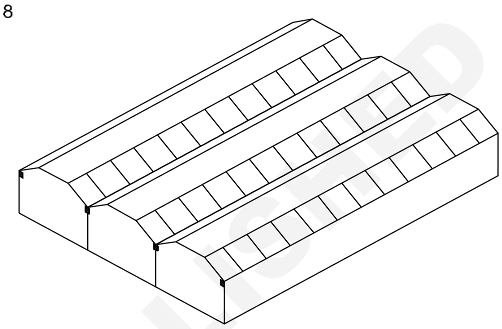
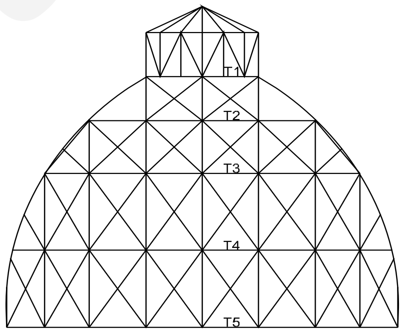
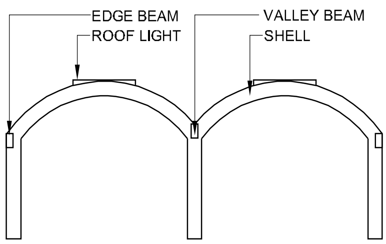
DRAINAGE OF A FLAT ROOF

Curved roof

Objectives : At the end of this lesson, you shall be able to,
- **define curved roof**
- **explain the features & uses of basic forms curved roofs.**

Definition : These are just the modifications of pitched roofs and are frequently employed in the modern age to cover large areas and to give architectural effects. The shell roofs and domes are the varieties of the curved roofs. They are useful for big structures such as factories, monumental works, libraries, theatres, recreation centres, etc. The curved roofs may be constructed of timber or R.C.C the latter material being very common now - a- days. There are two common forms of a shell roof.

Types of curved roofs

Name	Description	Figure
North light shell roof	These shell roofs are useful for big structures such as factories these are used in northern area	Fig 8  NORTH LIGHT SHELL ROOF
Dome	An element of architecture that resembles the hollow upper half of a sphere. Made of various materials. Used for appearance	Fig 9  STEEL FRAME DOME
Barrel vault shell roof	It is useful when roof is to be pro vided on circular brick work.	Fig 10  BARREL VAULT SHELL ROOF

Roof covering for pitched roofs

Objective : At the end of this lesson, you shall be able to
- **state the types of pitched roof covering materials.**

Roof covering for pitched roofs : Roof covering is an essential component of pitched roof to be placed over the roof framework to protect it from main rain, snow, sun, wind and atmospheric agencies.

Following points should be considered before selecting the type of roof covering for a pitched roof.

1 Climate of the locality

2 Nature of the building

3 Initial cost and maintenance cost

4 Durability

5 Availability of the material

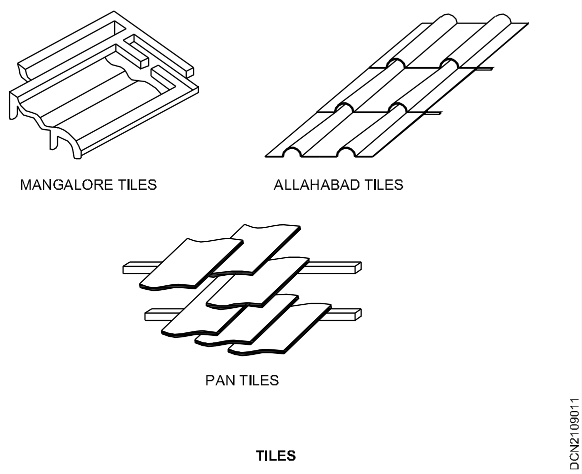
6 Fabrication facilities

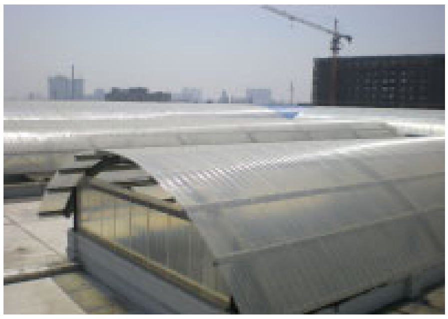
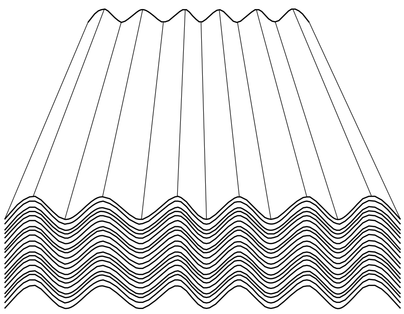
7 Type of roof framework

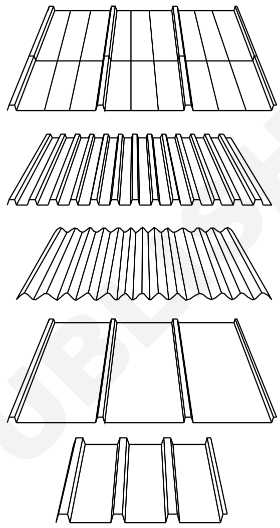
8 Resistance to fire and heat

9 Special feature of the locality.

Roof covering materials

Name	Description	
Thatch:	Extensively used in sheds & villages Cheapest & lightest material Unstable against wind. Laid on battens.	Fig 1 
Tiles:	These are largely used various kinds of tiles are used. Commonly used for covering sloped roof.	Fig 2 

Poly carbonate sheets	New type material with high strength, heat insulation and good light trans mission. Good weather resistance and UV protection.	Fig 3 
Glass	Structural glass slabs are available at in different gauges. Fibre glass is both strong and Height weight. Provide good light transmission,good appearance, etc.	Fig 4 
Slates	It is stratified rocks. Produced in large number of sizes. Obtained from either quarries or from mines.	Fig 5 
Asbestos cement sheets (AC sheets)	For AC sheets the cement is mixed with about 15% of asbestos fibres and the paste so formed are pressed under roll ers with grooves or teeth with series of corrugations. They are used for facto ries, workshops, garages, big halls etc. Available in different trade such as big six sheet, standard sheet, Trafford sheet etc.	Fig 6  ASBESTOS CEMENT SHEETS DCN2109012

Shingles:	Wood shingles are the sawn or split thin pieces of wood obtained from well sea soned timber resembling slates or tiles. Generally restricted in hilly areas. Laid in a manner as slates or tiles.	Fig 7 
Corrugated galvanized iron sheet:	Prepared by pressing flat wrought iron plates between rollers with grooves or teeth and then galvanized with coat of zinc. Corrugations are present to in crease strength and rigidity.	Fig 8  CORRUGATED GALVANIZED IRON SHEET
Ruberoid	Light, flexible & waterproof, Not affected by heat or cold & not attacked by fire. Available in rolls.	Fig 9 

Introduction and terms used

Objectives : At the end of this lesson you shall be able to
- **define levelling**
- **describe the uses of levelling**
- **explain the various terms used in levelling.**

Introduction : It is the art of determining the relative heights of various points on the surface of the earth. levelling is the branch of surveying which deals with the measurements in the vertical plane.

Uses: Levelling is usually carried out for the following purposes

1 To prepare contour map for fixing sites for reservoirs, dams, barrages etc. and to fix the alignments of road, railways, irrigation canals etc.

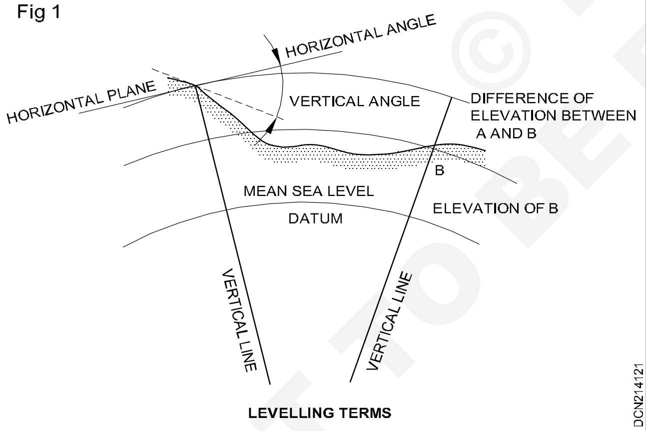
2 To determine the altitudes of different important points on a hill or to know the reduced levels of different points on or below the surface of the earth.

3 To prepare a longitudinal section and cross section of a project (roads, railways, irrigation canals, etc,) in order to determine the volume of earth work.

4 To prepare a layout map for water supplying, sanitary or drainage schemes.

Terms Used (Fig 1)

Fig 1



LEVELLING TERMS

1 **Level Surface:** The Surface which is normal to the direction of gravity at all points is known as level surface. All the points on level surface is equidistant from the centre of the earth and so it is curved surface. It is perpendicular to the plumb line all points Eg., surface of a still lake.

2 **Level line**: A line lying on a level surface is a level line. This is normal to plumb line at all points.

3 **Horizontal Surface:** A horizontal surface is the one which is tangential to the level surface at any point.

4 **Horizontal line:** A horizontal line is the line lying in a horizontal surface. It is a straight line tangential to the level line.

5 **Vertical line**: A vertical line is a line perpendicular to the level line. It is also otherwise known as plumb line as it passes through the centre of the earth.

6 **Vertical plane:** A vertical plane is the one, which consists of many number of vertical lines.

7 **Vertical angle:** Vertical angle is an angle measured between a line and a horizontal line in a vertical plane

8 **Datum surface:** Datum surface is an imaginary or any arbitarily assumed level surface, from which vertical distances of the points above or below the surface are measured. The datum surface adopted by the Great trigonometrical survey (G.T.S) department of India is the mean sea level at Mumbai which is taken as zero.

Mean Sea level (M.S.L) is the average height of the sea for all stages of tides. It is the average of hourly tides for a long period of 19 years.

9 **Elevation:** The elevation of any point is it vertical height or depth above or below the datum surface. It is also otherwise known as the Reduced Level (R.L).

10 **Difference in Elevation:** The difference in Elevation is the vertical distance between the level surfaces passing through the two points.

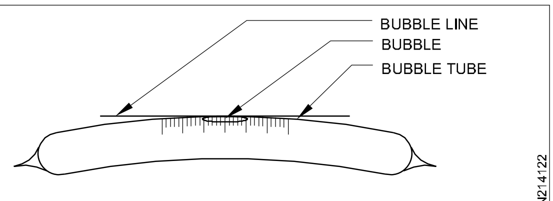
11 **Bench Mark (B.M):** A bench mark is the reference point of known elevation.

12 **Line of collimation:** A line of collimation is the line joining the intersection of cross-hairs in the diaphragm and the optical centre of the object glass, and its continuation. It is also otherwise known as line of sight.

13 **Axis of the telescope:** An axis of the telescope is the line joining the optical cente of the object glass and the centre of the eye piece. In general, the axis of telescope and the line of collimation coincides each other in case of a perfect levelling instrument.

14 **Bubble line:** A bubble line is an imaginary line tangential to the longitudinal curve of the bubble tube at its middle point. It is horizontal when the bubble is centered. (Fig 2)

Fig 2



BUBBLE LINE

15 **Vertical Axis:** A vertical axis through which the telescope is revolving in the horizontal plane i.e, the axis of rotation. Normally vertical axis is the plumb line from the centre of the instrument when it is levelled.

16 **Back Sight (B.S):** Back sight is the first sight taken on a levelling staff held over a point or known elevation (i.e. B.M. or C.P) after the instrument is setup and levelled. It gives the amount of height by which the line of collimation is above or below the point, and enables the surveyor to calculate the R.L of line of collimation. It is also known as positive or plus sight as this reading is added with the R.L of the point on which it is taken to obtain the R.L of line collimation. (Except in the case of Inverted Staff readings).

17 **Fore Sight (F.S):** Fore sight is the last sight taken on a levelling staff held over a point of unknown elevation (C.P) before shifting the instrument. It gives the amount of height by which the point is above or below the line of collimation, and enables the surveyor to calculate the R.L. of the point. It is also known as 'negative' or minus sight' as this reading is subtracted from R.L. of line of collimation to obtain the R.L. of the point.

18 **Intermediate Sight (IS):** Intermediate sight is the sight taken between the back sight and fore sight on levelling staff held over a point of unknown elevations. It is also known as 'minus or negative sight' as this reading are separated from R.L of line of collimation.

19 **Change point (CP):** A change point is the one which makes the instrument to shift from one point to another. It is a point on which both the fore sight and back sight readings are taken from the previous and new positions of instrument. Stable and well defined objects are selected as change point. A bench mark may also be taken as a change point. It is also otherwise known as turning point.

20 **Height of Instrument (H.I**): Height of instrument is the elevation of reduced level of line of collimation when the instrument is perfectly levelled. It is also otherwise known as 'Height of collimation'. (Not the height of telescope from the ground).

Types of bench marks : Depending upon the permanency and the precision, bench marks may be classified into four categories as follows:

1 G.T.S Bench Mark

2 Permanent Bench Mark

3 Temporary bench Mark

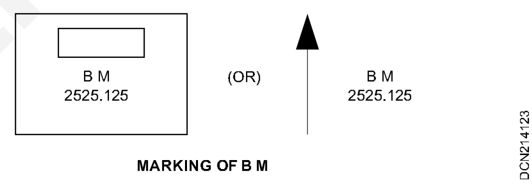
4 Arbitrary bench Mark

1 **GTS (Great Trignometrical Survey) bench mark :** The bench marks established by the survey of india department, at an interval of 100 km all over the country with respect to the mean sea level at Mumbai as datum is known as GTS bench mark. Their positions and reduced levels are shown on GTS maps and catalogues.

2 **Permanent bench mark :** These are bench marks established in between the GTS bench marks by various government department like PWD and other engineering agencies, on some permanent points, such as kilomatre stone, corners of plinths of building, top of parapets of bridge etc.

3 **Arbitrary Bench Mark (Fig 3) :** For small levelling work, any convenient well defined point may be assumed as a bench mark and elevations of other points are determined with reference to this bench mark. Such bench mark is known as arbitrary or assumed bench mark.

Fig 3



4 **Temporary Bench Mark:** The bench marks, which are established for short duration, such as at the end of a day's work, are called temporary bench marks. The work should be resumed from these bench marks.

Principle of levelling - Auto level - Dumpy level- Tilting level

Objectives : At the end of this lesson you shall be able to
- **describe the principle of levelling**
- **list the instruments required for levelling**
- **explain the parts of a level.**

Principle of levelling : Principle of levelling is to obtain a horizontal line of sight from which vertical distances of the points above or below this line are found. They are achieved with the help of a level and a levelling staff respectively.

Instruments required for levelling : Two instruments are required for levelling namely

1 a level and

2 a levelling staff

1 **The level :** Level is an instrument used for furnishing a horizontal line of sight. The essential part of a levelling instrument are the following.

1 Levelling head

2 Limb plate

3 Telescope

4 Bubble tube

5 Tripod stand

1 **Levelling head:** A levelling head consists of a tribrach plate having three arms each carrying a levelling screw in the ball and socket arrangement. These levelling or foot screws are used to bring the telescope bubble to the centre of its run. It is also an outer follow conical socket into which fits the inner solid spindle of the telescope, thus representing its vertical axis. The levelling head has an arrangement to fix the instrument over the tripod.

2 **Limb Plate:** A limb plate is the one to which the telescope is fixed by means of standards or supports. The lower portion of the limb plate has a solid spindle which fits into the hollow socket of the levelling head. This spindle freely revolves in the outer socket and locked at the bottom by means of a locking nut.

3 **Telescope:** A telescope is an essential component part, which provides the basic line of sight for making observations in the levelling operation. Telescope consists of two tubes, one slides into the other and fitted with lens and a diaphragm having cross hairs. Depending upon the arrangements made for the movement of this tubes, telescopes are classified into two categories such as:

1 External focusing telescope

2 Internal focusing telescope

1 **External focusing telescope:** In this type of telescope, the body consists of two tubes, one of which is capable of sliding axially within the other by means of rack and pinion arrangements. This action of sliding takes place by operating a focusing screw available in the telescope. As one of this tube moves out of the other and the length gets altered, the telescope is known as external focusing telescope.

2 **Internal focussing telescope:** In this type of telescope, out of two tubes on slides into the other, the outer tube is fitted with both the eyepiece and object glass at its either end. The other interior tube carries a double concave lens, which moves inside to and fro between the diaphragm and the object glass. As the movement of inner tube is within the outer one and the length remains same, the telescope is known as internal focusing telescope.

3 **Bubble Tube:** A bubble tube consists of a sealed curved glass tube set in a brass tube with plaster of paris. It is nearly filled with alcohol or either or a mixture of two, and the remaining space is occupied by air bubble. The tube is graduated on both the directions from its centre, which enables to centre the bubble by operating the foot screws available in the levelling head. One division on graduation is equals to 2 mm. The bubble tube is attached to the top of the telescope by means of capstan headed nuts, it is also otherwise known as 'level tube' and used for levelling up the instrument. In levelling up operation bubble in the bubble tube is brought to the centre (highest point) and a line tangential to the curvature of the tube at that point is known as bubble line. The bubble line is horizontal when the bubble is in the centre.

4 **Tripod Stand:** A tripod stand is the one, which supports the instrument when in use. It consists of three legs either solid or framed one. These legs are made of mahogany wood and its lower end is fitted with a pointed steel shoes so that it can be firmly pressed into the ground. The tripod should be rigid and if it has any looseness it affects the position of instrument. The tripod head, as its top carries external threads to which internal threads of the instrument is fitted.

Types of Levels

There are various types of levels, viz.

1 The dumpy level

2 The wye or Y level

3 The cooke's reversible level

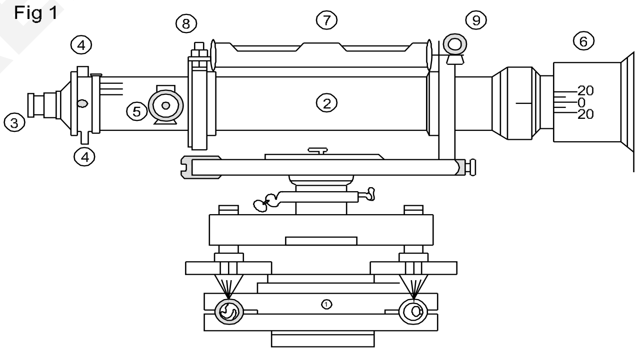
4 The cushing's level

5 Tilting level and

6 The automatic level

1 **The dumy level (Fig 1) :** The dumpy level is simple, compact, and stable. The telescope is rigidly fixed to its supports and, therefore, can neither be rotated about its longitudinal axis, nor can it be removed from its supports. It has greater stability of adjustments than the Y level.

Fig 1



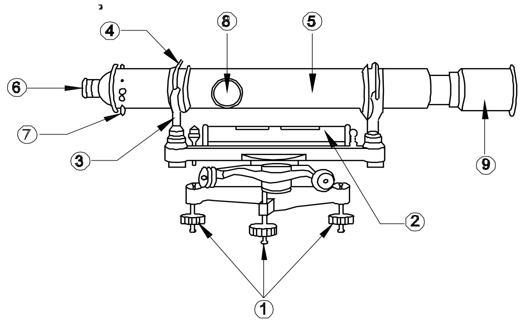
1. LEVELLING HEAD
2. TELESCOPE
3. EYE-PIECE
4. DIAPHRAGM
5. FOCUSSING SCREW
6. RAY-SHADE
7. LEVE TUBE
8. LEVEL TUBE NUTS
9. CROSS BUBBLE TUBE
10. CROSS BUBBLE TUBE

DUMPY LEVEL

2 **The Wye or Y level (Fig 2)** : The Y level is a very delicate instrument. It consists of many loose and open parts, which are liable to frictional wear. The telescope can be removed from the Y supports, and reversed end for end. It can also be revolved about its longitudinal axis in the Ys.

3 **The cooke's reversible level :** The cooke's level combines good features of both the dumpy and Y levels. By slackening the stop screw the telescope can be rotated about its longitudinal axis in its sockets and can also be withdrawn from its sockets and replaced and for end. (Fig 3)

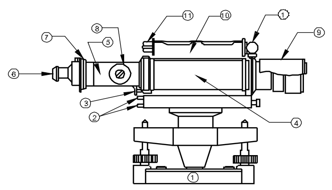
Fig 2



1. Levelling screw.
2. Level tube.
3. y-support.
4. Clips.
5. Telescope.
6. Eye-piece.
7. Diaphragm screws.
8. Focussing screw
9. Ray shade.

DCN245312

Fig 3



Cooke's Reversible Level

1. Levelling head.
2. Limb Nuts.
3. Stop screw.
4. Socket.
5. Telescope.
6. Eye-piece.
7. Diaphragm screws.
8. Focussing screw.
9. Ray shade.
10. Level tube.
11. Level tube nuts.
12. Cross-bubble tube.

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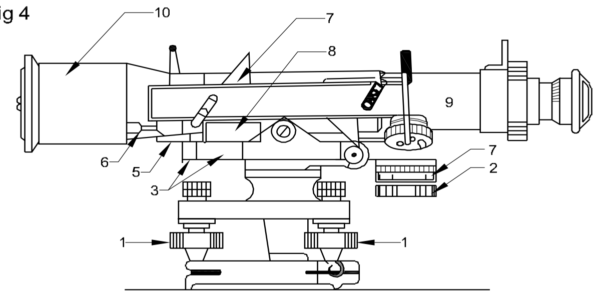
4 **The cushing's level :** In the case of the crushing's level, the telescope can neither be removed from its socket, nor can it be revolved about its longitudinal axis. However, the eye-piece (carrying with it the diaphragm) and the object glass are removable, and can be interchanged to reverse the telescope end for the end, both collars being exactly alike. Similarly, the eye-piece end can be rotated in its fitting.

5 **The Modern (Tilting) Level** : In the case of this instrument the telescope has a small motion about a horizontal axis. It is, therefore, known as the tilting level. The main peculiarity of this level is that the vertical axis need not be truly vertical, since the line of collimation is not perpendicular to it. The line of collimation, is however, made horizontal for each pointing of the telescope by means of a tilting screws. It is mainly designed for precise levelling work. (Fig 4)

6 **The automatic level :** The automatic level also designated as self aligning level. The fundamental difference between the self alignment level and the classic spirit level is that, in the former the line of sight is no longer levelled manually using a tubular spirit level but is levelled automatically. Within a certain tilt range this is achieved by an inclination compensating device called tilt compensator suspended like a pendulum and inserted in the path of light rays through the telescope. (Fig 5)

Fig 4



1. LEVELLINGS SCREWS.
2. MICROMETER SCREW
3. CROSS LEVELS
4. SCALE
5. MILLED HEAD
6. CLAMP SCREW
7. PRISM
8. REDECTOR
9. TELESCOPE
10. RAY SHADE

TILTING LEVEL

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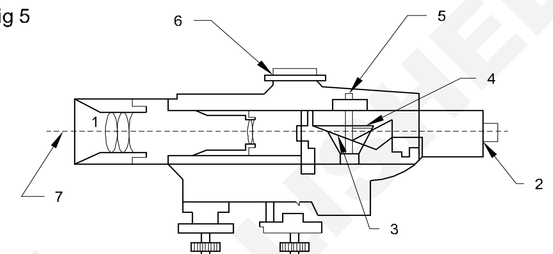
Fig 5



1. OBJECTIVE LENS
2. EYEPIECE
3. COMPENSATOR OBJECT
4. COMPENSATOR SUSPENSION
5. MAGNETIC DAMPENING SYSTEM
6. SIGHTING COLLIMATOR
7. LINE OF SIGHT

AUTO LEVEL - CROSS SECTIONAL VIEW

DCN245315

Advantages of using auto level

1 **Operational comfort:** Measurement is not fatiguing Control of level which is so try to the eyes, nerves and hands is eliminated. The automatic level does not require any protection from the sun.

2 **High precision:** Mean elevation error on invar staff graduated to 5mm divisions varies between $\pm$ 0.5 to 0.8 mm per km of forward and backward levelling.

3 **High speed:** Time required for levelling work is about 50% of that required with ordinary level. This is an advantage where work is to be carried out in a limited time. Errors due to settlement are thereby eliminated.

4 **Freedom for errors:** The accuracy of a single measurement is increased by an erect telescope image, the levelling rods with erect figures in proper sequence, freedom from fatigue, the possibility of forgetting to get the bubble in the centre as well as simple and quick means of operation.

5 **Freedom from external influences:** The external influences like marshy ground, rain, wind, sun, loss of light due to clouds, magnetic fields, continuous vibrations, transport vibrations, have no influence of the levelling work.

6 **Range of application:** The level can be used on medium and large sized projects and setting Bench Marks of the 3rd to 1st order.

Levelling staff - Its Graduation & Type

Objectives : At the end of this lesson you shall be able to
- **describe levelling staff**
- **explain the classification of levelling staff**
- **explain the constitution of various types of levelling staff.**

Levelling Staff : A levelling staff is a straight, rectangular wooden rod graduated into meters and smaller divisions. The bottom of the rod (Levelling staff) represents zero reading. The levelling staff is used to determine the amount of height of depth by which the point is above or below the line of sight. It is usually made up of well-seasoned wood.

The graduations on the levelling staves are such that a metre length is divided into 10 main divisions of one vision equals to 10 cm or 1 decimetre. Again this one main division is sub divided into 20 more strips of alternate black and white in colour of width 5 mm. Hence the smallest value, which we can observe with the levelling staff is 5 mm, therefore the least count is 0.005m. Main divisions in each metre length is marked with the numerals 1 to 9 in black colour. The readings corresponds to metre's length is marked with numerals 1,2,3 …. etc. in red colour.These numerals are marked in such a way that its top is coinciding with the end of that graduation. For convenience the numbers like 5 and 9 are marked as V and alphabet N respectively, to avoid confusion with the numerals 2 and 6, as the staff is invertedly seen when viewed through the telescope

Types of Staves : The levelling staves are mainly classified into two categories based on the method of observation as follows:

1 Self reading staff   2 Target staff

Self reading staff : Self reading staff is the one, by which the readings are observed directly by an observer (instrument man) who views through the telescope. These staves are further classified based on the construction as follows:

i Solid staff   ii Folding staff

iii Telescopic staff   iv Invar staff

i Solid Staff: A solid staff is one, which is made of seasoned wood either Pine or Deodar. It is usually 3m long in one piece length. It has the cross section of 75 mm in width and 25mm to 40 mm in thick. Due to the absence of range or socket on these staves greater accuracy is achieved. On the other hand it is inconvenient to carry them in the field. Its use is restricted only to precise levelling.

ii Folding Staff: Folding staff is the one, which is also made of seasoned wood and available in two pieces of length equals to 2 m. The total length of this staff is 4 m. These two pieces are connected by means of a hinge. The folding staff has the cross section of 75 mm in width and 18 mm in thick. The joint provided in the folding staff in such that.

a The staff may be folded to a length of 2 m when it is not in use.

b The pieces may be easily detachable from one another for easy handling.

c When the two pieces are locked together the staff is quite rigid at the joint and perfectly straight.

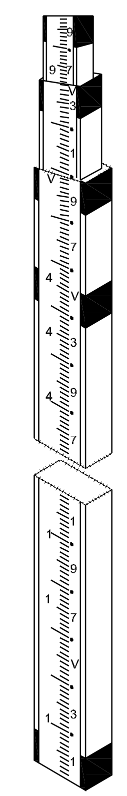
The foot of the staff is provided with a brass cap to avoid wear and tear due to usage.

iii Telescopic staff: A telescopic staff is the one which consists of three pieces. One slide into the other. It has the maximum lengths of 4 m or 5 m when fully extended. The 4 m telescopic staff has a top solid piece of length 1.25m, which slides into the cental box of 1.25 m length, which is turn slides into the lower box of length 1.5 m. Brass spring catches are provided to hold the extensions in position (Fig 1).

iv Invar Staff: The invar staff is also 3 m long. An invar band is fitted to a wooden staff. The band is graduated to millimeters. It is used for precise levelling work.

2 Target Staff: A target staff is the one by which the readings are observed by the staff man has the target is viewed by the instrument amn. This target staff is provided with a movable target. The target is provided with nernier, which is adjusted by the staff man as directed by the instrument man until its centre line coincides with the horizontal cross hair in the diaphragm. The readings are then observed and recorded by the staff man. This type of staves are used when the sights are long.

Fig 1

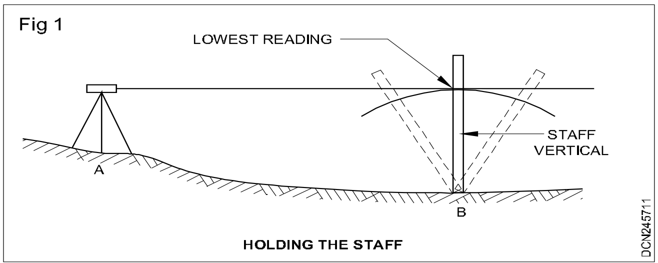


TELESCOPIC STAFF

Holding of levelling staff - Temporary adjustments

Objectives : At the end of this lesson you shall be able to
- **hold and read levelling staff**
- **explain the various adjustments of level**
- **explain the temporary adjustments of level**
- **state the instruction for a staff man and level man**
- **explain about hand signals used during observations.**

Holding the staff (Fig 1) : Utmost care should be taken in holding the staff truly vertical while the reading is being taken. To hold the staff in a vertical position, the staff man stands behind the staf, heels together, with the heel of the staff between his toes, and holds it between the palm of his hands at the height of his face. If it is not vertical, the reading will be too great.



In precise levelling, the staff is equipped with a folding circular level or a pendulum plumb bob to make it plumb while in ordinary levelling, the staff is waved slowly forward, i.e., towards the level, and backward, i.e., away from the level, and the lowest reading taken to avoid these errors.

Reading the staff : The staff readings should be taken in the following order

i Having set up and levelled the instrument carefully, direct the telescope towards the staff held vertically on the staff station and focus it.

ii Always bring the staff between the two vertical hairs, and always use the portion of the horizontal cross-hair between them in reading staff as the horizontal cross-hair may be slightly inclined. By means of the vertical hairs, the level man can see if the staff is out of plumb (sloping) sideways. If there be only one vertical hair, a reading should be taken at the intersection.

iii Observe if the bubble is central. If not, centre it by using one of the foot screws most nearly in line with the telescope, and note the reading at which the horizontal cross-hair appears to cut the staff. First note the red figure, then the black figure, and finally count the spaces. Record the reading.

When the graduations on the staff are inverted they look erect when seen through the telescope. The staff should be read upwards.

If the target staff is used, the procedure is the same except that the target is set by the staff man as directed by the instrument man, and the reading is then taken and recorded by the staff man.

Adjustments of the level : There are two types of adjustments

1 Permanent, and
2 Temporary

Permanent : The permanent adjustments are made to establish the fixed relationship between the fundamental lines of an instrument. Once made, the permanent adjustments last for a long time depending on the type of the instrument. The temporary adjustments are made at each set up of the instrument before starting to take the various staff readings.

Temporary adjustments of the level : These are performed to make the axis of rotation vertical and to eliminate the parallel every time when the instrument is shifted and set up in a new position. It is also known as "setting up" of the instrument and is made in the following steps:

1 Fixing the instrument on stand
2 Levelling up the instrument
3 Focussing

Fixing level with tripod stand : The tripod stand is placed at the required position with its legs well apart, and pressed firmly into the ground.

The level is fixed on the top of the tripod stand according to the fixing arrangement provided for that particular level. It should be remembered that the level is not to be set up at any station or point along the alignment.

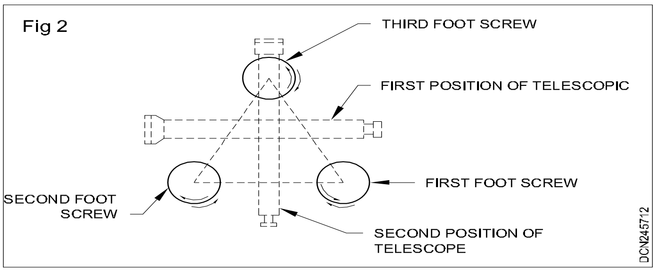
Levelling up the instrument: It is done approximately by legs and correctly by the levelling screws.

Levelling by legs: Bring all the foot-screws in the centre of their run and place the instrument in a desired position at a convenient height with the tribrach plate as nearly horizontal as possible. Fix any two firmly into the ground by pressing them with hand and turn the telescope to be nearly parallel to the line joining the feet of these two legs.

Then move the third leg to right or left and in or out to bring the long and cross bubbles respectively in their central positions much time is saved if nearly all the levelling is done by the tripod legs.

Levelling by foot-screws: Place the telescope parallel to any pair of the foot-screws and bring the long bubble to the centre of its run by turning these screws equally either both inwards or both outwards. To move the bubble to the right turn the screws inwards and to move it to the left turn the screws outwards (right in and left out) (Fig 2).

Fig 2



Then turn the third foot screw to bring the cross bubble to its central position. Repeat this until both the bubbles are centered. If the instrument is in permanent adjustment, then the bubbles will traverse for all directions of the telescope.

i The instrument should, as far as possbile, be set up on a solid ground to avoid its settlement in the course of observation in a setting. However, if such stable ground is not available, the tripod legs should be pressed firmly into the ground.

ii While setting the instrument on a pucca floor, the shoes of the tripod should, as far as possible, be placed in the joints to prevent the legs from spreading out through slipping.

iii When setting on a sloping ground, two legs should be kept down slope and the third up slope.

Focusing : This is done in two steps viz.

i Focussing the eye-piece for distinct vision of the cross-hairs at diaphragm, and

ii Focussing the object-glass for bringing the image of the object into the plane of the diaphragm.

Focussing the eye piece

This operation is done to make the cross-hairs appear distinct and clearly visible. The following steps are involved:

1 The telescope is directed skywards or a sheet of white paper is held in front of the objective.

2 The eye piece is moved in or out till the cross-hairs appear distinct.

Focussing the objective : This operation is done to bring the image of the object in the plane of the cross-hairs. The following steps are involved:

1 The telescope is directed towards the staff.

2 The focussing screw is turned until the image appears clear and sharp.

Instruction for a staff man

- The staff should be vertical and upright.
- The staff should be held on stable ground.
- When working with telescopic staff care should be taken to the extend all the parts by the spring catches
- When using aluminium staff extra care should be taken while extending near electric posts.

Instruction for a level man : Levelling should always commence from a permanent BM and end on a permanent BM

The level should be setup on a firm ground and at a place where maximum number of sights can be taken. To avoid errors due to imperfect adjustment of the instrument, the instrument should be setup approximately mid way between the change points.

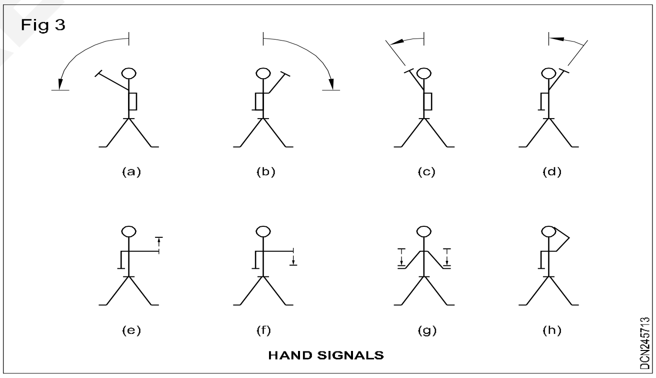
Move the telescope laterally by gentle tapping to bring the staff exactly between the vertical hairs and focus it. While looking through the telescope, the staff is seen inverted. Therefore, it should always be read from above downwards and not upwards.

When a group of surveyors are working, one's own staff should be carefully recognized.

Following hand signals should be observed

Hand signals during observations : When levelling is done at construction site located in busy, noisy areas, it becomes difficult for the instrument man to give instructions to the man holding the staff at the other end through the vocal sounds. In that case, the following hand signals are found to be useful. (Table 1 and Fig 3)

Fig 3



	Signal	Message
a	Movement of left arm over 90	Move to my left
b	Movement of right arm over 90	Move to my right
c	Movement of left arm over 30	Move top of staff to my left
d	Movement of right arm over 30	Move top of staff to my right
e	Extension of arm horizontally and moving hand downwards	Raise height of peg or staff
f	Extension of arm horizontally and moving hand downwards	Lower height of peg or staff
g	Extension of both arms and slightly thrusting downwards	Establish the position
h	Extension of arms and placement of hand on top of head	Return to me

Types of levelling

Objectives : At the end of this lesson you shall be able to
- **name the various types of levelling**
- **explain simple levelling**
- **explain differential levelling**
- **Complete the reduced levels of points.**

According to the method adopted, levelling may be classified into two

1 Direct levelling

2 Indirect levelling

Direct levelling

The method of levelling in which the relative heights of points are found out by some direct observation is called direct levelling.

Various methods of direct levelling:

1 Simple levelling

2 Differential levelling.

3 Reciprocal levelling

4 Profile levelling

  i Longitudinal sectioning

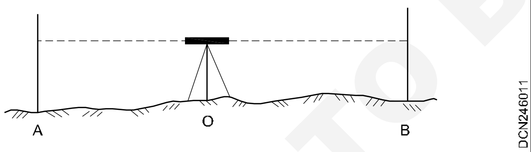
  ii Cross Sectioning

5 Fly levelling

6 Check levelling

Simple levelling (Fig 1)

Fig 1



When the difference of level between two points is determined by setting the levelling instrument midway between the points, the process is called simple levelling.

Suppose A and B are two points whose difference of level is to be determined. The level is set up at O, exactly midway between A and B. After proper temporary adjustment, the staff readings on A and B are taken. The difference of these readings gives the difference of level between A and B.

Differential levelling (Fig 2)

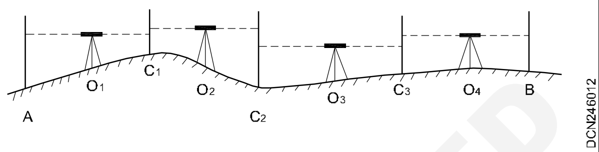
Differential levelling is adopted when

i the points are a great distance apart,

ii the difference of elevation between the points in large

iii there are obstacles between the points.

Fig 2



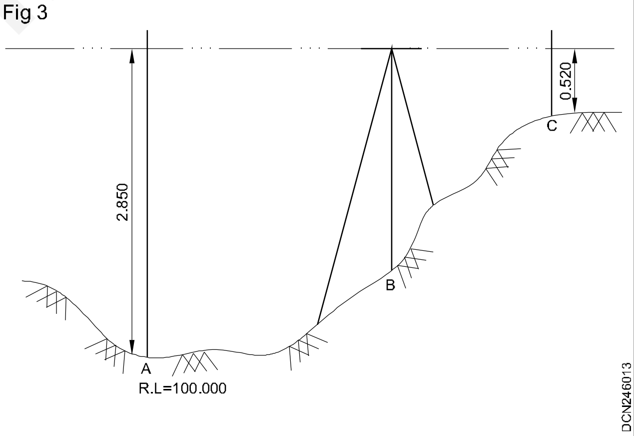
The method is also known as compound levelling or continuous levelling. In this method, the level is set up at several suitable positions and staff readings are taken at all of these.

Suppose it is required to know the difference of level between A and B, the level is set up at points O_1,O_2, O_3, etc. After temporary adjustments, staff readings are taken at every set up. The points C_1, C_2 and C_3 are known as change points. Then the difference of level between A and B is found out. If the difference is positive, A is lower than B. If it is negative, A is higher than B.

Knowing the R.L. of A that of B can be calculated.

Problems in levelling (Fig 3)

Fig 3



Example 1

In a simple levelling the Back sight takn from a point A of R.L. 100.000 is 2.850 m and Foresight taken from point C is 0.520 m find.

i The difference of level between the A and C

ii The R.L. at point C

Solution

i The difference of level between A and C

= 2.850 – 0.520

= 2.330

Height of collimation = R.L at point A + B.S. taken from point A

= 100.000 + 2.850

= 102.850 m

ii R.L. at point C

= Height of collimation – Foresight reading at C

= 102.850 – 0.520

= 102.330 m

Exercise 1

The back sight reading at A is 3.560m and the foresight reading at B is 2.860m Find the difference in level of A and B.

Exercise 2

The back sight reading on a staff held vertically on a bench mark whose R.L. 100.000 was 2.960 m and the foresight on the staff held vertical on a rail was 0.880m and the reduced level of the rail.

Inverted

When the BM or staff station is above the line of sight

In this case, it occurs when the underside of a string course or sunshade is made a Benchmark, or when the elevation of the underside of girder, and arch or the beam is to be determined. It is easy to hold the staff inverted and the reading being negative, is entered in the level book with a minus sign. To avoid confusion "Staff inverted" should be written in the Remarks column against the entry of the reading.

Problems in inverted level

Example 1

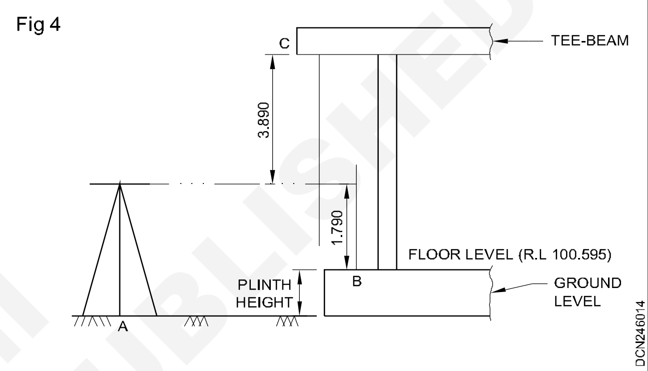
The R.L of the floor is 100.595 m and staff reading on the floor is 1.790m. The reading on the staff held upside down against the underside of the tee beam is 3.890m. Find the height of the beam above the floor level.

Solutions (Fig 4)

i Sketch

ii Tabulation

Fig 4



Back Sight	Inter Sight	Foresight.	HCL	Reduced Level	Remarks
1.790			102.385	100.595	Staff reading on the floor (B)
		-3.890		106.275	Inverted Staff reading at bottom of tee beam

Calculation

R.L of the floor = 100.595 m

Staff reading on the floor (B) = 1.790m

∴ Height of collimation at A

= R.L of the floor + Staff reading on the floor

= 100.595 + 1.790

= 102.385 m

R.L. of the underside of the tee beam

= 102.385

= 102.385 – (-3.890)

= 106.275 m

Height of the tee beam above the floor level

= 106.275 – 100.595

= 5.680m (Ans)

Exercise 1

Find the height of the tee beam above the floor level from following data. R.L. of the floor level = 100.000, Staff reading on the floor = 1.150 reading on the staff held inverted the bottom touching the underside of tee beam = 3.450m

Exercise 2

The back sight reading on a staff held vertical on a benchmark whose R.L. is 501.00 m is 1.580 m and the foresight on a staff held vertically inverted against a beam is 3.580 m Find the reduced level of the beam.

Problems in differential levelling

Example

Tabulate and enter the following staff reading were taken in the differential levelling and also find the R.L. of all the points. The first reading was taken on a B.M of R.L 100.000 by.

i HCL method (height of collimation method)

Apply usual check

2.045, 2.680, 2.860, 2.120, 2.975 and 2.860

Solution

Height of Collimation Method

Back sight	Inter sight	Foresight	HCL	Reduced Level	Remarks
2.045			102.045	100.00	Reading taking on B.M
	2.680			99.365	Point 1
	2.860			99.185	Point 2
	2.120			99.925	Point 3
	2.975			99.070	Point 4
		2.860		99.185	Point 5
2.045		2.860			

Calculation

Height of collimation = R.L. of B.M + Back sight

= 100.000 + 2.045

= 102.045 m

R.L of point 1 = HCL – I.S reading on point 1

= 102.045 – 2.680

= 99.365

R.L. of point 2 = HCL – I.S. reading on point 2

= 102.045 – 2.860

= 99.185

R.L. of Point 3 = HCL – I.S. reading on point 3

= 102.045 – 2.120

= 99.925

R.L. of point 4 = HCL – IS. reading on point 4

= 102.045 – 2.975

= 99.070

R.L. of point 5 = HCL – F.S. reading on point 5

= 102.045 – 2.860

= 99.185

Arithimetic Check

The difference between the sum of back sights and the sum of fore sights should be equal to the difference between the last and the first RLS.

$\sum$ B.S – $\sum$ .F.S = Last R.L – First R.L

2.045– 2.860 = 99.185 – 100.000

= - 0.815

Rise and fall method

B.S	I.S.	F.S	Rise	Fall	Reduced Level	Remarks
2.045					100.00	Readiong taken on B.M
	2.680			0.635	99.365	Point 1
	2.860			0.180	99.365	Point 2
	2.120		0.740		99.925	Point 3
	2.975			0.855	99.070	Point 4
		2.860	0.115		99.185	Point 5
2.045	2.860	0.855	1.670			

Calculation

i B.S. on B.M. – I.S. on point 1

= 2.045 – 2.680

= 0.635 (Fall)

ii I.S on point 1 – I.S.on point 2

= 2.680 – 2.860

- 0.180 (Fall)

iii I.S. on point 2 – I.S on point 3

= 2.860 – 2.120

= 0.740 (Rise)

iv I.S. on point 3 – I.S. on point 4

= 2.120 – 2.975

= 0.740 (Rise)

v I.S on point 4 – F.S. on point 5

= 2.975 – 2.860

= 0.115 (Rise)

R.L of point 1 = R.L of B.M – Fall of point 1

= 100.000 – 0.635

= 99.365

R.L. of point 2 = R.L. of point 1 – Fall of point 2

= 99.365 – 0.180

= 99.185

R.L. of point 3 = R.L of point 2 + Rise of point 3

= 99.185 + 0.740

= 99.925

R.L of point 4 = R.L. of point 3 – Fall of Point 4

= 99.925 -0.855

= 99.070

R.L of point 5 = R.L of point 4 + Rise of point 5

= 99.070 + 0.115

= 99.185

Arithmetic Check

∑B.S. -∑ F.S.	=	∑Rise – ∑fall
	=	Last R.L – First R.L
2.045-2.860	=	0.855 – 1.670
	=	99.185 –100.000
-0.815	=	- 0815 - 0.815

Exercise 1

Tabulate and enter the following reading on the level field book and find the reduced levels of the points.

i Height of collimation method

ii Rise and fall method

2.200, 2.430, 2.400, 2.120, 2.900 and 2.750

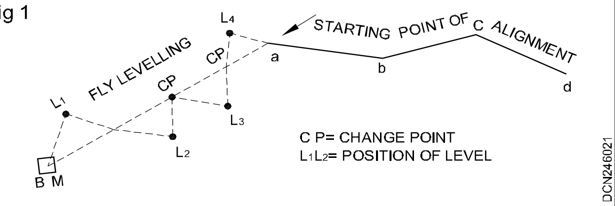
Apply usual check

Differential levelling (Fly levelling & check levelling)

Objectives: At the end of this lesson you shall be able to
- **explain fly levelling**
- **explain check levelling**
- **explain indirect levelling.**

Fly Leveling (Fig 1) : When different levelling is done in order to connect a bench mark to the starting point of the alignment of any project, it is called fly levelling. Fly levelling is also done to connect the BM to any intermediate point of the alignment for checking the accuracy of the work.

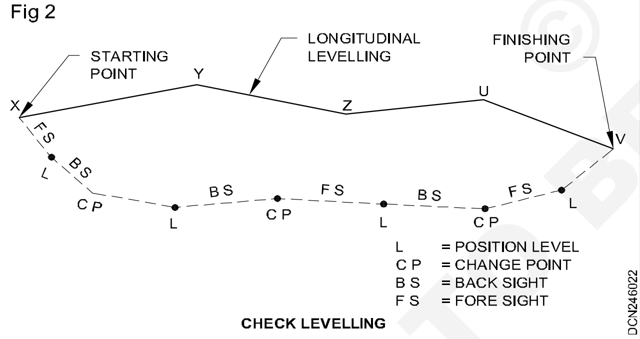
Fig 1



In such levelling, only the back sight and fore-sight readings are taken at every set up of the level and no distances are measured along the direction of levelling. The level should be set up just midway between the BS and the FS.

Check Levelling (Fig 2)

Fig 2



The fly levelling done at the end of day's work to connect the finishing point with the starting point on that particular day is known as check levelling . It is undertaken in order to check the accuracy of the day's work.

Indirect Levelling

The method of levelling in which the relative elevations of the point are found out by some indirect observation is known as indirect levelling. It may be carried out in this following three forms.

a Barometric levelling

b Hypsometry

c Trigonometrical levelling.

Barometric levelling

The indirect levelling which is conducted to fix the relative elevations of points by the measurement of pressure at these points using barometer is known as barometric levelling.

Barometric levelling is based on the principle that the atmospheric pressure varies inversely with the height. This method gives approximate result and so it is adopted in the reconnaissance or the preliminary survey.

Hypsometry

The method of indirect levelling adopted to find the relatives elevations of points by the measurement boiling points at these points using hypsometer is known as hypsometry. It works based on the principle that boiling points of water decreased at higher altitudes.

Trigonometric levelling

The method of indirect levelling in which the relative elevations of different points are obtained by measuring the vertical angles and horizontal distance is known as trigonometric levelling.

Problem on reduced levels

Objective: At the end of this lesson you shall be able to
- **compute the reduced levels of points and gradiants of lines on sloping ground.**

Problem in differential levels

Example

Following consecutive readings were taken on point 1 to 7 along a line

0.785, 1.326, 2.538, 3.435, 1.367,2.328, 1.234, 1.657

The instrument was shifted after the fourth readings and the first reading was taken on BM with RL = 100.00 rule out a page of level book and work out the RL of all points by collimation method and rise and fall method.

Solution

H.I = R.L. + B.S. = 100.00 + 0.785

= 100.785

R.L = H.I – I.S / F.S = 100.785 – 1.367

= 99.459

Arithmetical Check

∑ B.S. - ∑ F.S. = 02.152 – 5.092

= - 2.940

Last R.L – First R.L = 97.060 – 100.00

= 2.940 Ans.

Arithmetical Checks

∑ B.S. - ∑F.S = 2.152 – 5.092

= - 2.940

Station		Readings		Height of line of collimation	RL	Remark
	B.S.	I.S.	F.S			
1	0.785			100.785	100.00	BM
2		1.326			99.459	RL = 100
3		2.538			98.247	
4	1.367		3.435	98.717	97.350	
5		1.238			96.389	
6		1.234			97.483	
7			1.657		97.060	
Total	2.152		5.092			

Solution for the above problem is rise and fall method

Station	Readings			Rise	Fall	RL	Remark
	B.S.	I.S.	F.S				
1	0.785					100.00	BM
2		1.326			0.541	99.459	RL = 100
3		2.538			1.212	98.247	
4	1.367		3.435		0.897	97.350	CP
5		2.328			0.961	96.389	
6		1.234		1.094		97.483	
7			1.657		0.423	97.060	
Σ B	2.152	Σ F.S	5.092	1.094	4.034		

∑ Rise - ∑ Fall = 1.094 – 4.034

= - 2.940

Last R.L – First R.L = 97.060 -100.00

= 2.940 Ans.

Exercise 1

Following staff readings were taken with a level. The instrument having been shifted after the fourth, seventh and tenth readings. R.L of the starting BM is 150.00m.

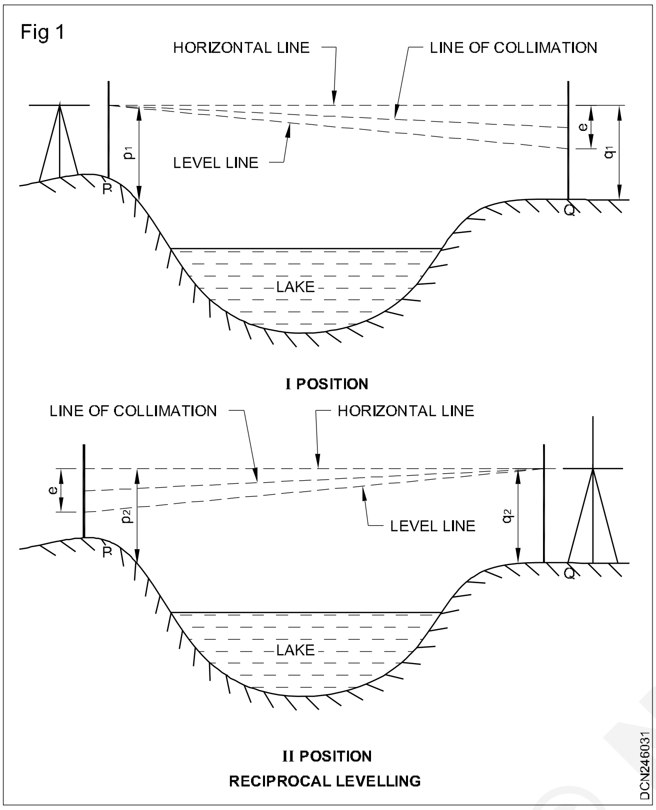
Enter the readings in the level book page and reduce the level by the collimation method and apply the usual checks.

1.420, 0.650,3.740, 3.830,0.380, 2.270, 4.640, 0.960, 1.640, 2,840, 4.680 and 4.980.

Reciprocal levelling

Objectives: At the end of this lesson you shall be able to
- **state the necessity of reciprocal levelling**
- **explain the procedure of conducting reciprocal levelling.**

Reciprocal Levelling (Fig 1)



When It is not possible to set up the level midway between two points, as in the case of levelling across a river or lake, the reciprocal levelling is used.

Let P and Q be two points on opposite banks of a lake.

The difference of level between two points P and Q is found by this method.

Procedure

Set up the level very near to P

With bubble tube central, take staff readings on staff held at P & Q.

Let the staff readings on P be P_1 and Q be q, reading on P is usually taken through objective. Since the staff is very close, to get the readings clear, a pencil point is moved up and down.

Transfer the instrument to Q and set it up very near to q. With the bubble central, read the staff held at P& Q.

Let the staff readings at P and Q be p_2 and q_2 respectively.

Computation

Let h = true difference of level between P & Q

E = Combined error due to curvature refraction and imperfect adjustment of line of collimation.

First Position

The correct readings on staff Q = $q_1 - e$

The correct reading on staff P = p_1

Assuming P to be higher than Q, true difference of level

$$h = (q_1 - e) - p_1$$

(or)

$$h = (q_1 - p_1) - e \rightarrow 1$$

Second position of level

The correct reading on Staff Q = q_2

The correct reading on staff P = $(p_2 - e)$

The true difference in level

$$H = q_2 - (p_2 - e)$$

(or)

$$h = (q_2 - p_2) + e \rightarrow 2$$

Adding equation 1 and 2

$$h = (q_1 - p_1) - e \rightarrow 1$$

$$h = (q_2 - p_2) + e \rightarrow 2$$

$$h+H = (q_1 - p_1) - e + (q_2 - p_2) + e$$

$$2h = (q_1 - p_1) + (q_2 - p_2)$$

i.e $$h = \frac{(q_1 - p_1) + (q_2 - p_2)}{2}$$

(i.e) The apparent difference of a level between p and q is equal to the mean of the apparent differences of level.

The combined error can be obtained by equating the equation 1 and 2

$$(q_1 - p_1) - e + (q_2 - p_2) + e$$

$$2e = (q_1 - p_1) + (q_2 - p_2)$$

$$e = \frac{(q_1 - p_1) + (q_2 - p_2)}{2}$$

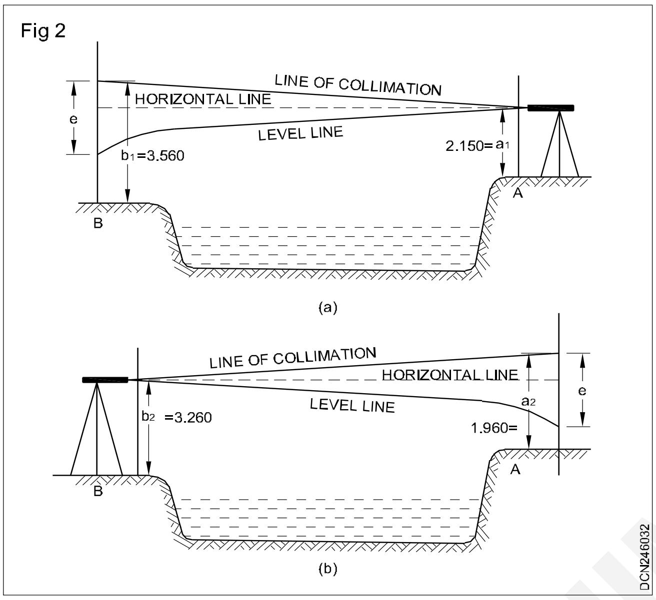
(i.e) combined error is equal to the half of the apparent difference of the level.

Reciprocal levelling

Example 1

In levelling between two points A and B on opposite banks of a river, the level was setup near A and the staff readings on A and B were 2.150 and 3.560 respectively. The level was then moved and setup near B, and the respective staff readings on A and B were 1.960 and 3.260. Find the true differences of level of A and B.

Solution (Fig 2)



a When the level was setup near A,

Incorrect difference of level = 3.560 – 2.150

= 1.410

b When the level was setup near B,

Incorrect difference of level = 3.260 – 1.960

= 1.300

True difference of level of A and B

= mean of the two incorrect differences of level

$$=\frac{1.410+1.300}{2}=\frac{2.710}{2}=1.355$$

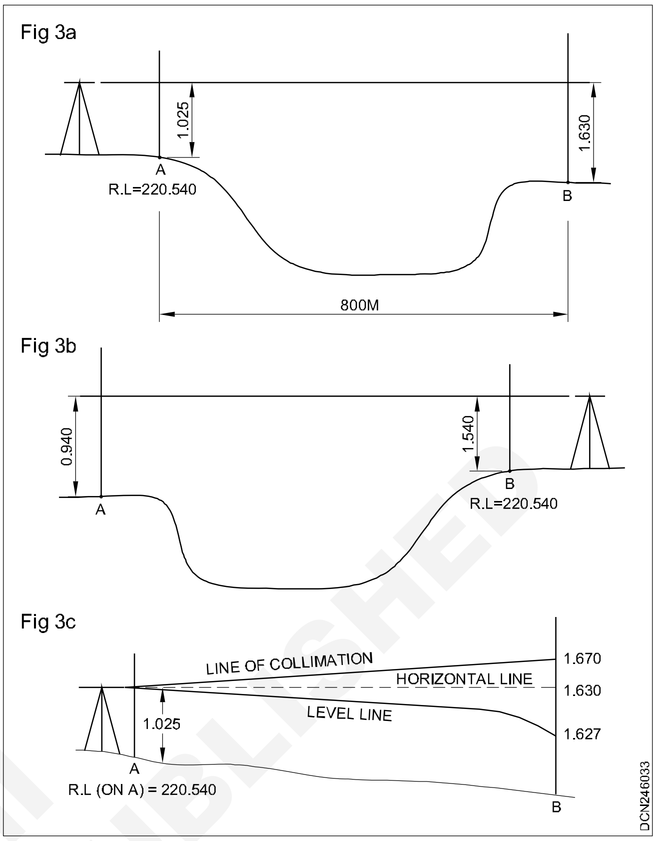
Fall from A to B

Example 2

The following notes refer to the reciprocal levels taken within level.

Instrument station	Staff readings on A	Staff readings on B	Remarks
A between A	1.025	1.630	Distance and B = 800 m
B	0.940	1.540	R.L. of A = 220.540

Find (Fig 3)



i The true R.L. of B

ii Combined correction for curvature and refraction.

iii The error in collimation adjustment of the instrument.

i When instrument at A

In correct difference of level between A and B

= 1.630 - 1.025

= 0.605

When Instrument at B

Incorrecct difference of level between A and B

= 1.540 – 0.940

= 0.600m

True difference of level between A and B

= mean of the two in correct difference

$$=\frac{0.605+0.600}{2}=0.6025m \text{ (fall from A to B)}$$

R.L. at A = 220.540 m

R.L. at B = 220.54 – 0.6025m (Subtract fall)

= 219.938 m

ii Combined correction for curvature and refraction,

= $0.0673D^2$

= $0.0673 \times (800 / 1000)^2$

= 0.043 m

iii Instrument at A

Reading at A = 1.025

Fall from A to B = 0.602

The required reading touching the level line

= 1.025 + 0.602

= 1.627

(Showing correct readings when the instrument is at A)

The combined effect of curvature and refraction is to increase the staff readings.

Therefore, the observed staff readings at B, touching the horizontal line should be:

= 1.627 + 0.043 (combined effect of curvature and refraction)

= 1.670

But the actual observed reading at B. The reading touching the line of collimation = 1.630 which is less than 1.670 the line of collimation is inclined downward and the error due to this

= 1.670 – 1.630

= 0.040 m

Exercise 1

A dumpy level was setup with its eye piece vertically over a peg C. The height from the top of C to the centre of its eye piece was measured and found to be 1.570m. The reading on the staff held on the peg D was 1.005, the level was then moved and setup at the peg D. The height of the eye piece above D was 1.250 and the reading on the staff held on the peg C was 1.810. Determine the true reduced level of peg D, if that of peg C was 160.000

Exercise 2

The following details refer to reciprocal levels taken with a dumpy level.

Determine

a True difference of level between A and B

b The R.L. of A

c The error in collimation adjustment of the level.

Instrument station	Staff readings on		Remarks
	A	B	
A	1.405	2.775	Distance between A and B = 1500 m
B	0.600	1.705	R.L. of B = 100.000m

Level field book

Objectives : At the end of this lesson you shall be able to
- **describe the term level field book and its various forms**
- **explain the point to be observed while recording a level book**
- **compute the reduced levels of the staff stations.**

Form of a level book

Whenever the levelling operation is carried out and number of observations are taken in the field, they are to be entered in a note book called a 'Level Book.' Each page of this level book has the following columns which helps to enter the readings and reduce the levels. Left side of each page consists of column corresponds to the staff readings and reduction of levels. Right side of each page consists of columns for remarks to note down the details of bench marks for which the readings have been taken

Two forms of level book

Page of a level book

1 Height of collimation method

B.S.	I.S.	F.S.	H.I. or H.C.	R.Ls.	Remarks

2 Rise and fall method

B.S.	I.S.	F.S.	H.I. or H.C.	R.Ls.	Remarks

Apart from the above, details such as name of work, instrument number, name of the surveyor etc. are to be furnished in each page of a level book.

Name of the work……….................…. Date…………….

Name of the Surveyor………....... Instrument No…………

Points to be observed while booking readings in a level book

1 Every horizontal line in a page of level book represents one station only.

2 Readings are to be entered in the respective columns in the order of observation.

3 First reading in a page of level book should be Back sight and the last reading should be Fore sight.

4 If the last entry happens to be an intermediate sight, enter it in the Fore sight column of that page and the same is repeated in the Back sight column of the next page

5 Fore sight and Back sight reading of a change point should be entered in the same horizontal line

6 R.L. of line of collimation or height of collimation should be written in the same horizontal line corresponds to its back sight.

7 Details of staff station should be written briefly in the remarks column.

8 All the readings should be entered in ink only.

9 When observations of a work is continued in many number of pages, no reduction of levels in the next page is done unless the previous page is checked.

Reduction of levels

Reduction of levels is the process of calculating the R.L. for various points to which observation are taken. There are two methods of calculating the RL. such as:

1 Height of collimation method

2 Rise and fall method

Height of collimation method

In this method height of collimation i.e., the R.L. of line of collimation for each set up of the instrument is obtained by adding the back sight reaching to the R.L. of a bench mark on which back sight is taken. The R.L. of line of collimation is taken as a reference and the R.L. for various other points from that set up of the instrument is obtained by subtracting their respective staff readings such as Intermediate sight of Fore sight.

When the instrument is shifted to a new station, the height of collimation for that set up is obtained by adding the staff reading taken on a change point (i.e., the point of which the last observation is taken from the previous instrument station) to its R.L. The R.L. of the other staff stations observed from the new station are obtained by subtracting their respective staff readings from its height of collimation. This process is repeated until the last point is reached.

In general height of collimation method is given by

Height of collimation = R.L. of a BM + Back sight reading

R.L. of other staff stations = Height of a collimation – I.S./F.S. readings

After the completion of the above calculation it can be checked for its correctness by an Arithmetical check.

Arithmetical check

Σ BS – Σ FS = Last R.L. – First R.L.

Rise and fall method

In this method the difference of level between the two consecutive points is obtained by comparing the staff readings taken from the same set up of the instrument. This difference indicates whether the next point is at Rise or Fall than the previous one. If the staff reading is greater, the point is at Fall. If the staff reading is smaller, the point is at Rise. The R.L. of any point is determined

by either adding or subtracting the respective rise or fall values from the R.L. of the previous point. The above procedure is repeated until the last point is reached.

In general Rise and Fall method is given by:

First reading – Second reading = ± Rise / Fall.

(When the second reading is subtracted from the first one, the positive result means the rise and the negative result means fall)

R.L. of any point = R.L. of the previous point ± Rise / Fall of that point (use positive sign for rise and negative sign for fall).

After the completion of the above calculations it can be checked for its correctness by an Arithmetical check.

Arithmetical check

This Arithmetical check also provides check only for calculations not the result.

In this the differences between, the sum of B.S. and F.S. the sum of rise and Fall and the last R.L. and first R.L. should be equal.

Σ .B.S. – Σ F.S. = Σ Rise - Σ Fall = Last R.L - First R.L which depends upon the respective values.

This method provides a complete check on the intermediate sight also.

Comparison of line of collimation method with rise and fall method

S.No	Line of collimation method	Rise and fall method
1	It is more rapid and the computation is easier and faster.	Computation is labourious and time consuming, because each and every staff reading is compared.
2	It is simple method used for reduction in profile levelling.	This method is used where more accuracy is required.
3	There is no check in reduction of levels for intermediate stations.	There is a complete check for all intermediate
4	Errors if any commited in reduction of levels for intermediate stations, cannot be deducted	Errors can be noticed and rectified for intermediate stations.

Problems on levelling

Objectives: At the end of this lesson you shall be able to
- **determine the reduced levels of the station points by height of collimation method**
- **determine the reduced levels of the station points by rise and fall method.**

Problems in levelling

Example 1

Following consecutive readings were taken on points 1 to 7 along a line.

0785, 1.326, 2.538, 3.435, 1.367, 2.328, 1.234, 1.657.

The instrument was shifted after the fourth reading and the first reading was taken on BM with RL = 100.00. rule out a page of level book and work out the RL of all points by collimation method and rise and fall method.

Collimation method

Solution

Station	Readings			Height of Instrument	RLs	Remarks
	B.S.	I.S.	F.S			
1	0.785			100.785	100.00	BM
2		1.326			99.459	RL = 100
3		2.538			98.247	
4	1.367		3.435	98.717	97.350	
5		1.238			96.389	
6		1.234			97.483	
7			1.657		97.060	
Total	2.152		5.092			

solution for the above problem in rise and fall method

Station	Readings			Rise	Fall	RL	Remark
	B.S.	I.S.	F.S				
1	0.785					100.00	BM
2		1.326			0.541	99.459	RL = 100
3		2.538			1.212	98.247	
4	1.367		3.435		0.897	97.350	CP
5		2.328			0.961	96.389	
6		1.234		1.094		97.483	
7			1.657		0.423	97.060	
Σ B	2.152	Σ F.S	5.092	1.094	4.034		

H.I. = R.L. + B.S. = 100.00 + 0.785 = 100.785

R.L. = H.I. – I.S / F.S. = 100.785 – 1.367 = 99.459

Arithmetical check

Σ B.S. – Σ F.S. = 02.152 – 5.092 = -2.940

Last R.L. – First R.L. = 97.060 – 100.00 = 2.940 Ans.

Arithmetical checks

Σ B.S. – Σ F.S. = 2.152 – 5.092 = -2.940

Σ Rise – Σ Fall = 1.094 – 4.034 = -2.940 Ans

Last R.L. – First R.L. = 97.060 – 100.00 = 2.940 Ans.

Example 2

Problem 2 : The readings are entered in the page of level field book as shown below. Reduce the levels by both the height of collimation method and Rise and Fall method, given the R.L. of a B.M. 1 as 200.000 m. Apply the check.

Station	B.S.	I.S.	F.S.	R.L.	Remarks
1	1.430			200.000	B.M. 1
2		2.015			
3		1.005			
4	3.370		0.400		C.P.
5		2.975			
6		1.415			
7			0.695		B.M. 2

Solution: By Height of collimation method

Station	B.S.	I.S.	F.S.	Height of collimation	R.Ls.	Remarks
1	1.430			201.430	200.00	B.M. 1
2		2.015			199.415	
3		1.005			200.425	
4	3.370		0.400	204.400	201.030	C.P.
5		2.975			201.425	
6		1.415			202.985	
7			0.695		203.705	B.M. 2

General rule in height of collimation method is

Height of collimation = R.L. of B.M. + B.S. on that B.M.

R.L. of any point = Height of collimation - I.S. / F.S. of that point.

∴ Height of Collimation for the 1st set up

= 200.00 + 1.430 = 201.430

R.L. of a point 2 = 201.430 - 2.015 = 199.415

3 = 201.430 - 1.005 = 200.425

R.L. of C.P. (4) = 201.430 - 0.400 = 201.030

Height of collimation for the 2nd set up

= 201.030 + 3.370 = 204.400

R.L. of a point 5 = 204.400 - 2.975 = 201.425

6 = 204.400 - 1.415 = 202.985

R.L. of B.M.2 (7) = 204.400 - 0.695 = 203.705

Arithmetical check

$\sum$B.S. = 1.430 + 3.370 = 4.800

$\sum$F.S. = 0.400 + 0.695 = 1.095

$\sum$B.S. - $\sum$F.S. = 4.800 = 1.095 = 3.705

Last R.L. - First R.L. = 203.705 - 200.000 = 3.705

$\sum$B.S. - $\sum$ F.S. = last R.L. - First R.L.

Hence OK.

By rise and fall method

Station	B.S.	I.S.	F.S.	Rise	Fall	R.Ls.	Remarks
1	1.430					200.00	B.M. 1
2		2.015			0.585	199.415	
3		1.005		1.010		200.425	
4	3.370		0.400	0.605		201.030	C.P.
5		2.975		0.395		201.425	
6		1.415		1.560		202.985	
7			0.695	0.720		203.705	B.M. 2

General rule

Difference in level between the successive points

1st reading - 2nd reading = ± Rise / Fall.

R.L. of any point = R.L. of the previous point ± Rise/Fall

Difference in levels for station 2

= 1.430 - 2.015 = - 0.585 (Fall)

For Station 3 = 2.015 - 1.005 = + 1.010 (Rise)

4 = 1.005 - 0.440 = + 0.605 (Rise)

5 = 3.370 - 2.975 = + 0.395 (Rise)

6 = 2.975 - 1.415 = + 1.560 (Rise)

7 = 1.415 - 0.695 = + 0.720 (Rise)

R.L. of a station point 2 = 200.00 - 0.585 = 199.415

3 = 199.415 + 1.010 = 200.425

4 = 200.425 + 0.605 = 201.030

5 = 201.030 + 0.395 = 201.425

6 = 201.425 + 1.560 = 202.985

7 = 202.985 + 0.720 = 203.705

Arithmetical check

$\sum$ B.S. = 1.430 + 3.370 = 4.800

$\sum$ F.S. = 0.400 + 0.695 = 1.095

$\sum$B.S. - $\sum$. F.S. = 4.800 - 1.095 = 3.705

$\sum$ Rise = 1.010 + 0.605 + 0.395 + 1.560 + 0.720 + 4.290

$\sum$Fall = 0.585

$\sum$ Rise - $\sum$ Fall = 4.290 - 0.585 = 3.705

Last R.L. - First R.L. = 203.705 + 200.00 = 3.705

$\sum$ B.S. - $\sum$ F.S. = $\sum$ Rise - $\sum$ Fall = Last R.L. - First R.L.

Hence OK.

Temporary adjustments of level

Objectives : At the end of this lesson you shall be able to
- **explain the various adjustments of level.**
- **explain the various steps involved in the temporary adjustments of level.**

Adjustments of the level

There are two types of the adjustments.

1 Permanent, and

2 Temporary

The permanent adjustments are made to establish the fixed relationship between the fundamental lines of an instrument. Once made, the permanent adjustments last for a long time depending on the type of the instrument. The temporary adjustments are made at each set up of the instrument before starting to take the various staff readings.

Temporary adjustments of the level

These are performed to make the axis of rotation vertical and to eliminate the parallel every time when the instrument is shifted and set up in a new position. It is also known as "setting up" of the instrument and is made in the following steps:

1 Fixing the instrument on stand.

2 Levelling up of the instrument.

3 Focussing.

Fixing level with tripod stand

The tripod stand is placed at the required position with its legs well apart, and pressed firmly into the ground.

The level is fixed on the top of the tripod stand according to the fixing arrangement provided for that particular level. It should be remembered that the level is not to be set up at any station or point along the alignment.

Levelling up of the instrument

It is done approximately by legs and correctly by the levelling screws.

Levelling by legs : Bring all the foot-screws in the centre of their run and place the instrument in a desired position at a convenient height with the tribrach plate as nearly horizontal as possible. Fix any two firmly into the ground by pressing them with hand and turn the telescope to be nearly parallel to the line joining the feet of these two legs.

Then move the third leg to right or left and in or out to bring the long and cross bubbles respectively in their central positions. Much time is saved if nearly all the levelling is done by the tripod legs.

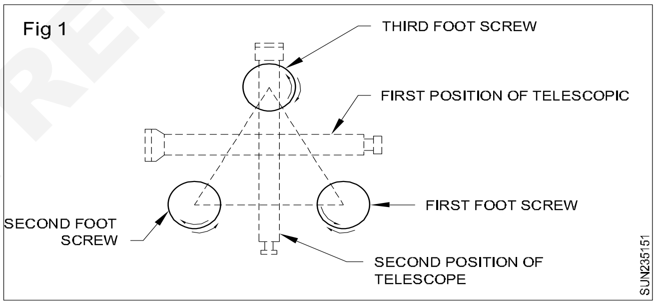
Levelling by foot-screws : Place the telescope parallel to any pair of the foot-screws and bring the long bubble to the centre of its run by turning these screws equally either both inwards or both out-wards (Fig 1) To move the bubble to the right turn the screws inwards and to move it to the left turn the screws outwards (right in and left out)

Then turn the third foot screw to bring the cross bubble to its central position. Repeat this until both the bubbles are centred. If the instrument is in permanent adjustment, then the bubbles will traverse for all directions of the telescope.

(i) Note. The instrument should, as far as possible, be set up on a solid ground to avoid its settlement in the course of observation in a setting. However, if such stable ground is not available, the tripod legs should be pressed firmly into the ground.

(ii) While setting the instrument on a pucca floor, the shoes of the tripod should, as far as possible, be placed in the joints to prevent the legs from spreading out through slipping.

(iii) When setting on a sloping ground, two legs should be kept down slope and the third up slope.



Focussing

This is done in two steps viz. (i) Focussing the eye-piece for distinct vision of the cross-hairs at diaphragm, and (ii) focussing the object-glass for bringing the image of the object into the plane of the diaphragm.

Focussing the eyepiece

This operation is done to make the cross-hairs appear distinct and clearly visible. The following steps are involved:

1 The telescope is directed skywards or a sheet of white paper is held in front of the objective.

2 The eyepiece is moved in or out till the cross-hairs appear distinct.

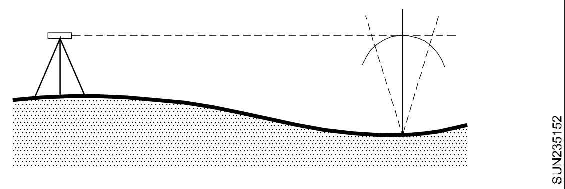
Focussing the objective (Fig 2)

This operation is done to bring the image of the object in the plane of the cross-hairs. The following steps are involved:

1 The telescope is directed towards the staff.

2 The focussing screw is turned until the image appears clear and sharp.

Fig 2



Holding the staff It is imperative that the levelling staff be held vertically while a reading is being taken. If the staff is inclined in any direction, the reading will be erroneous; always more than the actual. The staff reading will be correct only when the staff is truly vertical.

To find the true vertical position of the staff, it is waved slowly towards and away from the level. The lowest reading on the staff will be when the staff is truly vertical.

Reading the staff

1 Setup the instrument and level it carefully.

2 Direct the telescope towards the staff and focus it. The telescope is moved till the staff bisects the vertical hair of the diaphragm.

3 Observe if the bubble on the telescope is at the centre before taking the reading. If not, centre it by using one of the footscrews most nearly in line with the telescope.

4 Note the reading at which the horizontal hair appears to cut the staff. The staff should be read upwards.

Permanent adjustment of level

Objectives: At the end of this lesson you shall be able to
- **state the need of permanent adjustment**
- **list the names the fundamental lines of a levelling instrument**
- **describe the types of adjustment.**

Permanenet adjustment

It is made to establish the fixed relationship between fundamental lines of a levelling instrument, once made, they will last for a long time. Depending upon the construction of the instruments different levels need different permanent adjustments.

The fundamental lines are

- The line of collimation
- The axis of the bubble tube
- The vertical axis
- The axis of the telescope

There are only two permanent adjustments are required in a dumpy level

1 The first adjustment, to make the axis of the bubble tube perpendicular to the vertical axis.

2 The second adjustment, to make the line of collimation parallel to the axis of the bubble tube.

Tilting level

In this type of instrument, a single permanent adjustment is required. (i.e) bubble axis should be made parallel to the collimation axis of the telescope.

Permanent adjustment of a dumpy level

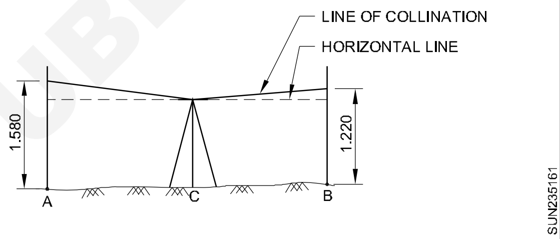
Two peg method (Fig 1)

Example 1

In a two peg test of a dumpy level, the following readings were taken.

i) Instrument at C, midway between A and B (AB = 150 m)

Fig 1



Staff reading on A = 1.580, Staff reading on B = 1.220

ii) Instrument near A

Staff reading on A = 1.420, Staff reading on B = 1.150

Is the line of collimation inclined upwards or downwards and by how much? with the instrument at A what should be the staff reading on B in order to place the line of collimation truly horizontal.

a) Dumpy level is at mid point 'C' (Fig 1)

Staff reading on A = 1.580

Staff reading on B = 1.220

True difference of level = 1.580-1.220 = 0.360m

Rise from A to B

b) Level at A (Fig 2)

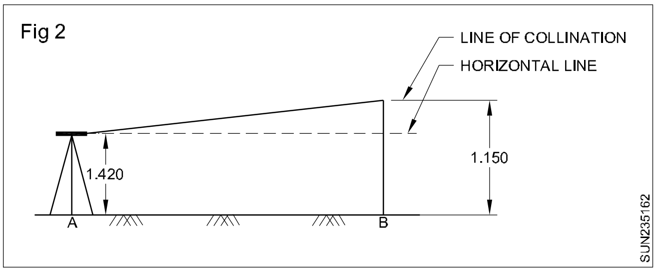
Staff reading on A

= 1.420m correct reading (uneffected by error of collimation)

Subtract true rise = 0.360m

True staff reading on B = 1.420 - 0.360 =1.060m

Observed staff reading on B = 1.150 m



Observed staff reading is more than the required true staff reading, the line of collimation is inclined upwards.

The collimation error = 1.150 - 1.060 = 0.090 m

Staff reading on B which makes the line of collimation truely horizontal

= 1.150-0.090 = 1.060m

Example 2

Following observations were taken for testing of a dumpy level.

i) Instrument exactly at the midpoint of line AB

Staff reading at station A = 1.855

Staff reading at station B = 1.600

ii) Instrument is very near to station B

Staff reading at station A = 0.675

Staff reading at station B = 0.925

Find out,

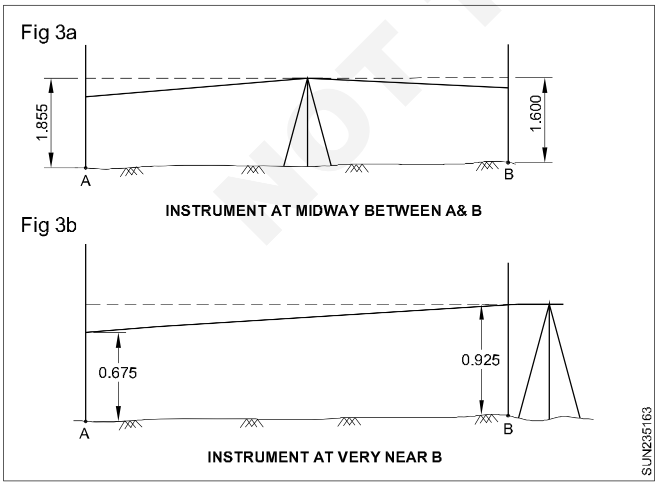
Find i) whether the line of collimation is on adjustment or not.

If it is not in adjustment what is the nature and amount of the error in distance AB?

ii) What will be the correct readings on staff at A and B from station B. When the line of collimation is adjusted.

Solution

Instrument exactly at the midpoint (Fig 3a)



i) Staff reading at station A = 1.855

Staff reading at station B = 1.600

True difference in level between A and B.

= 1.855-1.600 = 0.255 m

Station B is higher than station A.

ii) Instrument at station B (3b)

Reading at B, 0.925 is correct

Correct Reading at A = 0.925 + 0.255 = 1.180 m

But observed reading on A = 0.675

Collimation error = 1.180 - 0.675 = 0.505

The observed reading is less than true reading the line of collimation is inclined downwards.

Example 3

Following observations were taken for testing of a dumpy level by two peg method.

Instrument at E, mid way between point C and D, 100m apart

Reading at C = 2.000m

Reading at D = 3.000m

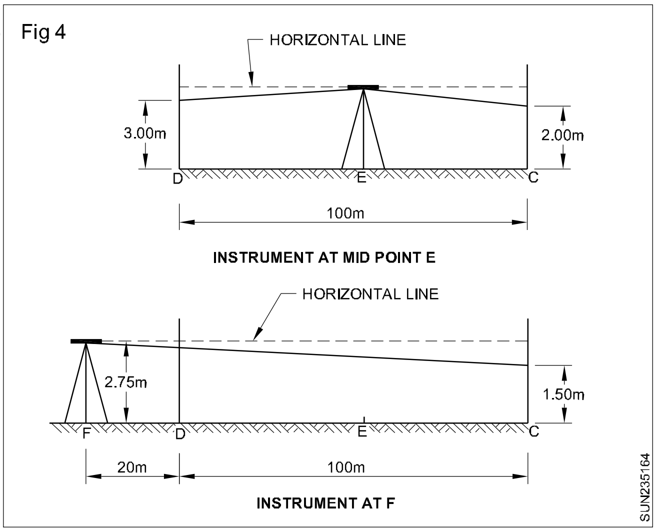
Instrument at peg F in line of CD such that CF = 120m and DF = 20m

Reading at point C = 1.500m

Reading at point D = 2.750m

Check whether the instrument needs permanent adjustment or not and whether the line of sight is inclined upwards. What should be the correct reading at C is the instrument is to be adjusted.

Solution (Fig 4)



Dumpy level at mid point E

Staff reading on D = 3.000m

Staff reading on C = 2.000m

True difference of level = 3.000 - 2.000

= 1.000 (C is at higher)

Dumpy level at point F

Staff reading on D = 2.750m

Staff reading on C = 1.500m

Apparent difference in level = 2.750 - 1.500

= 1.250m (C is at higher)

The staff reading on the point C at the level of D

= Reading on D -True difference in level

= 2.750-1.000 = 1.750m

As the observed reading 1.500m is less than the calculated value 1.75m the line of collimation is inclined downwards.

The net collimation error is 100m = 1.750-1.500 = 0.25m

Correction to the reading on point C,

$$= \frac{120}{100} \text{ x } 0.25 = 0.30 \text{ m}$$

Correction for 100m = 0.25m

Correction for 120m

Correct staff reading on the point C

= Observed reading + correction

= 1.500 + 0.300 = 1.800 m

Correction for 20m = 2

$$= \frac{20}{100} \text{ x } 0.25 = 0.05 \text{ m}$$

Correction staff reading at the point

D = Observed reading + correction

= 2.750 + 0.050 = 2.800m

Check: Correction level difference = 2.800 - 1.800 = 1.000m

(Same as calculated as the instrument at mid way position)

Exercise 1

While checking a dumpy level, the following readings were obtained.

Level setup midway between two staff stations A and B 100m apart. Staff readings on A is 1.900m and on B is 1.400m level is setup 10m behind B and in line AB. Staff readings on B = 1.100m and on A = 1.350m. Determine the amount of instrument error and its inclination.

Exercise 2

The following observations were taken during the testing of dumpy level.

Instrument station	**Staff readings on A**	**B**	**Remarks**
C	1.150	1.795	i) C is exactly midway between A and B
D	1.530	1.930	ii) AB = 100 m apart iii) D lies on BA produced and 20m behind 'A'

Find the readings on A and B to give a horizontal line of sight when the instrument was setup at D.

Longitudinal sectioning and cross sectioning

Objectives : At the end of this lesson you shall be able to
- **explain profile levelling and cross sectioning**
- **explain plotting profile and cross sectioning and working profile.**

Longitudinal Sectioning (or) Profile levelling

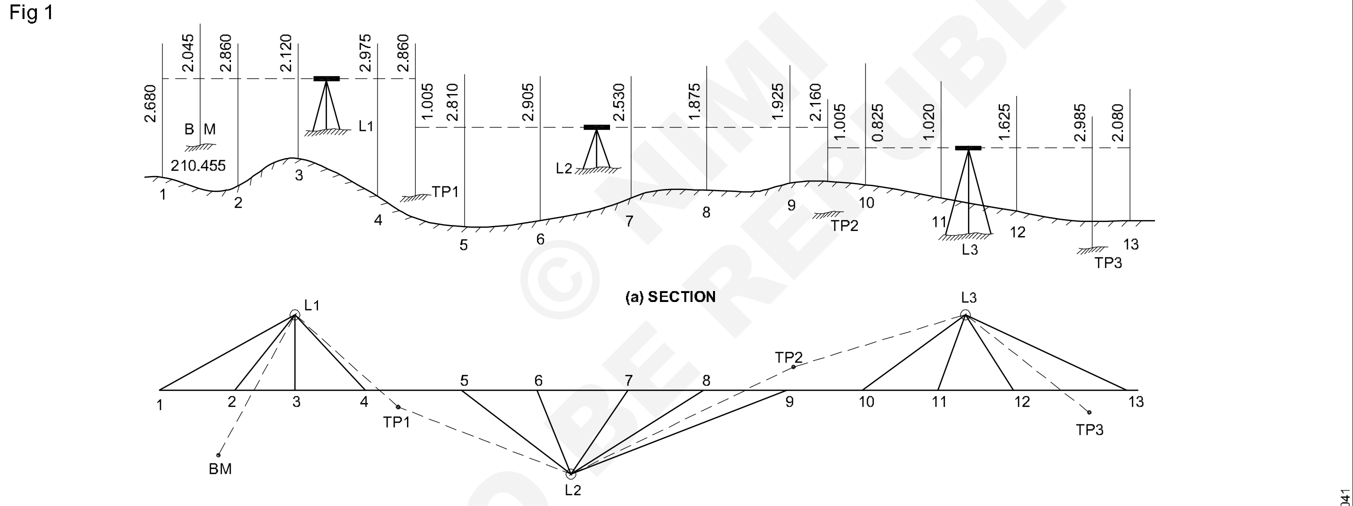
The object of this levelling operation is to obtain a record of the undulations of the gound surface along the centre line of a proposed engineering project such as a road, railway projects, sewage and drainage projects, water line network projects etc.

The outline of the surface thus obtained is called the longitudinal section or profile. Therefore, it is also known as profile levelling. From such a section an engineer is in a position to study the relationship between the existing ground surface and the proposed formation of the new work in the direction of its length.

The operation involves observing the elevations of a number of points along the centre line and also their distances along it. The line of section may be a single straight line running in the centre or may consists of a series of straight lines according to the change of direction and connected by curve.

The levels are taken at uniform intervals of distance along the centre line depending upon the requirements of work and nature of ground. (A typical profile levelling is shown in Fig 1)

Fig 1



(b) PLAN
TYPICAL PROFILE LEVELLING

Besides these points the staff readings are taken at the fairly significant point where outlines of the ground changes appreciably, so that the profile may be obtained as natural as possible.

The change point may or may not be on the line of section.

The instrument is then shifted and set up in a new commanding position and the readings are taken and entered in the field book.

The same procedure is adopted until the end of last point on the section.

If the permanent bench mark is available near the end joint of the section line, the work may be closed on it by running fly levels from the last station.

While entering the readings in the field book with salient topographic features like river, road, railway, canals, foot path, drains etc. recorded in remarks column.

Running the longitudinal section

The line of section is set up on the ground and marked with pegs driven at equal intervals (varies 10m – 30m) before starting the levelling operation.

The levelling operations always commence at a bench mark and end on a bench mark.

If the permanent bench mark is not available near the line of section, a flying level is to run from any permanent bench mark to establish a bench mark near the line of section.

The instrument is set up in such a manner as to command as many points on the section as possible. Staff readings are taken on pages fixed already at desired regular intervals and also at significant points of change of slope.

The readings are entered in the appropriate columns of the levels book against the respective chainages along the line which are recorded in the distance column.

It is necessary to shift the instrument, when the line of sight is within 100m distance and a change point is selected on a firm ground or a well-defined object.

Checking the Levels

At the end of day's work, the accuracy of work should be checked by taking fly levels either from permanent bench mark to another permanent bench mark if available (or) returning back to the permanent bench mark at which the work started.

The closing error = (Σ B.S. - Σ F.S) - (Last R.L - First R.L.) is calculated.

If the closing error exceeds the permissible limit, the work must be repeated.

Plotting the 'L' Section

In plotting the longitudinal section, a horizontal line drawn as datum line and chainages of the staff points are marked along this line to a convenient scale and in black colour.

At the plotted points, perpendiculars are erected and on each lines, the respective levels are set off usually in black, and the perpendiculars are in thin blue lines.

The plotted points are then joined by straight lines to obtain the outlines of the ground surface are in black ink.

(Usually horizontal scale be 1 cm = 10 m or 1 cm = 20 m, depends on the vertical scale chosen)

The vertical scale for showing the reduced levels is enlarged to ten times the horizontal scale (i.e) = 1 cm = 1 m or 2 m

The plotting of maximum level above datum is usually limited for an engineer at site.

Working profile

It is used for the purpose of executing the construction works for an engineers at site.

It shows the features of original ground surface, formation levels of new work, the proposed gradient. The depths of cutting and heights of filling and any other information which may be used for the construction work. The new work and the formation levels are represented by thick red line. The original ground (i.e) natural surface levels are written in black.

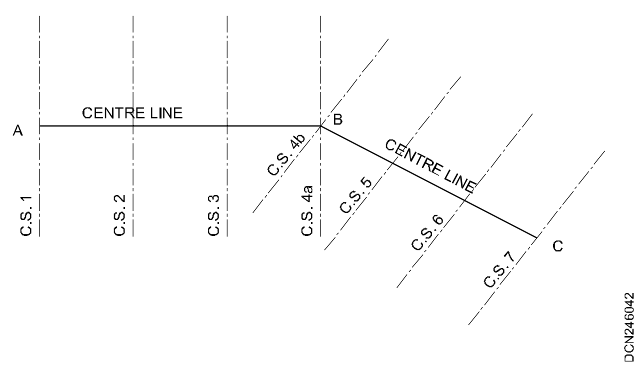
The gradients of new work are shown prominently and the limits of each clearly shown by arrows.

The depths of cutting are written in red.

The heights of filling are written in blue.

Cross-Sectioning (Fig 2)

Fig 2



Cross- sections are run at right angles to the longitudinal sectioning and on either side of it for the purpose of lateral outline of the ground surface. They provide the data for estimating quantities of earth work and other purposes.

The cross-sections are numbered consecutively from the beginning of the centre line and are set out right angles to the centre line of the section with use of cross staff.

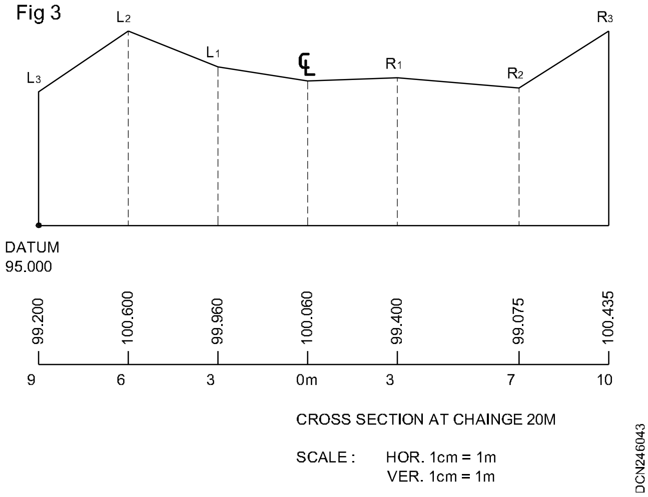
The distances are measured left and right from the centre line. Cross-sections are taken at each of these points. The length of cross-section depends upon the nature of work.

The longitudinal and cross sections are worked together and the observations are recorded in the field work showing left and right of the centre line as given in the model tabulation below.

Plotting the Cross Section

Cross sections are plotted in the same manner as the longitudinal section except that in this case both the scales are kept equal (i.e) horizontal 1 cm = 1 metre and vertical 1 cm = 1 metre. (Fig 3)

Fig 3



The points to left the centre point are plotted to the left and those to the right are plotted to the right.The points obtained are joined by a straight line.

Station	Distance (m)			B.S	I.S	F.S	H.I	R.L	Remarks
	L	C	R						
BM					1.325		101.325	100.000	Cross-section at 0 m chainage
O		0				1.865		99.460	
L_1	3					1.905		99.420	
L_2	6					2.120		99.205	
L_3	9					2.825		98.500	
R_1			3			1.705		99.620	
R_2			7.5			1.520		99.805	
R_3			10			1.955		99.370	
I		20				1.265		100.060	
L_1	3					1.365		99.960	Cross - section at 20m chainage
L_2	6					0.725		100.600	
L_3	9					2.125		99.200	
R_1			3			1.925		99.400	
R_2			7			2.250		99.075	
R_3			10			0.890		100.435	
T.P						2.120		99.205	
Check				1.325		2.120		100.00	
						1.325		99.205	
					Fall	0.795	Fall	0.795	

Errors in levelling

Objectives: At the end of this lesson you shall be able to
- **list the errors occured during levelling operation**
- **state permissible errors in levelling.**

Errors in Levelling

a Instrumental

- Error due to imperfect adjustment.
- Error due to defective bubble tube.
- Error due to sliding movement of objective lens
- Levelling staff of incorrect graduation.
- Defective joint of Telescopic staff.
- Loose joint of the tripod.

b National

- Error due to curvature of Earth
- Error due to refraction
- Error due to variation in Tempeature
- Wind Vibrations.

c Personal

Errors in manipulation

- Careless in setting up of level
- Imperfect focusing of eye piece and object glass.
- Non verticality of staff.
- The bubble not being central at the time of taking readings

Errors in reading staff

- Reading the staff upwards instead of downwards.
- Reading the inverted staff as in normal vertically held staff.
- Reading wrong metre mark, when the staff is very near to the level.
- Reading against the top or bottom hair instead of central hair

Errors in recording and computation

- Entering a reading in the wrong column
- Recording the readings with digits interchanged (i.e) 3.275 instead of 3.572
- Omitting an entry
- Entering the inverted staff reading without a minus sign.
- Instead of adding the B.S to B.M of a point, subtracting the same to get the H.I
- Instead of subtracting the F.S. from H.I of a point, adding the same to get RL.
- Ordinary arithmetical mistakes.

Permissible limits of error in levelling

The degree of accuracy depends upon the following:

- Type of instrument used
- Skill of the observer.
- Character of the country.
- Atmospheric conditions.
- Length of sight.
- Number of setups of instrument

The levelling work starts with a B.M. and ends with the same B.M of the R.L. is same there will be no error. Otherwise there is an error exists.

The permissible closing error is expressed as,

$E=C \times \sqrt{K}$ in metric units

E = permissible closing error in mm

C = constant varies according to the type of survey

K = distance in km

Rough levelling $E \pm 0.100 \sqrt{Km}$

Ordinary Levelling : $E \pm 0.025 \sqrt{Km}$

Accurate levelling : $E \pm 0.012 \sqrt{Km}$

Precise levelling: $E \pm 0.006 \sqrt{Km}$

Introduction to contouring

Objectives : At the end of this lesson you shall be able to
- **define contouring**
- **explain the terms used in contouring**
- **narrate the characteristics of contour.**

Introduction

Relief

The topographical map showing the configuration of the earth's surface by the use of suitable symbols is called relief. Contour lines are used for representing relief.

Contour line

A contour line is an imaginary line of constant elevation on the ground surface. It may be the line of intersection of level surface with ground surface.

E.g: show line of still pond or a lake.

Contouring

The process of locating the contour lines on the surface of the earth or on the plan or map is known as contouring.

Contour interval

The vertical distance between two consecutive contours is called contour interval. It is kept constant for a contour plan to correctly represent the topography of the terrain.

Horizontal equivalent

The least horizontal distance between two consecutive contours is called horizontal equivalent. It is different at different part of the contours and it depends upon the slope of the ground. It is usually less in hills than in plains.

Factors for deciding contour interval

Contour interval on a map is decided on the following considerations.

Scale of the map

The contour interval is kept inversely proportional to the scale of the map. Smaller the scale of map, larger the contour interval. On the other hand, if the scale of the map is large, the contour interval should be small.

Purpose of map & extent of survey

For small extent of survey and for detailed design work contour interval should be small. For large extent of survey, the contour interval shall be large. For the survey of canal, railway, road etc, if the work is very important, contour interval should be less and vice versa.

Nature of the ground

The contour interval generally depends upon the topography of the terrain. In flat ground contour interval is small so that it will be suitable to depict the general nature of the ground. Whereas in hilly areas it can be depicted with contours at larger interval.

Availability of time and fund

If the time and fund available is less, large contour interval is adopted or vice versa. This is due to the fact that the greater the interval, the smaller is the amount of field work, reduction and plotting required in the preparation of the plan.

The contour interval for general topographical may be computed by the following rule.

$$\text{Contour interval} = \frac{25}{\text{Number of cm per km}}\ \text{m}$$

Considering the above factors the contour intervals recommended for the contour plans for various purposes are as follows.

Contour intervals

Type of ground	Scale of map	contour intervals in (M)
Flat rolling Hilly	Large 1Cm = 10m or less	0.2 to 0.5, 0.5 to 1.01, 1.5 or 2 meters
Flat rolling hilly	Intermediate 1cm = 10 to 100m	0.5, 1 or 1.51, 1.5 or 2 2, 2.5 or 3 meters
Flat rolling hilly mountainous	Small 1cm = 100m.	1,2 or 3, 2 to 5, 5 to 10, 10, 25 or 30 meters

Sl.No	Purpose of survey	Scale	Contour interval in metre
1	Building site	1 cm = 10 m or less	0.2 to 0.5
2	Town planning schemes, reservoirs landscape grading	1cm =50m to 100 m landscape grading	0.5 to 2
3	Location surveying	1 cm = 50 m to 200 m	2 to 3
4	For general topographical work	1 cm = 100 m or more	3m & above

Characteristics of contours

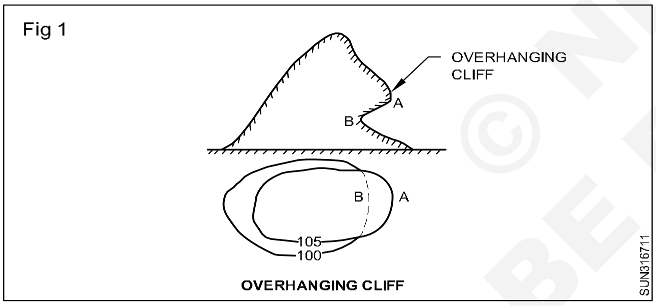
Objective: At the end of this lesson you shall be able to
- **explain characteristics of contours.**

Characteristics of contours

For the preparation of contour plan, it is essential to have a clear knowledge of the important qualities of the contours. Following are the important characteristics or peculiarities of the contours which are kept in mind while plotting.

- All the points lying on one contour line have same elevation.
- Two contours of different elevations do not cross each other except in the case of overhanging cliff. (Fig 1)

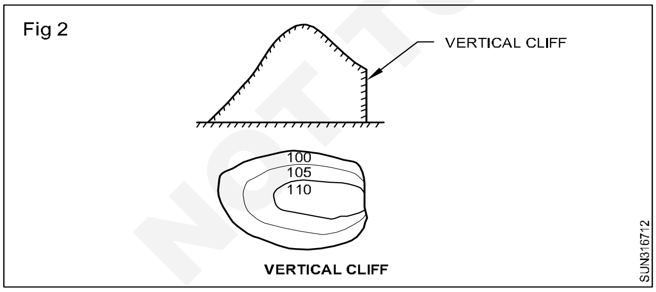
Fig 1



OVERHANGING CLIFF

- Contours of different elevations do not unite to form one contour except in case of vertical cliff. (Fig 2)

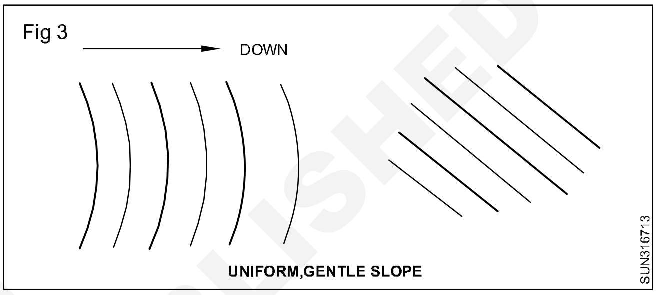
Fig 2



VERTICAL CLIFF

- Contours drawn closer represent a steep slope and if they are drawn far apart, represent a gentle slope. (Fig 3)
- Contours equally spaced represent a uniform slope. When contours are parallel, equidistant and straight they represent a plane area.
- The steepest direction through a point on the contour line is indicated by the perpendicular direction through that point.

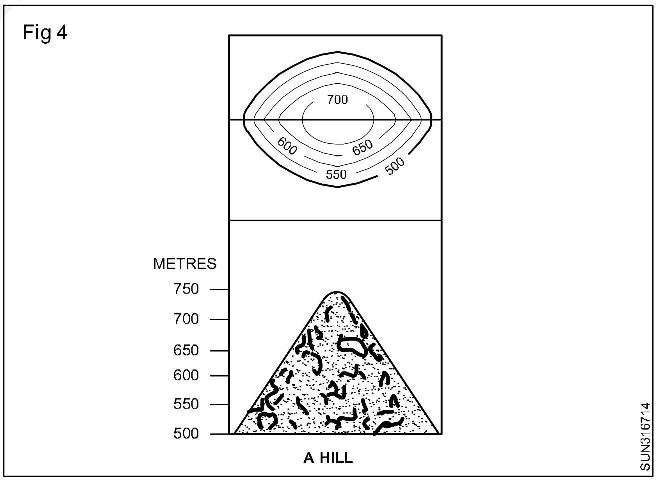
Fig 3



UNIFORM,GENTLE SLOPE

- Contour line must close itself but not necessarily within the limits of the map.
- A set of closed contours with lower values inside indicates a pond or depression.
- A set of closed contours with higher values inside indicates a hill.(Fig 4)

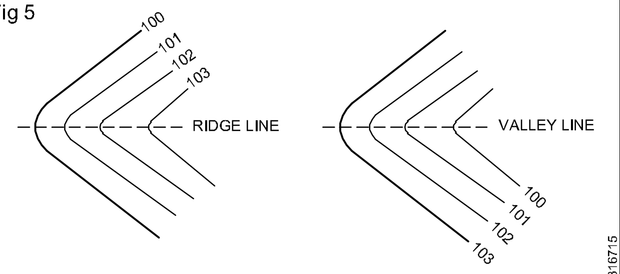
Fig 4



A HILL

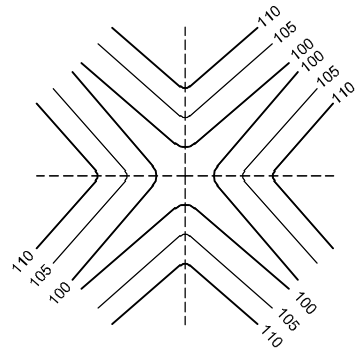
- Contours do not have sharp turnings.
- A set of 'V' shaped contours crosses the ridge line and valley line at 90°. If the higher value contours are inside the bent or loop, it represents a ridge line. V shaped contours represent a valley line, if the lower values are inside the bent or loop.
- The same contour must appear on both the sides of the ridge or valley line. (Fig 5)
- Depression between summits are called saddles. (Fig 6)

Fig 5



RIDGE LINE VALLEY LINE

Fig 6



SADDLE

Uses of contours

Objectives: At the end of this lesson you shall be able to
- **explain the uses of contour**
- **explain the methods of contouring.**

Uses of contour maps

- To study the general character of a tract of land without visiting the ground if the contour map of the area is available.
- To decide the most economical and suitable site for engineering works such as canals, sewers, reservoirs, roads, railway etc.
- To determine the capacity of the reservoirs and the catchment area of drainage basins.
- To compute quantity of earth work required for filling or cutting along the proposed alignment of the project such as canals, roads etc.
- To ascertain the indivisibility of points.
- To trace gradient for the road alignment.
- To draw longitudinal section and cross section to ascertain the nature of the ground in any desired direction.
- To decide the best positions for the guns, the line of march and campaigning grounds by the army commanders during wars.

Locating contours

The location of contour on a map can be plotted only after knowing the horizontal position and vertical elevation of the points consisting of the contours. The fixing of the horizontal position of points is known as horizontal control and it depends upon the size, shape and importance of work. It may be carried out either by chain surveying or compass survey or plane table survey. For small areas, chain survey is adopted and for large areas traversing is adopted.

The fixing of the vertical height of points is known as vertical control and it is carried out by the process of levelling.

Methods of contouring

The method of locating contours may be classified into two. Direct method and indirect method.

Direct method

In this method, the contours to be located are directly traced out in the field with a level or hand level by marking various points along a contour. These points are then surveyed and whose positions are plotted. The line joining these points gives the required contour.

This method is very slow and tedious, but it gives very accurate results. It is used for small areas and for works of high precision.

In this method, first a temporary BM is established in the area where contouring is to be done by running fly levels from a permanent BM. Then the level is set up at a position from where maximum area can be visible. for A BS reading is taken on the BM. From that calculate the height of instrument. To locate the points along a particular contour, required staff reading is calculated by subtracting the reduced level from the height of instrument.

Then contour points are located by moving the staff up and down along the slope until the desired staff reading is obtained. The points are surveyed and whose positions are plotted on the plan.

Direct method by radial line

In this method, contour points are located along the radial lines from a common point at the centre.

Select a point at the centre of the area to be surveyed so that all the points can be commanded from that point and their relative positions are fixed by measuring the horizontal angles or bearings. Place the levelling instrument over the selected point and find the height of instrument with reference to the temporary BM established on the contour site. Calculate the staff readings required, to locate the points along various contours of different reduced levels.

Hold the staff vertically and move up and down along these radial lines until desired staff readings for their respective contours are obtained. The positions of these points obtained are located by measuring their distances from centre point. Join the points of same elevations to get the required contours.

Indirect method of contouring

Objectives: At the end of this lesson you shall be able to
- **explain the indirect method by squares**
- **explain the indirect method by cross section**
- **explain the indirect method by tacheometric.**

Indirect method

This method of contouring is commonly used because it is simple, quick and cheaper. In this method spot levels are taken along a series of lines laid over the area. The positions of these points are then plotted on the plan already prepared by other method of surveying and the contours of required reduced levels are drawn by interpolation. This method is also known as contouring by spot levels. This is done by any one of the following methods.

1) by squares

2) by cross section

3) by tacheometric

1 By squares

This method is suitable for small & low undulating area. In this method the area to be surveyed is divided into a network of squares by running a serious of lines at right angles. The corners of these squares are marked with pegs or arrows. Depending upon the nature of ground, the sides of squares may be uniform or varying. The reduced levels of the corners of the squares are determined by levelling. If required, reduced level of salient positions within the squares are also taken and are located.

The squares are plotted to the desired scale on the plan and reduced levels of the corners as well as salient points are entered. The contours of desired values are then interpolated.

2 By cross section

This method is suitable for long and narrow strips of land such as road or canal or railway. A centre line is laid down through the centre of the area to be contoured. Cross sections perpendicular to the centre line are erected at regular intervals.

The spacing of the cross section depends up on the nature of the ground, contour interval and scale of plan. Usually the interval being 20m in hilly area and 100m in flat country. Then, points at an interval of 5m or 10m are marked along the cross section lines. Points of salient features along the centre line and cross section line are also located.

The layout of the cross sections need not be at right angles to the centre line. They may be inclined at suitable angles to the centre line. The reduced levels of the points are determined. The contours of required reduced level are plotted by interpolation.

3 By tacheometric method

This method is suitable for the contouring of hilly areas. An instrument station is chosen at the peak of area. Set up the tacheometer over that point and a number of radial lines at known angular interval are drawn on the ground. The interval may vary from 10° to 30° depending upon the nature of ground.

Number of representative points are chosen along these radial lines. These points are located by observing the vertical angles and the staff readings of the bottom, middle and top wires. The horizontal distance of these points from instrument station and reduced levels are calculated by using the tacheometric formula.

The radial lines and the positions of the points on each line are plotted to the desired scale and their elevations are also noted. Then the contour lines are drawn by interpolation.

Comparison between direct and indirect method

Direct method	Indirect method
It is the most accurate method. But it is slow and tedious.	This method is cheaper and rapid and less tedious. But not very accurate.
It is used for small areas, where great accuracy is desired	It is used for large area where great accuracy is not the main consideration.
It is not suitable in hilly areas	The tacheometric method of contouring is particularly used for hilly areas. The indirect method by cross section is used in route surveys such as road, canal etc.
The calculation work of reducing the level is comparatively more, since the number of points in command from one set of the level is very less.	Area command from one set up of the tacheometer is more, therefore the calculation work is less.

Preparation of Topographic map

Objectives : At the end of this lesson you shall be able to
- **state topographic terminology**
- **explain topographic map**
- **describe representation of colours and scale.**
- **explain grid of map and find a location of map**
- **describe navigate with a compass and a topographic map.**

Topographic terminology : **Bearing:** The horizontal angle at a given point, measured clockwise form magnetic north or true north to a second point.

Classified roads: Roads for which surface type, width and use are identified.

Contour lines: Lines on a map connecting points of equal elevation above mean sea level. using contour lines, relief features can be profiled into a three-dimensional perspective.

Elevation: Vertical distance from a datum (Usually mean sea level) to a point or object on the earth's surface.

Horizontal datum: The positional reference or basis for the geographic location of features on a map.

Legend: A description, explanation table of symbols, or other information, on a map or chart to provide a better understanding and interpretation of it.

Magnetic north: Direction to which a compass needle points.

Mean sea level: The average height of the surface of the sea for all stages of tide. Used as a reference surface from which elevations are measured.

National topographic system: An orderly index system suitable for a series of maps of different scales

Projection: Geometric representation of the curved surface of the earth on a flat sheet of paper.

Relief: The physical configuration of the Earth's surface, depicted on a topographic map by contour lines and spot heights.

Spot elevation: A point on a map where height above mean sea level is noted, usually by a dot and elevation value, it is shown wherever practical (road intersections, summits, lakes, large flat areas and depressions).

Symbols: A diagram, design, letter or abbreviations, placed on maps, that (By convention, usage or reference to a a legend) is understood to stand for or represent a specific feature or object.

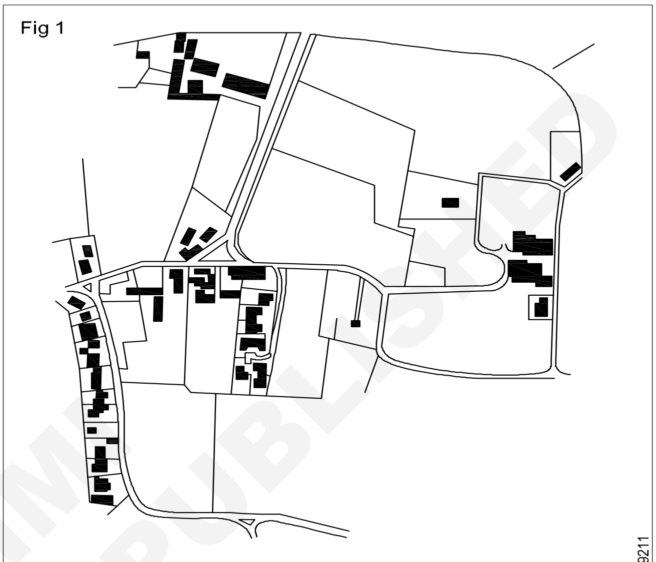
Topography: Surface features both natural and man-made, collectively depicted on topographic maps.

Unclassified roads: Roads for which the surface is unidentified.

Topographic map (Fig 1) : Topographic maps represent the Earth's features accurately and to scale on a two-dimensional surface. Topographic maps are an excellent planning tool and guide.

A topographic map is a detailed and accurate illustration of man-made, and natural features on the ground such as roads, railways, power transmission lines, contours, elevations, rivers, lakes and geographical names.

Fig 1



TOPOGRAPHIC PLAN SHOWING PHYSICAL DETAIL

The topographic map is a two-dimensional representation of the Earth's three-dimensional landscape. The most frequently used topographic map is at the scale of 1:50.000.

Topographic maps identify numerous ground features, which can be grouped into the following categories.

Relief: Mountains, valleys, slopes, depressions as defined by contours

Hydrography: lakes, rivers, streams, swamps, rapids, falls

Vegetation: Wooded areas

Transportation: Roads, trails, railways, bridges, airports/ airfield, seaplane anchorages.

Culture: buildings, urban development, power transmission line, pipelines, towers

Boundaries: international, provincial/ territorial, administrative, recreational, geographical

Toponymy: Place names, water feature names, landform names, boundary names

Refer to the map legend for a complete listing of all features and their corresponding symbols. Information along the map borders provides valuable details to help you understand and use a topographic map. For example, here you will find the map scale and other important information about the map such as the year, the edition and information pertaining to the map data.

Representation of colours: A variety of colours can be found on a map, each relating to different types of features.

- **Black:** shows cultural features such as buildings, railways and power transmission lines. It is also used to show geographical names (toponymy). Certain symbols, geographic coordinates and precise elevations.
- **Blue:** represents water features, such as lakes, rivers, falls, rapids, swamps and marshes. The name of water bodies and water courses are also shown in blue, as are magnetic declination and UTM grid information.
- **Green:** indicates vegetation such as wooded areas, orchards and vineyards.
- **Scale:** Maps are made to scale. In each case, the scale represents the ratio of a distance on the map to the actual distance on the ground. A standard topographic map is produced at 1: 50 000, where 2cm on the map represents 1km on the ground.

$$\frac{\text{MAP DISTANCE}}{\text{GROUND DISTANCE}} = \frac{2\text{ CM}}{1\text{ KM}} = \frac{2\text{ CM}}{1{,}00{,}000\text{ CM}} = \frac{1}{50{,}000}$$

scale = 1: 50,000

Medium-scale maps (e.g. 1:50 000) cover smaller areas in greater detail, whereas small-scale maps (e.g. 1:250000) cover large areas in less detail. A 1:250 000 scale national topographic system (NTS) map covers the same area as sixteen 1:50 000 scale NTS maps.

Grid of map: A grid is a regular pattern of parallel line intersecting at right angles and forming squares, it is used to identify precise position. To help you locate your position accurately on the surface of the earth (or map sheet), topographic maps have two kinds of referencing systems.

Universal transverse mercator (UTM) projection (easting /northing)

Geographic: Degrees and minutes (longitude/latitude)

The projection used for topographic maps is UTM.

The UTM grid is a square grid system of lines depicted on maps and based on the transverse mercator projection. it can be used to accurately locate the position of features on the map by distance or direction. To express your location in grid coordinates or geographic coordinates, read the following section.

Find a location of map: You can find or express a location on a map by using geographic coordinates (longitude, latitude) or by using UTM grid coordinates (easting, northing)

Geographic coordinates are expressed in degrees, minutes and seconds and can be determined on the map by using the longitude and latitude graticules placed along the edges of the map. Latitude graticules are placed along the east and west edges of the map and longitude graticules are placed along the north and south edges of the map. The longitude and latitude of your location can be determined by projecting your location to the map edges and then by reading the corresponding latitude and longitude values.

UTM grid coordinates are expressed in metres and can be determined on the map by using the UTM grid lines. These grid lines are equally spaced horizontal and vertical lines superimposed over the entire map. The coordinate value for each grid line can be found along the edge of the map. Northing values can be read along the east or west edges of the map and easting values can be read along the north or south edges of the map. The easting and northing of your location can be determined by projecting your location to the nearest horizontal and vertical grid lines and then reading the corresponding easting and northing values.

How can i determine where i am on a map using a GPS receiver? : If you have a GPS receiver, your location can be determined very quickly. This satellite receiving system displays a position in terms of latitude, longitude, and height, providing you with precise coordinates for map reference. (Some receivers also provide a direct conversion of position to a selected map grid such as UTM.) with this GPS coordinate, you can then use the geographic or UTM grid reference system on the map to determine where you are..

How can i determine “where I am” on a map without using a GPS? : If you do not have a GPS receiver, identify as many features around you as you can, man-made or natural, and locate those same features on your map. Then orient the map, in relation to yourself, so that its orientation corresponds to the ground features that you have identified. If this is difficult to do, use a compass to help you orient the map to north and try again to identify surrounding features. By estimation, or by using a compass, take bearings to the known features and then from the know features, plot the bearing lines. The intersection of these lies should indicate your location.

Navigate with a compass and a topographic map : Navigating by compass requires determining bearings with respect to true or grid north from a map sheet and converting them to magnetic bearings for use with a compass. One way of doing this is described in the following steps.

Place the compass on the map with the direction-of-travel arrow pointing along the desired line of travel.

Rotate the compass dial so that the parallel lines within the capsule line up with the grid lines on the map. Convert the grid bearing to a magnetic bearing by using the information given (as in the accompanying diagram) on the map sheet. If declination is west, add it to the grid bearing, if declination is east, subtract it from the grid bearing.

Adjust the dial to read the value of the magnetic bearing opposite the direction-of-travel arrow. Make certain to account for the difference between grid north and true north.

Now pick up and rotate the whole compass until the red end of the needle points to the north marker on the dial. The direction-of-travel arrow on the compass card will point to your destination. Choose a landmark in that direction and walk toward it.

Topographic tip: Using a compass along with a topographic map ensures obtaining an exact direction for locating features. An approximate but quick way to orient your map is to align the compass needle (when it is pointing north) with the top of the map.

Remember that north is always at the top of a topographic map.

Trignometric levelling (Indirect levelling)

Objectives : At the end of this lesson you shall be able to
- **state advantage of indirect levelling.**
- **explain various cases of trignometric levelling.**
- **deduce the reduced level using the appropriate formula.**

This is an indirect method of levelling in which the difference in elevation of the points is determined from the observed vertical angles and the measured distances.

The vertical angles are generally measured by theodolite and the horizontal distances are either measured or computed.

Trignometric levelling is commonly used in topographical works because of it is very advantages in mountainous terrain.

Depending upon the field conditions, different cases may arrive. Some of the cases are discussed below.

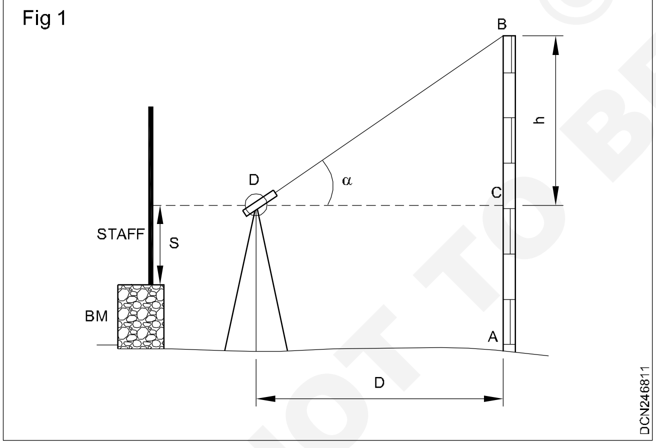
Case 1. Base of the object accessible.

Case 2. Base of the objects inaccessible, instrument stations in the same vertical plane as the elevated object.

Case3. Base of the object inaccessible, instrument stations not in the same vertical plane as the elevated object.

Case 1 (a) (Fig 1)

Fig 1



Base of the object accessible- the object vertical

Let AB is the vertical object.

D is the horizontal distance between the object and the instrument.

S is the staff reading on the levelling staff held vertical on the B.M.

h is the height of the object above vertical axis.

α is the angle of elevation to the top of the object.

From triangle BCD.

BC = CD x tan α

h = D X tan α

R.L. of B = R.L. of B.M + S + h

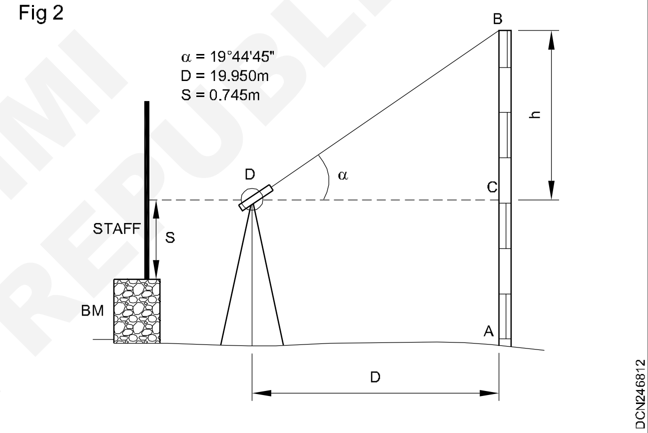
= R.L. of B.M + S+D tan α

Exercise

In instrument was set up at point O. With horizontal sight when staff held at a bench mark of 100.000m, reading was 0.745m The horizontal distance between a point, A from O is 19.950m and A was observed at an angle of elevation 19^0 44'.45". Determine the RL of A.

Solution (Fig 2)

Fig 2



α = 19° 44'45"

D = 19.950 m

S = 0.745m

h = D x tan α

= 19.950 x tan 19° 44'45"

= 7.160 m

R.L. of A = R.L. of BM + S +h

= 100.00 + 0.745 + 7.160

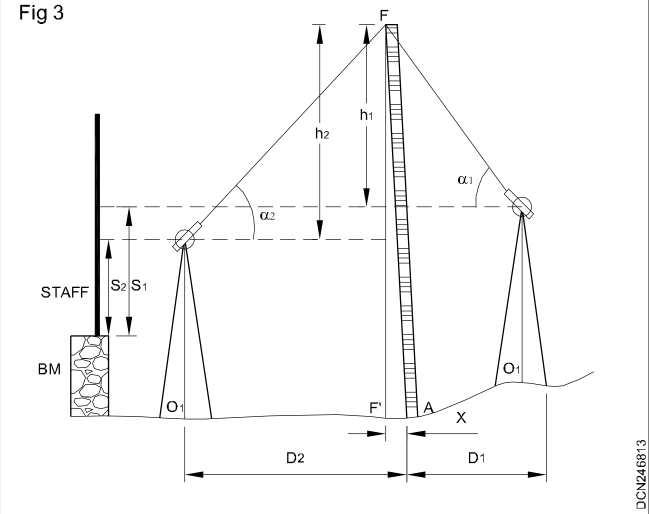
= 107.905m

Case 1 (b) (Fig 3)

Base of the object accessible – the object inclined

In figure AF is the inclined object, x is the distance between the foot of the object and the projection F' of the top O_1 and O_2 and A are in the same vertical plane, D_1 and D_2 are the distances of the foot of the object from the instrument stations O_1 and O_2 respectively. S1 and S_2. Are the staff reading on B.M from instrument positions at O_1 and O_2 respective and α_1 and α_2 are the angles of elevation from O_1 and O_2 respectively.

Fig 3



R.L of F as per set up of instrument at O_1

= R.L. of B.M + S_1 + h_1

= R.L of B.M + S_1 + (D_1 + x) tan α_1 - Eq (1)

R.L of F as per set up of instrument at O_2

= R.L. of B.M + S_2 + h_2

= R.L. of B.M + S_2 + (D_2 – X) tanα_2 - Eq (2)

From Eq (1) and Eq (2)

$$x = \frac{(S_1 - S_2) + D_1 \tan\alpha_1 - D_2 \tan\alpha_2}{\tan\alpha_1 + \tan\alpha_2}$$

R.L of F can be calculated after computing the value of x.

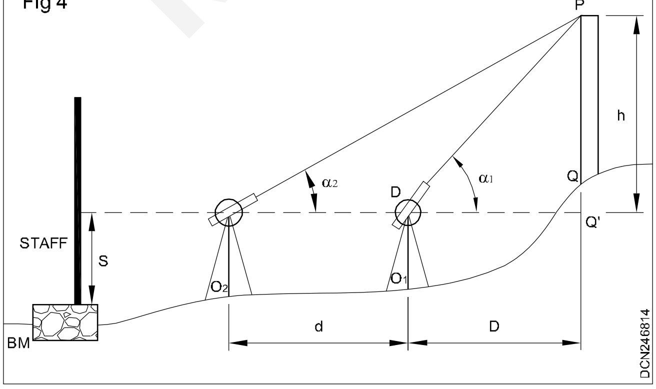
R.L of F = R.L of B.M + S_1 + (D_1 + X) tan α_1

R.L of F = R.L of B.M + S_2 + (D_2 + X) tan α_2

Case 2

Base of the object inaccessible – instrument stations and the elevated object the same vertical Plane (Single plane method) Fig 4.

Fig 4



If the horizontal distance between the instrument and the elevated object is in accessible, the observations are made from two instrument stations. Assuming the two instrument stations and the object to be in the same vertical plane there may be two cases.

Height of instrument are same,

Heights of instrument are at different levels.

Heights of instrument are same

h is the vertical distance PQ'

S is the staff reading on the B.M

α_1 and α_1 are the angles of elevation measured at instrument station O_1 and the object

d is the horizontal distance between the two stations.

Single plane, 'H' Bottom & 'S' Top are at same level

From triangle Q_1 Q'P, = h D tan α_1 → Eq (1)

From triangle Q_2 Q''P, h =(D + d) tan α_2 → Eq (2)

Equating both equations

$$D = \frac{d \tan\alpha_2}{(\tan\alpha_1 - \tan\alpha_2)}$$

$$h = \frac{d \tan\alpha_1 \tan\alpha_2}{(\tan\alpha_1 - \tan\alpha_2)}$$

R.L of P = R.L.of B.M + S + h

Heights of Instrument are at different Levels

There are three cases

Instrument axis at O_1 higher than that at O_2

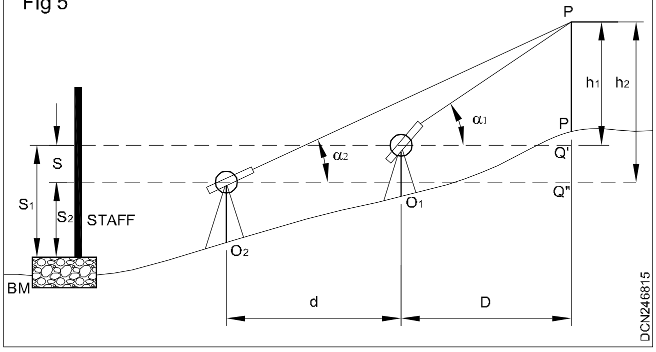
Instrument axis at O_2 higher than that at O_1

Instrument axis at different levels

Instrument axis at O_1 higher than that at O_2

Single Plane: O_1 higher than O_2 (Fig 5)

Fig 5



h_1 - h_2 =Q'Q" = S_1- S_2 = S

From triangle O_1 Q'P,h_1 = D tan α_1 - Eq (1)

From triangle O_2 Q"P, h2 = (D+d) tan α_2 - Eq (2)

From equations 1 and 2

$$D = \frac{(d \tan \alpha_2 - S)}{(\tan \alpha_1 - \tan \alpha_2)}$$

therefore $h = \dfrac{d \tan \alpha_1 \tan \alpha_2}{(\tan \alpha_1 - \tan \alpha_2)}$

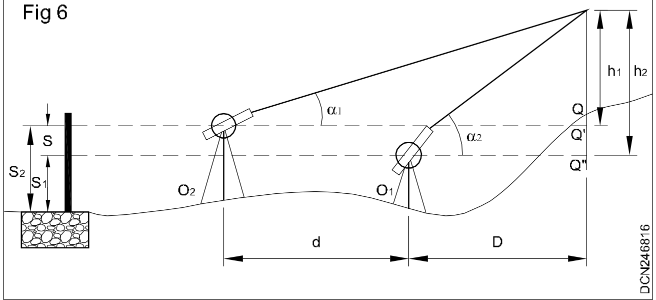
R.L of P = R.L of B.M + S_1 + h_1 or

R.L. of P = R.L of B.M + S_2 + h_2

Instrument axis at O_2 higher than that at O_1

Single plane method O_2 higher than O_1 (Fig 6)

Fig 6



h_1 - h_2 = Q' Q" = $S_2 - S_1$ = s

From triangle O_1 Q'P,h_1 = D tan α_1 - Eq (1)

From triangle O2 Q"P, h2 = (D+d) tan α_2 - Eq (2)

From equations 1 and 2

$$D = \frac{S + d \tan \alpha_2}{(\tan \alpha_1 - \tan \alpha_2)}$$

$$h_1 = \frac{(S + d \tan \alpha_2) \tan \alpha_1}{(\tan \alpha_1 - \tan \alpha_2)}$$

R.L. of P = R.L of B.M. +S_1 +h_1 or

R.L. of P = R.L. of B.M. + S_2 +h_2

Instrument axes at different levels

If the difference in elevation (S_2- S_1) between the two instrument stations is too large and cannot be measured on a staff at the B.M then the following procedure is adopted.

Single plane method: Level difference between two stations is greater (Fig 7)

Set up the instrument at O_1 and measure the vertical angle at the point P.

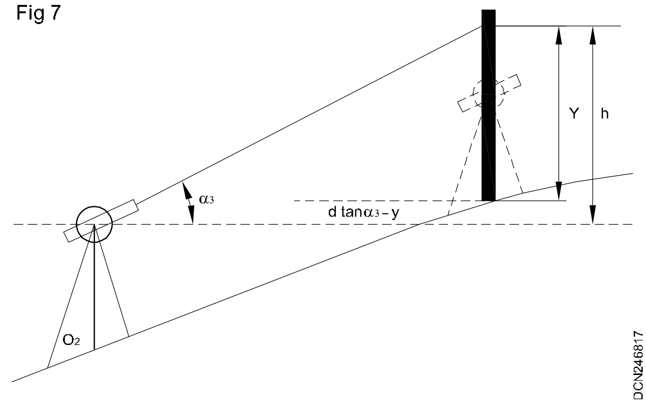
Transit the telescope and establish a point O_2

Shift the instrument to O_2 and measure the vertical angle at the point P.

Observe the staff reading Y on the staff at O_1

Let S be the difference in level between the two axes at O_1 and O_2

Fig 7



Therefore S = $h_2 - h_1$

$$D = \frac{(d \tan \alpha_2 - S)}{(\tan \alpha_1 - \tan \alpha_2)}$$

$$h = \frac{(d \tan \alpha_2 - S)}{(\tan \alpha_1 - \tan \alpha_2)}$$

Height of station O_1 at above the axis at O_2

= h – v

= d tan α_3 - y

S = d tanα_3 - r+h

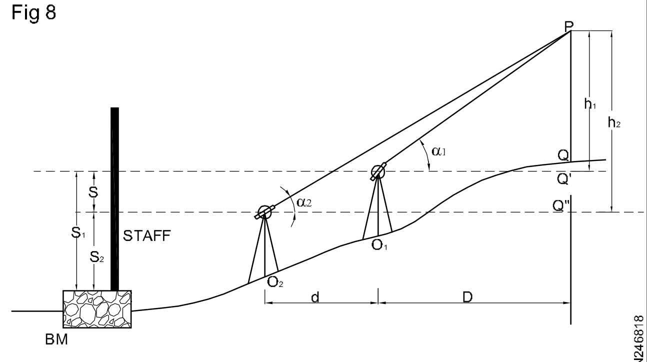
Hence R.L. of P = R.L. of B.M. + S_1 + S + h_1

= R.L. of B.M + S_1 + d tan α_3 - y +h'+h_1

Exercise

The following observations were made on chimney top to ascertain its elevation. (Fig 8)

Fig 8



SINGLE PLANE METHOD

Reduced level of BM was 100.000m. The instrument stations were 20.00m apart and were in line with the chimney top A. Find the RL of the A.

Solution

S_1	= 1.035m, α_1	=	20°00'00"
S_2	= 0.915M, α_2	=	13°00'00"
RL of BM		=	100°000 M
d		=	20.00M

S = 1.035 – 0.915 = 0.120 m

From staff reading we know that observations taken from near to the point A is lower than the other observation.

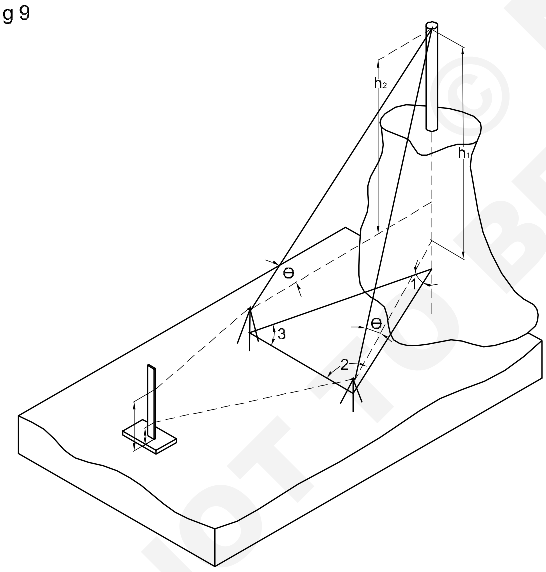
(i.e.) O1 is higher than O2 (single plane method, instrument axes at different levels.

So D	=	(d tanα_2 S) / (tan α_1 - tan α_2)
	=	(20 x tan 13°00'00" – 0.120) / (tan 20°00'00") – tan 13°00'00")
	=	(4.61 -0.120) / (0.3639 – 0.2308)
	=	33.78m
Therefore h_1	=	D tan α_1
	=	33.78 x tan 20° 0' 00" = 12.297m
RL of A	=	RL of BM + S_1 +h_1
	=	100.000 + 1.035 + 12.297
	=	113.332m
or, RL of A	=	RL of BM + S_2 + h_2
h_2	=	(D+d) x tan α_2 =(33.78 + 20) tan 13°00'00
Therefore RL of A	=	100.000 + 0.915 +(33.78+20) x tan 13°00'00

Case 3

Double plane method (Fig 9)

Fig 9



DOUBLE PLANE METHOD

The point P is sighted from two stations, hence point is contained in two vertical planes so it is called double plane method. The method is depicted in the picture.

Point P is sighted from two instrument stations O_1 and O_2

d is the horizontal distance between the instrument stations,

α_1 and α_2 are the angles the elevation to the point P from the stations respectively.

S_1 and S_2 are the staff reading on the B.M from the instrument stations.

In triangle $O_1 O_2 Q'$

$O_1 O'Q_2 = 180° - (\alpha + \beta) = \theta$

By the sine rule

$$\frac{O_2Q'}{\sin\alpha''} = \frac{O_1Q''}{\sin\beta} = \frac{O_1O_2}{\sin\theta}$$

$$O_2Q' = \frac{O_1O_2 \sin\alpha}{\sin\theta} = \frac{d\sin\alpha}{\sin\theta}$$

$$O_1Q' = \frac{O_1O_2 \sin\beta}{\sin\theta} = \frac{d\sin\beta}{\sin\theta}$$

h_1	=	Q'P	=	Q"O_1 tan α,
	=	A' O_1 tan α_1		
h_2	=	Q"P	=	Q" O_2 tan α_2
	=	Q' O_2 tan α_2		

R.L. of F from O_1 = R.L. of B.M. + S_1 + d (sinα tan α_1 / Sin)

R.L. of F O_2 = R.L. of B.M + S2 + d (sinβ tan α_2 / Sin)

Average of these two RLS is the required RL of F.

Double Plane method (Fig 9)

A point P is sighted from two instrument stations O1 and O2. Angle of elevations to the point P are 14°00'00" and 15°00'00" and staff readings on BM are 1.500m and 1.400m observed respectively. Horizontal distance between the instrument stations O_1 and O_2 is 10.00m. Horizontal angle observed at O_1 and between O_2 and P is 60°00'00", horizontal angle observed at O_2 at between O1 and P is 45°00' 00". Find the RL of the P if two instrument stations and point P are occurred in different vertical planes.

Solution

d	=	10.00m
α_1	=	14°00'00"
α_2	=	15°00'00"
S_1	=	1.500m
S_2	=	1.400m
α	=	60°00'00"
β	=	45°00'00"
θ	=	180° - (α+β)
	=	180° - (60°00'00" + 45°00'00")
	=	'75°00'00

By the sine rule

$$\frac{O_2Q'}{\sin\alpha}=\frac{O_1Q''}{\sin\beta}=\frac{O_1O_2}{\sin\theta}$$

$$\frac{O_2Q'}{\sin 60^\circ00'00''}=\frac{O_1Q''}{\sin 45^\circ00'00''}=\frac{10.00}{\sin 75^\circ00'00''}$$

$$O_1Q'=\frac{O_1O_2\sin\beta}{\sin\theta}=\frac{10.00\times\sin 45^\circ00'00''}{\sin 75^\circ00'00''}=7.320m$$

$$O_2Q'=\frac{O_1O_2\sin\beta}{\sin\theta}=\frac{10.00\times\sin 60^\circ00'00''}{\sin 75^\circ00'00''}=8.965m$$

$$O_2Q'=\frac{O_1O_2\sin\beta}{\sin\theta}=\frac{10.00\times\sin 60^\circ00'00''}{\sin 75^\circ00'00''}=8.965m$$

h1 = Q"P = Q"O1 tanα_1

= Q'O_1 tanα_1 = 7.3205 x tan 14°00'00"

= 1.825m

h_2 = Q"P

= Q" Q_2 tanα_2

= Q'O_1 tanα_2

= 8.9657 x tan 15°00'00"

= 2.402m

R.L. of F – R.L. of B.M + S_1 +d (sinα tanα_2 / Sinθ)

= 100.000 +1.5000 +1.8252

= 103.325m

R.L. of F – R.L. of B.M + S_2 +d (sinβ tanα_2 / Sinθ)

= 100.000 +1.4000 +2.4023

= 103.802m

Average of 103.325 and 103.802

= 103.5637m

Therefore RL of F = 103.563m

d	=	10.00m
α_1	=	14°00'00"
α_2	=	15°00'00"
S_1	=	1.500m
S_2	=	1.400m
α	=	60°00'00"
β	=	45°00'00"
θ	=	180° - (α+β)

Reconnaissance survey in road project

Objectives : At the end of this lesson you shall be able to
- **describe the necessity of road projects**
- **explain various types of surveys involved in road projects.**

Introduction

Before constructing a new road due to public demand or some strategic reason, a primary investigation is carried out to examine whether this road is necessary.

The following points are to be kept in mind at the time of such investigation.

- Total population benefitted by the project.
- Number of villages, towns, industrial places etc to be connected.
- Prospect of tourism, if any
- Strategic importance for the defence of the country.
- Any other information related to the project should be noted.

Types of surveys for the location of a road

Before finalising the alignment of a road, the engineering surveys must be carried out in four following stages.

1 Map study

2 Reconnaissance survey

3 Preliminary survey

4 Final survey

1 Map study

In this map study if the topographic map of the area is available, the selected routes of the road may be marked on it. The alignment can be located on the map from the following available details.

- Avoidable points, such as ponds, valleys, lakes etc.
- Possibly of crossing through a mountain pass.
- Location of a bridge site for crossing the river, avoiding bends etc.

2 Reconnaissance survey

The main object of this survey is to examine the general characteristics of the area for determining the most feasible route or routes for further detailed investigations. The reconnaissance survey may be conducted in the following sequence.

(i) Study of topographical survey sheets, agricultural soil, geological and meteorological maps and aerial photographs if available.

(ii) Aerial reconnaissance

(iii) Ground reconnaissance

(i) Study of topographical survey sheet

Reconnaissance begins with the study of all available maps. In India topographical sheets are available to the scale of 1:50,000. After the study of the topographical features on the maps, a number of alignment feasible in a general way are selected while selecting the alignment following points should be kept in view.

- The alignment should be shortest and most economical with the requirements of gradient and curvature.
- Shape of the alignment
- As far as possible avoid marshy ground, step terrain, unstable hill features.
- Need of connecting important villages and towns, industrial places, or religious importance etc.
- Number of bridges and their lengths.

If the photographs of the area are not available, aerial photography may be arranged for further study for the sake of overall economy. These photographs may be taken on a scale of 1:20,000 to 1:50,000.

(ii) Aerial reconnaissance

Final alignment is selected on the basis of the aerial reconnaissance. It will also help to identify factors which may be helpful with rejection or modification of any of the alignment. This will provide a bird's eye view of the alignments under consideration along with the surrounding area.

(iii) Ground reconnaissance

It consists of general examination of the ground by walking or riding along the selected alignment of a road. It may be done by using the following instruments.

- Compass
- Abney level
- Pedometer
- Cline meter
- Ghats tracer

During this survey following points should be kept in mind.

- Details of route
- Length of the road
- Number of bridges and their lengths
- Geometrics/Gradients, curves and hair pin bends etc.

- Right of way available.

Terrain and soil conditions - Geology of area, nature of soil, drainage conditions and nature of hill slopes.

Road length passing through

- Mountainous terrain
- Steep terrain
- Area subjected to inundation and flooding
- Area of poor soil and drainage conditions.
- General elevations of the road

Climatic conditions

- Temperature-maximum and minimum readings
- Rainfall
- Wind velocities and direction
- Water table conditions.

Value of land - agricultural land, irrigation land, built up land, forest land etc.

- Approximate cost of construction
- Period required for construction
- Important villages, towns and marketing centres connected
- Crossings with railway lines and other existing highways.
- Position of ancient monuments, burial grounds, religious structures, hospitals and schools etc.

3 Preliminary survey

This survey is relatively large scale instrument survey conducted for the purpose of collecting all physical information which affects the proposed location of a new highway. In case of new road it consists of running an accurate traverse line along the new route selected, on the basis of reconnaissance survey. During this phase of survey, topographic features and other features like houses, places of worships etc. are to be considered.

Longitudinal sections and cross sections are taken and bench marks established. This data will form the basis for the determination of final centre line of the road.

During preliminary survey usually levelling work should be kept to the minimum. Generally fly levels at 50 m intervals and at all intermediate breaks in ground should be taken along the traverse line.

The cross section at about 100m to 250m interval in plain terrain and at about 50m intervals in rolling terrain should be taken.

4 Final location survey

This survey is carried out to lay out the final centre line of the road in the field based on the alignment selected in the design office and to collect necessary data for the preparation of working drawings. In this survey only two steps are involved.

- Staking out the final centre line of the road by means of a continuous transit survey.
- Detailed levelling.

Road alignment

The position or the layout of the centre line of the highway on the ground is called the alignment. In a new road should be aligned carefully otherwise it is faulty. It causes more construction, maintenance cost and also increase the accident rates.

The alignment may be,

- Short
- It should be easy
- It should be safe
- It should be economical
- Height of embankment

The height of the embankment depends upon the desired grade line of the highway and topography of the area. Sometimes it is also governed by the stability of foundation specially when the soil is weak usually it is taken 0.6m

Road gradient

The rate of rise or fall along the length of the road with respect to the horizontal length is called gradient.

The maximum, ruling and exceptional gradients as recommended by Indian Road Congress are given below.

Sl.No.	Type of Terrain	Maximum gradient
1	Plain or rolling	1 in 20
2	Mountainous and steep terrain with elevation upto 3000m	1 in 16.7
3	Elevation more than 3000m	1 in 14.3

Road way

Road way comprises of the width of carriageway including traffic separator and shoulders on either side.

Road way width as per recommendations of I.R.C

National and State highway	12.0m
Major district roads	10.0m
Other district roads	8.0m
Village roads	7.5m

Introduction to theodolite

Objectives: At the end of this lesson you shall be able to
- **explain the uses of theodolite**
- **explain the classify theodolite**
- **explain the designate theodolite.**

Introduction

Theodolite is primarily used for measuring horizontal and vertical angles. It was invented by Roemer, a Danish astronomer in 1690. The instrument was used to observe astronomical observations. Later it was modified to suit the surveying requirements. It is primarily used for measuring horizontal angels. Later further aditions were made to make possible of several uses such as prolonging a line, establishing line, levelling, measuring the distance indirectly (tacheometry) etc.

It is sometimes referred to as universal instrument. Theodolite is very useful instrument for engineers.

Classification of theodolite

Theodolites may be classified into the following two types.

1 Transit or engineer's theodolite and

2 Non – transit theodolite.

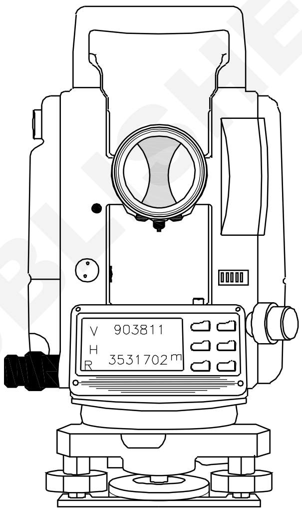
A theodolite is said to be transit one when its telescope can be revolved through 180^0 in a vertical plane about its horizontal axis, thus turning the telescope in exactly opposite direction. All modern theodolites are transit type.

A theodolite is said to be non-transit one if its telescope cannot ne revolved through 180^0 in a vertical plane about its horizontal axis. Non transit theodolities are obsolete nowadays (Fig 1)

Designation of theodolite

The size of a theodolite is defined by its diameter of the graduated circle of the lower plate. For example, a 25cm theodolte means the diameter of the lower graduated circle is 25cm.

Fig 1



THEODOLITE

DCN256911

Main parts of vernier theodolite - I

Objectives: At the end of this lesson you shall be able to
- **sketch sectional views of a theodolite**
- **explain main parts of theodolite**
- **state fundamental operations of theodolite.**

Main parts of a vernier theodolite

Schematic diagram of theodolite

Levelling head

Levelling head is used to level the instrument horizontal. It consists of two plates:

1 Upper tribrach plate and

2 Trivet or Lower tribrach plate.

The upper carries three levelling screws. The lower plate also known as foot plate, is provided with a large central hole with thread for fitting into the top of the tripod.A plumb bob can be suspended from a hook at the lower end of the inner spindle for centering purpose. (Fig 1& 2)

Fig 1

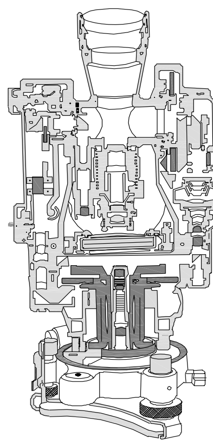


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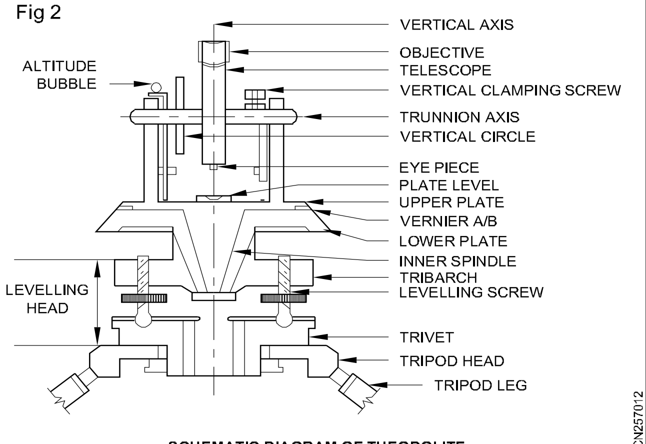
Fig 2



SCHEMATIC DIAGRAM OF THEODOLITE

Shifting head

This device helps in exactly centering the instrument over the station. When it is unlocked, the instrument can be moved slightly and independently of the leveling head.

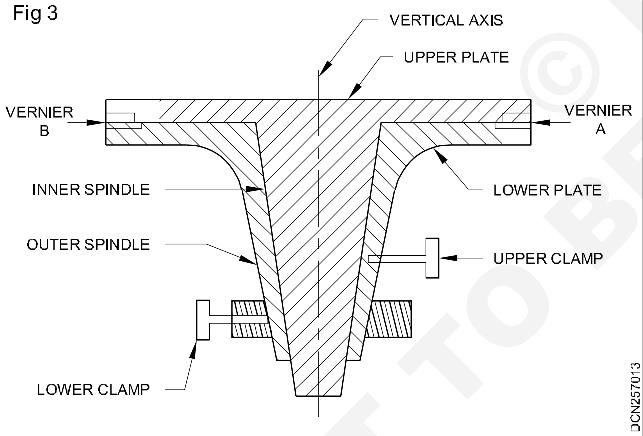
Therefore the instrument is first approximately centered over the station and exact centering is done using the shifting head.

Moved slightly and independently of the levelling head.

Therefore the instrument is first approximately centered over the station and exact centering is done using the shifting head.

Lower plate and upper plate (Fig 3)

Fig 3



It carries a circular scale which is graduated from 0° to 360°. It is attached to the outer spindle.

Upper plate is also called vernier plate. Two diametrically opposite verniers (A and B) provided with magnifiers are fixed to the upper plate. It is attached to inner spindle which rotates in the outer spindle.

Clamp and Tangents

Two Clamp screws and tangents are provided on the horizontal circle and one clamp screw and tangent screw are provided on the vertical circle They are called.

1 Upper clamping screws and its tangent

2 Lower clamping screw and its tangent and

3 Vertical circle clamping screw and its tangent.

Lower plate can be clamped to outer spindle at any desired position using lower clamps. The upper plate can be clamped to the lower plate using upper clamp screws. If the upper clamp is locked and lower clamp is loosened, the two plates rotate together on outer spindle without causing any change in the reading. If the upper clamp is loosened and the lower clamped, the upper plate rotates on its inner spindle with relative motion between two plates. This property is used for measuring horizontal angles.

Fundamental Operations

1 Upper and lower circles and locked together using upper clamping screw and small differential movement of plates is achieved using upper tangent screw.

2 Lower plate is clamped to the outer spindle using lower clamping screw and small differential movement between lower plate and spindle is achieved using lower tangent screw.

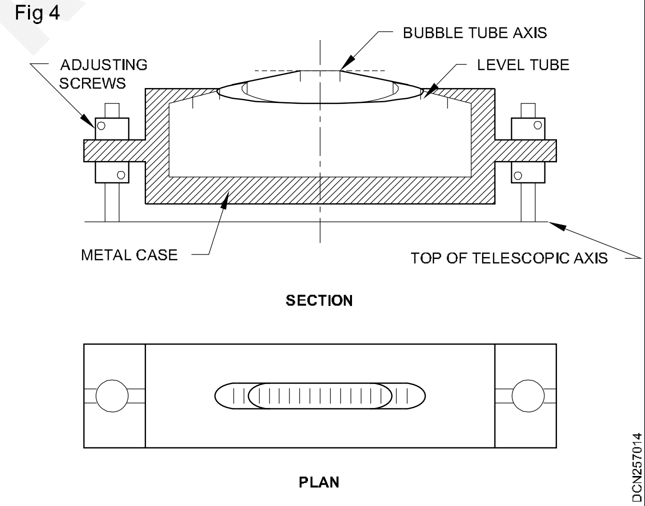
3 Vertical motion of telescope is controlled by vertical clamping screw and small movement is achieved using vertical tangent screw.

Clamping upper plates and loosening lower clamp, the upper and lower plates rotate as one unit relative to outer spindle. This enables to set predetermined angles.

Clamping lower plates and loosening lower clamp, the horizontal vernier plate moves relative to lower plate. This enables to measure angles.

Level Tubes (Fig 4)

Fig 4



There are two level tubes. One on the horizontal upper plate and another attached to the vertical vernier.

Sometimes it carries two plate levels. If two plate levels are provided, they will be at right angles to each other. A level tube is also known as a bubble tube or spirit level or level.

It is a glass tube which is curved and sealed at both the ends. It is filled with sensitive liquid such as alcohol or ether. The liquid should be sensitive, non –freezing and stable. The radius of the circular longitudinal curve of the tube varies according to use. Bubble sensitiveness is inversely proportional to the radius of the curvature of the bubble tube.

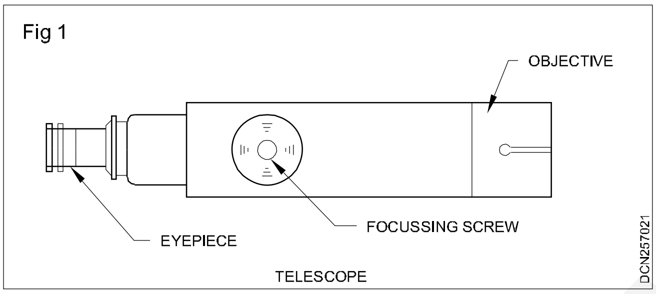
The bubble of the plate level is centered with help of the foot screws. These level help to make the vertical axis of the instrument truly vertical.

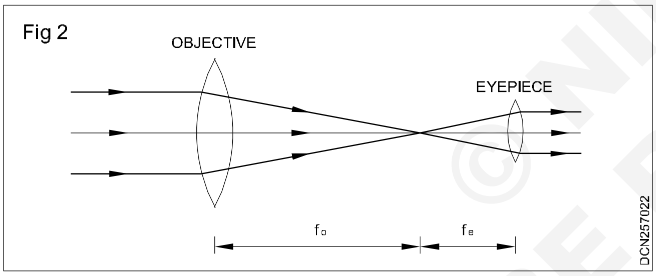
The level is provided with a scale having uniform graduations, generally of 2mm length etched on the exterior surface of the tube. The graduations are numbered and considered in both ways from the centre point. Position of the bubble is determined by nothing the positions of both the end because the bubble will change its length with changes in temperature and the reading of one end is not sufficient to determine the position of the bubble.

Main parts of a vernier theodolite -II

Objectives: At the end of this lesson you shall be able to
- **explain working principle of telescope**
- **type of telescope**
- **state functions of main of telescope.**

Telescope (Fig 1 & 2)





Function of telescope is to provide the line of sight. Telescope is mounted on horizontal axis (placed at right angles to the line of collimation). Vertical circle is also connected with telescope. It has,

i An eye piece (held next to the eye when sighting through telescope

ii A diaphragm and

iii An object glass or objective (towards object sighted)

Working principle of a telescope

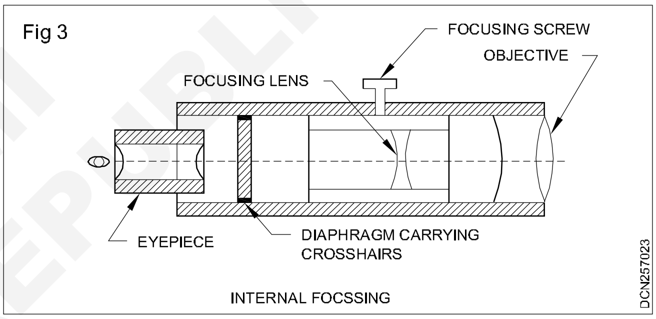
The telescope is used to produce enlarged virtual image of distance objects which can be easily read by human eye. The telescope consists of two convex lenses. The optical centre is usually located near the geometric centre of the lens.

The principle of telescope is that in a lens all rays passing through the optical centre of the lens go straight without any bending while the other rays get deflected and go through the principle focus F.

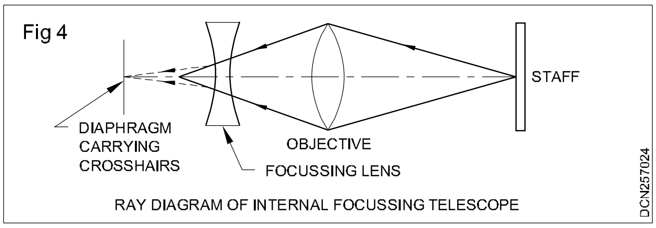
Types of telescope

Telescope of theodolite may be internal focusing type or external focusing type. Now a days the most commonly used telescopes are internal focusing type.

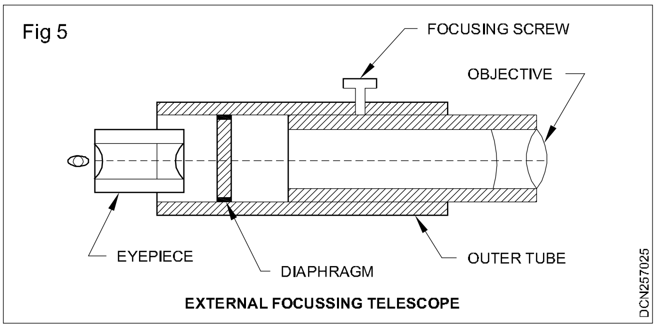
Internal focusing telescope (Fig 3)



Ray diagram of internal focusing telescope (Fig 4)



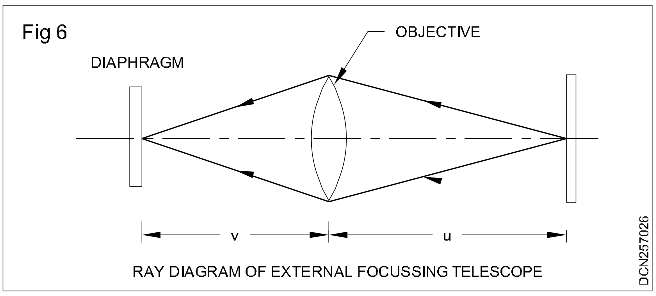
External focusing telescope (Fig 5)



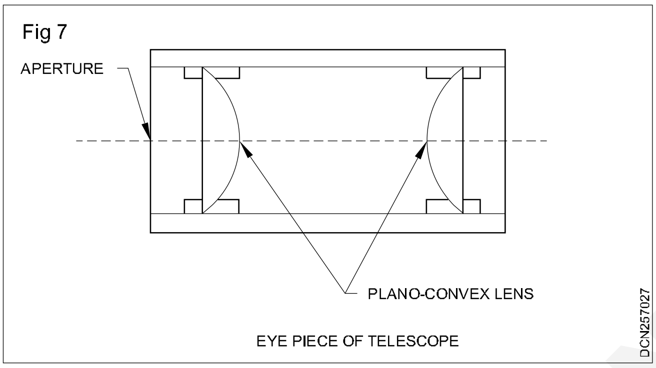
Ray diagram of external foussing telescope (Fig 6)

Eye piece

The eye piece lenses magnify the image together with the cross hairs.. Ideally the eye pieces should reduce chromatic and spherical aberration. Ramsden's eye piece is the most suitable eye piece and is commonly used. It is composed of two plano-convex lenses of equal focal length which kept equal to two-third of the focal length. The image formed by object glass in front of the eye piece, is at a distance lesser than its focal length, and hence eye piece magnifies the image which appeared erected to the observer.



Eyepiece of telescope (Fig 7)



Diaphragm

The diaphragm carries the recticle containing a horizontal and vertical hair. The diaphragm is fitted inside the main tube by capstan headed screw. Position of the crosshairs can be adjusted slightly (horizontally and vertically). In modern instruments, a thin glass plate with lines ruled or etched and filaments of dark metal deposited in them is used as reticle. Sometimes two additional horizontal hairs called stadia hairs are added. One above and the other below the usual horizontal cross hair for tacheometry surveying.

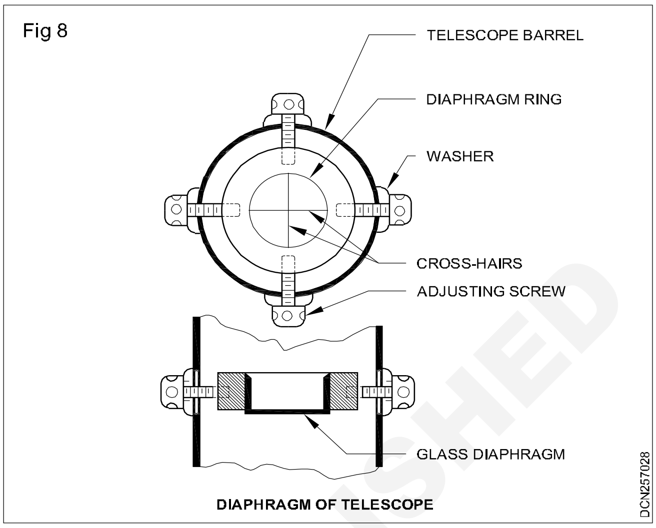
Diaphragm of telescope (Fig 8)

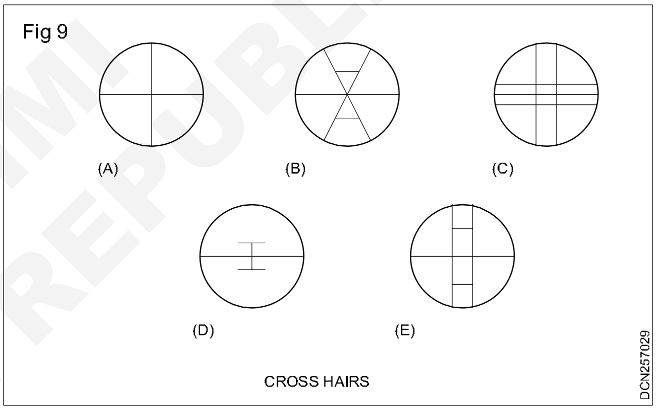
Commonly used cross hairs (Fig 9)

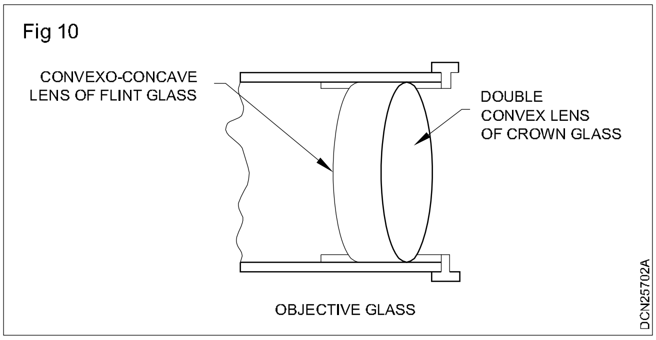
Object glass

A single lens has many defects like chromatic aberration and spherical aberration. These defects are overcome by using two lenses joined to form the object glass. Usually a convex lens of crown glass and a concave lens of flint glass are joined. To minimize loss due to refraction, the lenses are given a thin uniform coating which has an index of refraction smaller than that of glass.

Objective glass (Fig 10)







Main parts of a vernier theodolite -III

Objectives: At the end of this lesson you shall be able to
- **state graduations of vertical circle**
- **state main parts of theodolite**
- **differentiate a frame and frame.**

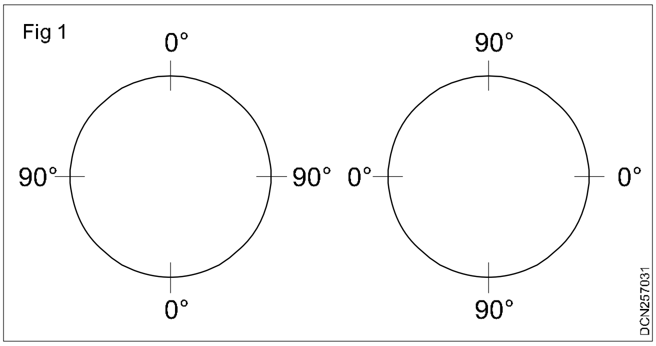
Vertical Circle : Vertical circle is connected to telescope and it moves with telescope when telescope is rotated in vertical plane. The following graduations are in common use.

1 The vertical circle is divided into four quadrants from 0° to 90° in both the directions. The 0° -0° line is a vertical line.

2 The vertical circle is divided into four quadrants from 0° to 90° in both the directions. The 0º - 0º line is a vertical line.

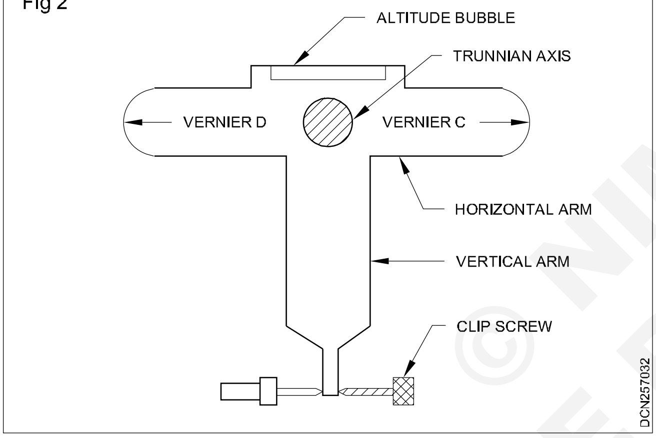
Graduation systems of vertical circle (Fig 1)

Fig 1



Index frame (or 'T' frame or vernier frame) (Fig 2)

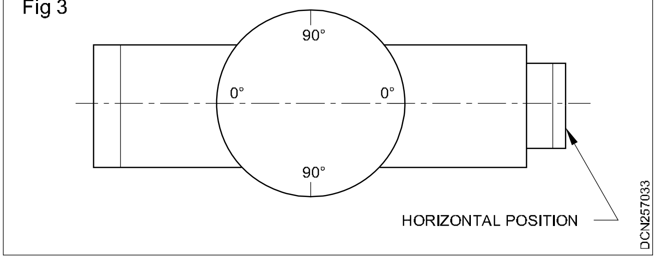
Fig 2



It resembles the English letter T and is centered on the horizontal axis of the instrument. It consists of a vertical arm and a horizontal arm. The vertical arm is called dipping arm and a horizontal arm is called an index arm. Clipping arm is provided with a fork and two clipping screws at its lower extremity. AT the top of the frame is attached a bubble called the altitudes bubble. At the two ends of index arm verniers C and D are fitted.

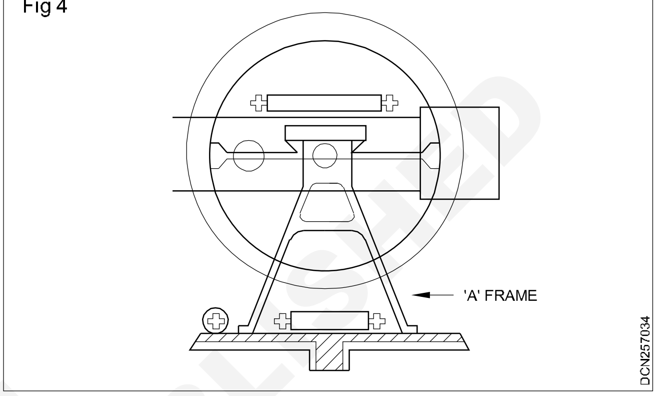
Vertical circle vernier (Fig 3)

Fig 3



The Standards or ('A' Frame) (Fig 4)

Fig 4



Two standards resembling English letter A are fixed on the upper plate. These frames support the telescope. They are known as standards or A frame. The horizontal axis of the telescope is supported on this a frame. The 'T' frame and vertical circle are attached to this frame.

Tripod

Theodolite is used by mounting it on a tripod when being used in the field. It consist of three legs which are provided with pointed steel shoes to get good grip on the ground. External screw is provided on the top of the tripod to facilitate screwing of theodolite. Nowadays telescopic theodolite is used where accurate centering is required.

Plumb bob

A hook is provided at the lower end of the inner spindle from which a plumb bob can be suspended. It facilitates exact centering of theodolite over the station.

Theodolite - definitions and terms

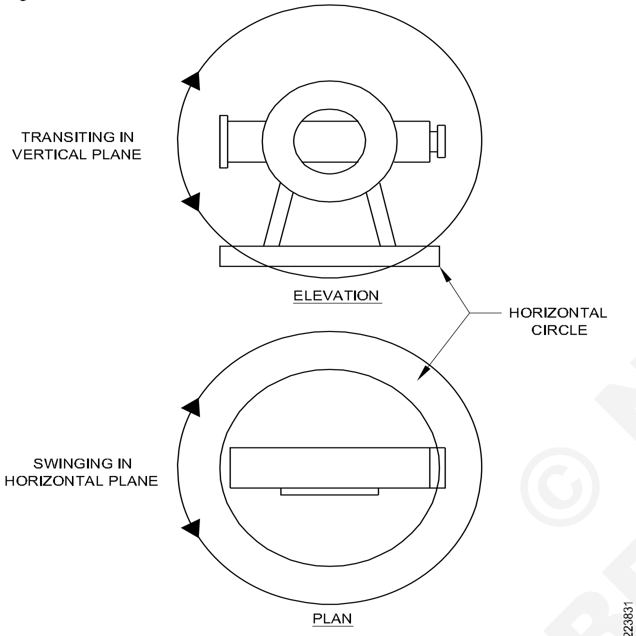
Objectives: At the end of this lesson you shall be able to
- **define the terms used in theodolite surveying**
- **state the difference between face left and face right observations**
- **explain least count.**

Definitions and other technical terms

Centering : The process of bringing the vertical axis of theodolite immediately over a mark or station is known as centering. This is achieved by suspending plumb bob along vertical axis of theodolite and shifting the head.

Transiting (or) reversing (or) plunging (Fig 1)

Fig 1



SWING

The process of turning the telescope in vertical plane, about its horizontal axis through 180° is known as transiting. the terms reversing or plunging are also used sometimes for transiting.

Swing (Fig 1) : Rotating telescope in horizontal plane, about its vertical axis is called swing. According to the direction of rotation there are two swings.

When the telescope is rotated clockwise it is called right swing.

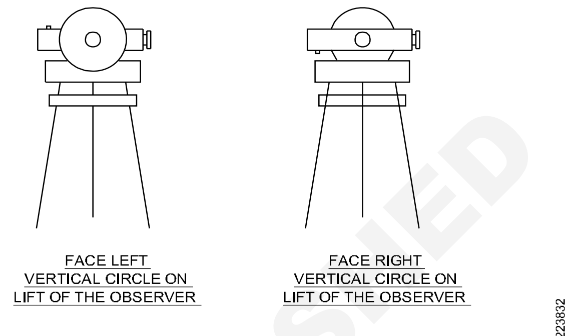
When the telescope is rotated anti-clockwise it is called left swing.

Telescope normal : When the vertical circle is on the left of the telescope and the target on telescope is up then it is called telescope normal.

Telescope inverted : When the vertical circle is on the right of the telescope and the target on the telescope is down then it is called telescope inverted.

Face left and face right observations (Fig 2) : The observations made keeping the vertical cicle of the instrument on the left side of the telescope is known as face left observations.

Fig 2



FACE LEFT AND FACE RIGHT OBSERVATIONS

The observations made keeping the vertical circle of the instrument on the right side of the telescope is known as face right observations.

Changing face

Process of changing face left to right or vice versa is known as changing face.

A set of observation: It consists of two horizontal observations; that is one face left and one face right observations.

Double sighting (Fig 3)

Operating theodolite twice, once with telescope in the normal condition and another with telescope in the reverse condition.

Least count (L.C.)

The smallest measurable unit is called Least Count.

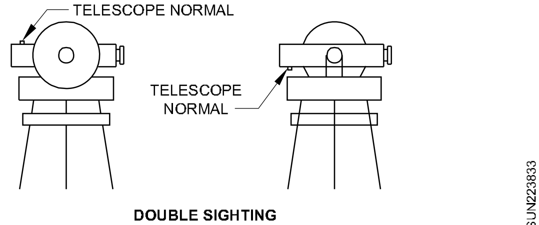
Lining in

The process of establishing intermediate points with a theodolite on a given straight line, whose both ends are intervisible is called lining in.

Balancing in

The process of establishing intermediate points with a theodolite on a given straight line, whose both ends are not intervisible (e.g. forest) is called balancing in.

Fig 3



DOUBLE SIGHTING

Fundamental axes and geometry of theodolite

Objectives: At the end of this lesson you shall be able to
- **explain fundamental axes of theodolite**
- **explain the classify theodolite**
- **explain the designate theodolite.**

Fundamental axes of theodolite

Vertical Axis : The axis about which a theodolite is rotated in horizontal plane is the vertical axis.

Horizontal axis (Trunnion axis) : The axis about which the telescope rotates in a vertical Plane is called horizontal axis or trunnion axis.

Line of collimation or line of sight : It is an imaginary line joining the intersection of the cross hairs with optical centre of the object glass and its continuation.

Line of colimation (Fig 1)

Axis of telescope (Fig 2)

Fig 1

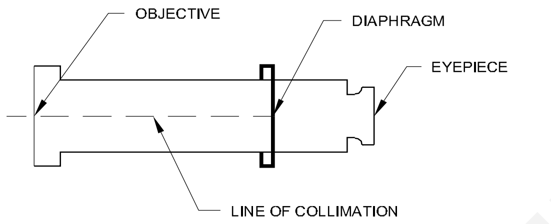
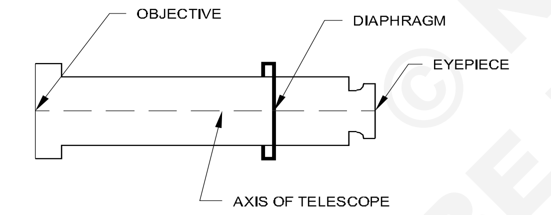


Fig 2



Axis of Telescope : It is an imaginary line joining the centre of the eye piece and the optical centre of the objective.

Axis of plate level bubble : An imaginary straight line tangential to the longitudinal curve of plate level at its centre.

Axis of the altitude level tube : An imaginary straight line tangential to the longitudinal curve of altitude level at its centre.

Fundamental axes of theodolite (Fig 3)

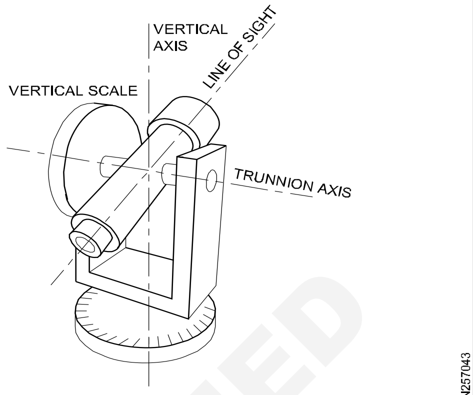
Schematic diagram of fundamental axes of theodolite (Fig 4)

Geometry of the theodolite

In a perfectly constructed theodolite, following relations between axes of the instrument should exist.

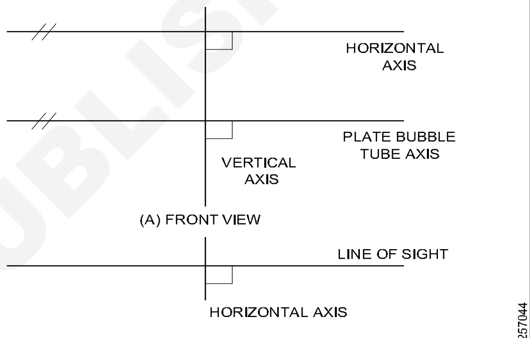
- The vertical axis of the instrument should be perpendicular to the axis of the plate bubble.

Fig 3



FUNDAMENTAL AXES OF THEODOLITE

Fig 4



SCHEMATIC DIAGRAM OF FUNDAMENTAL AXES OF THEODOLITE

- Line of sight should be perpendicular to the horizontal axis.
- The horizontal axis should be perpendicular to the vertical axis.
- The axis of the altitude bubble tube should be parallel to the line of sight.

A crude figure showing geometric of theodolite (Fig 5)

Fig 5

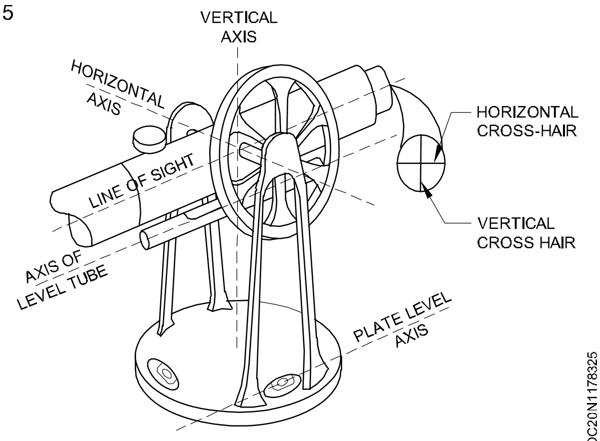
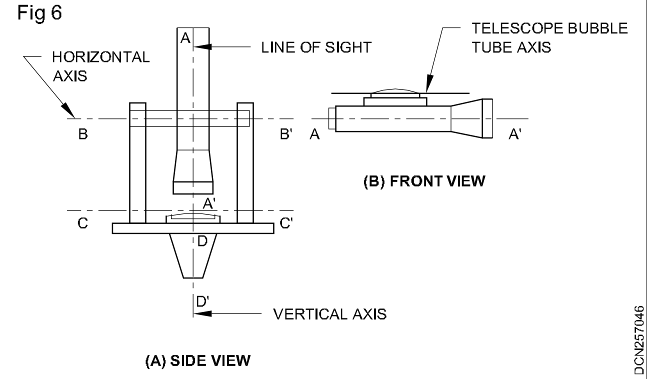


Figure showing geometry of theodolite (Fig 6)

Fig 6



Temporary adjustments of theodolite

Objectives: At the end of this lesson you shall be able to
- **set up and perform centering of the instrument**
- **level up the theodolite**
- **eliminate parallax.**

Temporary Adjustments of a Theodolite : Temporary adjustments are that adjustments required at every new set up of the theodolite. Following temporary adjustments are required for a new set up of a theodolite before starting the work. They are:-

1 Setting up

2 Centering

3 Levelling up

4 Focussing

 a Focussing the eyepiece

 b Focussing the objective.

Setting up : Initially tripod is set up at a convenient height over the station spreading and fixing three legs firmly on the ground. Fix the instrument over the tripod. Bring the leveling screw at the middle of the run. Then the instrument is approximately levelled by eye judgement. Some instruments are provided with a small circular bubble on the tribrach to check the horizontal level.

Centering will disturb if there is considerable dislevelment

Centering : Centering is achieved by suspending plum bob with a string attached to the hook fitted to the bottom end of the vertical axis. Approximate centering is done by moving the leg radially and circumferentially. Accurate centering by finer movements is done by shifting the head, unlocking the shifting head clamp.

Centering is done to place the vertical axis exactly over the station.

Levelling Up

Levelling operation is performed to make the vertical axis of the instrument truly vertical and pass through the station

Focussing

Focussing is done to eliminate parallax error.

Focussing the eyepiece : This is done by holding a white paper 15cm in front of the objective and turning the eyepiece in or out until the cross hairs are seen sharp and district.

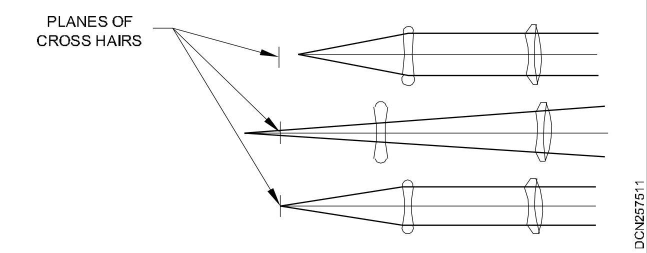
Focussing the objective : Object to be sighted is focused to bring the image in the plane of the cross hairs.

Move the eye up and down or sideways to check whether the cross hairs have any relative movement with respect to the object sighted.

Parallax is a condition that there exists relative movement between the cross hairs and the object sighted. This condition arises when the focusing lens is not in its proper position. Parallax can be eliminated by refocusing lens in proper position.

Fig 1 Parallax – Image not formed in the plane of cross hairs (a OR b). Refocus`sing brings the lens in proper position and parallax eliminated (c)

Fig 1



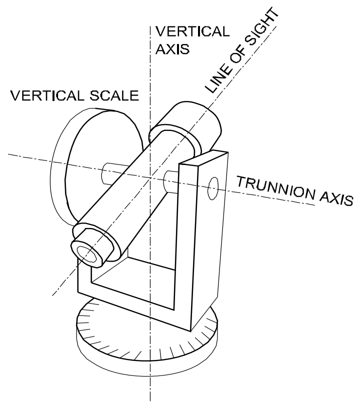
Permanent adjustments

Objectives: At the end of this lesson you shall be able to
- **list the permanent adjustments**
- **explain relationship satisfied by adjustments**
- **explain tests and adjustments.**

Permanent adjustments : The fundamental lines (see the terms) of theodolite have inter-relationships amongst each other. Manufactures of theodolite take care of this while manufacturing theodolite.

Axes of theodolite (Fig 1) : The relationships between fundamental lines are explained in the geometry of theodoite. However the prolonged use of theodolite and mishandling of instrument in field will make the fundamental lines relations altered, there by observations become erroneous.

Fig 1



So, the instrument has to be checked for these relations and if found erroneous the instrument should be correctly adjusted before using it for recording the observations. Such adjustments are called permanent adjustments.

The tests and permanent adjustments are done in the following order.

1 **Plate level Test** – to make the plate bubbles central to their run when the vertical axis of the theodolite is truly vertical.

2 **Cross – hair ring test** – to make the vertical and horizontal cross hairs lies in a plane perpendicular to the horizontal axis.

3 **Collimation test** – To make the line of sight perpendicular to the horizontal axis.

4 **Spire Test** – To make the horizontal axis perpendicular to the vertical axis.

5 **Bubble tube adjustment** – To make the telescope bubble central when theline of sight is horizontal.

6 **Vertical arc test** – to make the vertical circle indicate zero when the line of sight is perpendicular to the vertical axis.

Plate level test

Relation established : Axis of the plate level tube should be perpendicular to the vertical axis of the instrument.

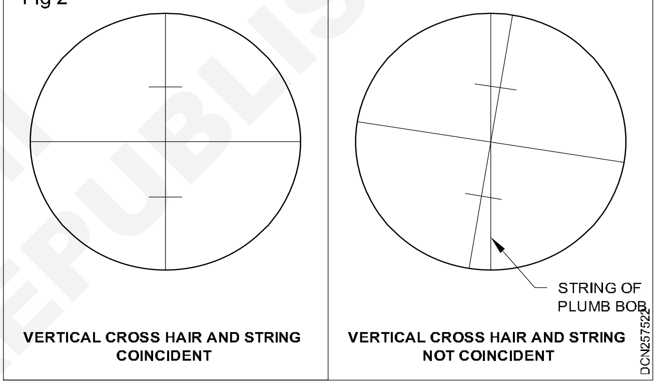
Bubble must remain at the centre of its run during complete revolution if the instrument is in perfect adjustment. This test is used to check whether the plate level axis is perpendicular to the vertical axis of the instrument.

Test : To test, the instrument is levelled and the telescope is rotated through 180º. If the bubble runs out of the centre, the adjustment is out of order. If the bubble is out of the centre, count the number of graduations on the bubble tube.

Adjustment : Correct the error by means of pair of leveling screws and the remaining correction is made by means of capstan headed screw provided at the end of the level tube.

Cross-hair ring test (Fig 2)

Fig 2



Relation established : The vertical cross-hair should lie in a plane perpendicular to the horizontal axis.

Test : Instrument is levelled. The telescope is directed towards a plumb bob string at rest. The string is bisected and telescope is rotated slightly in a vertical plane. If the relation is in perfect condition, the image moves off the cross hair it means the relation is not in adjustment.

Adjustment : To adjust the vertical cross hair, loosen all four capstan screws on the cross-hair ring. Rotate the ring carefully so that the image of the string and the vertical cross hair coincide. The screws are then tightened.

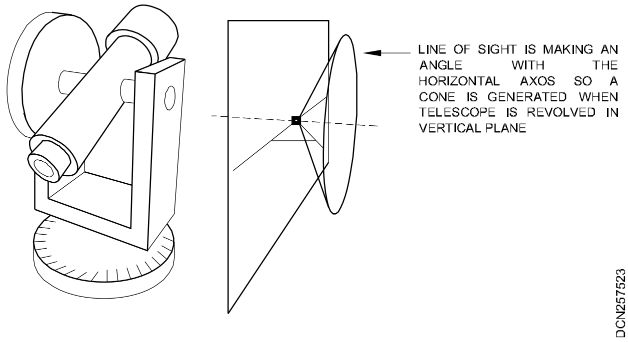
Note: If the vertical cross hair is set perpendicular to the horizontal axis, the horizontal axis is automatically made horizontal.

Collimation in azimuth test (Fig 3)

Relation Established : The line of sight should be perpendicular to the horizontal axis.

If the relation is in adjustment, the line of collimation will generate a plane when the telescope is revolved in vertical plane. If this relation is not in adjustment, the line of collimation will generate a cone with the horizontal axis.

Fig 3



Line of sight is making an angle with the horizontal axis so a cone is generated when telescope is revolved in vertical Plane.

Exaggerated figure showing line of sight not being perpendicular to the horizontal axis.

Test : The instrument is set up and levelled at a point in an open field so as to have an unobstructed view of 100m on either side of the instrument. Set up the instrument at midway, telescope in normal condition. Sight a point transit the telescope and fix another point on the same line.

Change face of the instrument and bisect the first point. Transit the telescope.

If the line of sight does not passes through the already fixed point then the line of sight is perpendicular to the horizontal axis.

If the line of sight pass through the point, the adjustment is done as follows.

Adjustment : Fix the new point. Measure the distance between points, Measure a quarter of the distance from the last point. Adjust the vertical hair by means of two opposite capstan headed screws so that the line of sight passes through the quarter distance. Repeat the test till line of sight passes through the same point in both face observations.

The instrument is at point I, the back sight is point A, and point F1 is set at the foresight. Line n is perpendicular to the trunnion axis, as the line of sight should be. The line of sight is deflected from line n by an angle. The error in the back sight reverses direction in the foresight. The foresight direction is in error by two times the deflection error (2)

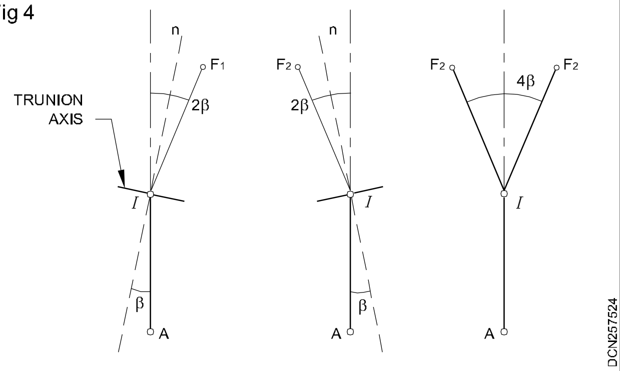
Turn to the same back sight in inverted position. Plunge the scope again, and in direct position, set another mark at the foresight, F2 as shown in the centre of the picture. The angle between the two foresight marks is four times the deflection error. It is corrected by moving the crosshair horizontally.

Foresight error is four times the deflection error (Fig 4)

Spire Test

Relation Established : The horizontal axis should be perpendicular to the vertical axis.

Fig 4



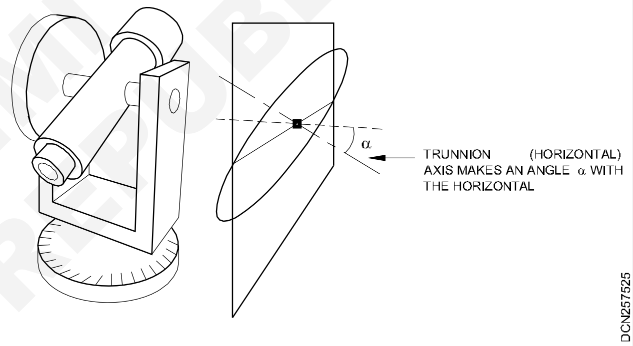
This adjustment ensures that the line of sight revolves in a vertical plane perpendicular to the horizontal axis when the instrument is levelled.

Trunnion (Horizontal) axis makes an angle with the horizontal.

Exaggerated figure showing horizontal axis not being perpendicular to the vertical axis.

Horizontal axis makes an angle α with the horizontal. (Fig 5)

Fig 5



Test : Set up the instrument near any tall object which has a well defined point available at 60º to 70º vertical angle.

With face left, sight the well defined point. Lower the telescope after arresting the horizontal movement of telescope and find foot of the point of the ground. Change face of the instrument and repeat above procedure. If foot of the point sighted is same in both face observations, then the horizontal axis is perpendicular to the vertical axis and if not the instrument needs adjustment.

Adjustment : Distance between foot distance is measured and mark half the midway between the distance. Centre point is bisected and raise the telescope to sight the point, but it in an error by a half the distance foot of the point.

One end of the horizontal axis is moved with the adjusting screw until the line of sight bisects the point. Repeat the test and check the adjustment.

Figure 6 showing well defined point ‘S’ is sighted and foot F_1 and F_2 established at ground.

Spire test (Fig 6)

The deflection error, refer the difference between the backsight and foresight directions. It is not a measure of the axis tilt. An angle of 2 will be subtended between the two foresights.

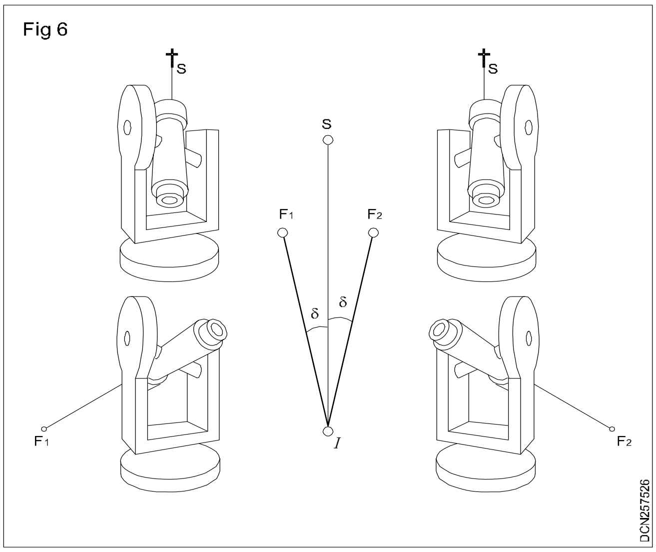


Fig 6

Fig 7 'S' is sighted

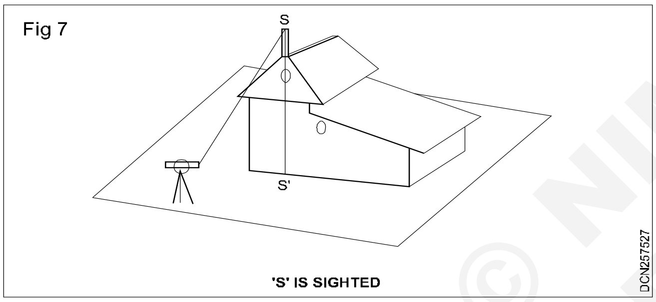


Fig 7

Find foot of S by face left observation (Fig 8)

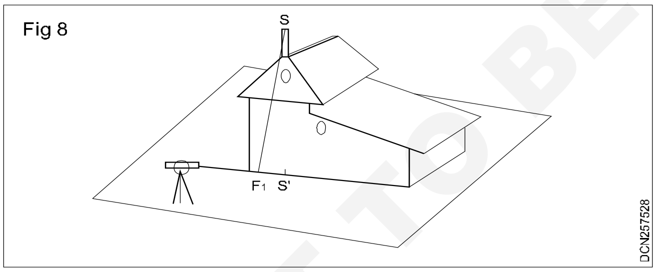


Fig 8

Find foot of S by face right observation (Fig 9)

Vertical Circle index test

Relation Established : The axis of the bubble tube attached to the telescope should be parallel to the line of sight. This is done so that the vertical circle reads zero when the telescope is horizontal.

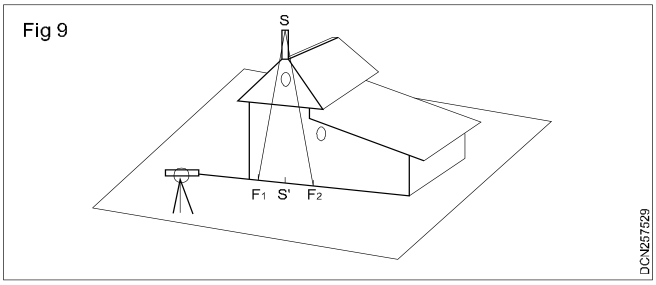


Fig 9

Test : Set the vertical vernier to zero. A staff is held vertical at about 60m from the instrument and the reading is taken by face left observation. Then the face is changed and the staff is read again. If there is an error, the face reading will be different.

Vertical Circle Index Test (Fig 10)

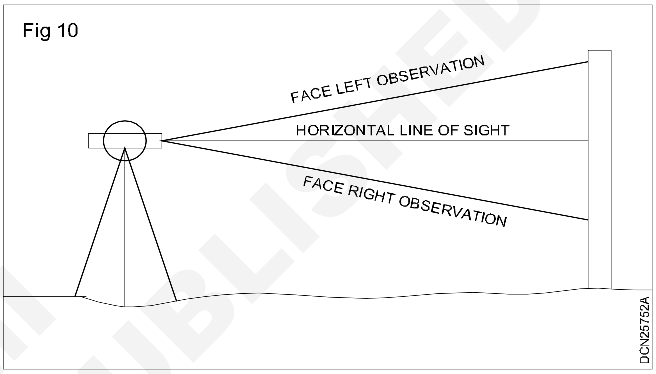


Fig 10

Adjustment : The telescope is set to read the mean of the two staff readings. Then the vertical circle should be brought back to read zero using the clip screws.

Vertical arc test

Desired relation : When the line of sight is perpendicular to the vertical axis the vertical circle should be zero.

Test : Centre the altitude bubble on the telescope. The zero of the vernier of the vertical circle should coincide with the zero on the main scale of the vertical circle. If it doesn't coincide, it needs adjustment.

Adjustment : The capstan head screws are loosened and the vernier is moved till the zero coincides with that of the main scale.

Instrumental errors

Objectives: At the end of this lesson you shall be able to
- **classify errors**
- **state instrumental errors**
- **state how to eliminate or minimize instrumental errors.**

Errors : The sources which cause error in the measurements are classified as:

1 Instrumental

2 Natural

3 Personal

Instrumental errors : Instrumental errors are caused due to fundamental axes going out of the adjustments.

Causes

1 Wear and tear of components due to prolonged use of the instrument.

2 Manufacturing defects.

Plate level axis not being perpendicular to vertical axis : If this fundamental relation is out of order, the actual measurements we are observing is in vertical plane instead of horizontal plane. It will affect seriously in vertical angle measurements and in calculation of elevation.

Elimination : Correcting by permanent adjustments.

Trunnion axis not being perpendicular to vertical axis: The Horizontal angls and vertical angles will be erroneous if this relation is out of order.

Elimination : Taking the average of observations on face left and face right.

Line of collimation not being perpendicular to trunnion axis : Line of collimation not revolve in a vertical plane when the telescope is raised or lowered if line of collimation is not being perpendicular to the trunnion axis.

Elimination: Taking the average of observations on face left and face right.

Eccentricity of liner and outer plate axes : Vertical axes of the inner spindle (carries vernier) and outer spindle (carries horizontal circle) should coincide otherwise error will occur.

Elimination: Reading both verniers are taking mean of both the vernier readings.

Eccentricity of Verniers : If verniers are not exactly diametrically opposite, ie.,180º to each other the two vernier readings will not differ by 180º. However, since the difference is constant, both the vernier readings will give same angle. Hence, this manufacturing defect has no effect on the observations.

Imperfect Vertical Circle Vernier : When the line of sight is not horizontal, vertical circle vernier will not show zero reading and will make the vertical angle error.

Elimination : Reading are taken on both faces.

Imperfect Graduations : If graduation on the horizontal circle are not uniformly spaced or if the scale is not properly centred, the horizontal angle readings will not be correct. Error is greatest when observations are taken on different vertical angles and different lengths.

Minimizing error: Taking observations at different portions of the horizontal scale and taking mean of the observations and measuring angles by repetition method.

Traverse survey (Closed and open)

Objectives: At the end of this lesson you shall be able to
- **state uses of traverse surveying**
- **state types of traverse**
- **differentiate open and closed traverse.**

Traverse : Thorough knowledge of traverse surveying is required for surveying using theodolite. In subsequent lessons, traverse and theodolite traverse will be explained.

A traverse is a series of connected lines whose lengths and directions are known.

The lengths of the lines are determined either

- by direct measurement, or
- by EDM equipment, or
- by indirect measurement (tacheometry).

The angles are measured with

- Theodolite, or
- Magnetic compass

When the extent of survey is not large and desired accuracy is not high, angles are not measured but directions of lines are fixed by chain angles.

Use of traverse surveying

- To establish the positions of boundary lines.
- To determine the positions of existing boundary lines.
- To calculate area within a boundary.
- To establish ground controls for photogrammetric work.
- To establish ground controls for calculating earth work quantities.
- To establish control for locating highways, railways and other construction works.
- To establish control for mapping.

Types of traverse : Two general classes of traverse are

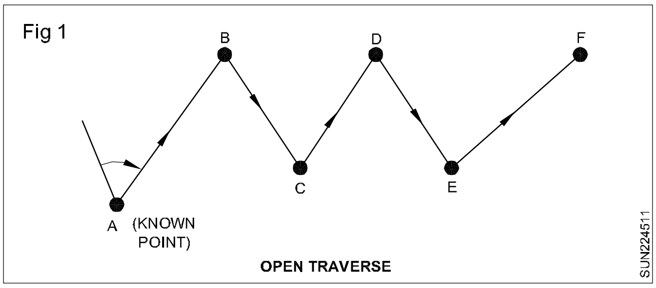
- Open traverse.
- Closed traverse

Open traverse : Open traverse (Fig 1) is that type of traverse in which origin point starts at known location and terminate point ends at unknown location.

There is no opportunity for checking the accuracy of the ongoing work in open traverse. So all survey measurements are carefully repeated at the time of the work. The major disadvantages of open traverse are,

1 There is no check on summation of angles.

Fig 1



2 There is no check on positions of intermediate points.

Steps to minimize errors in open traverse are,

1 Each distance should be measured twice in both directions and also should be roughly checked by tacheometry method.

2 Angles should be measured by method of repetition and also should be checked by magnetic bearings.

An open traverse is usually run for establishing control in preliminary surveys and construction surveys such as roads, pipelines, etc., because the results are always open to doubt.

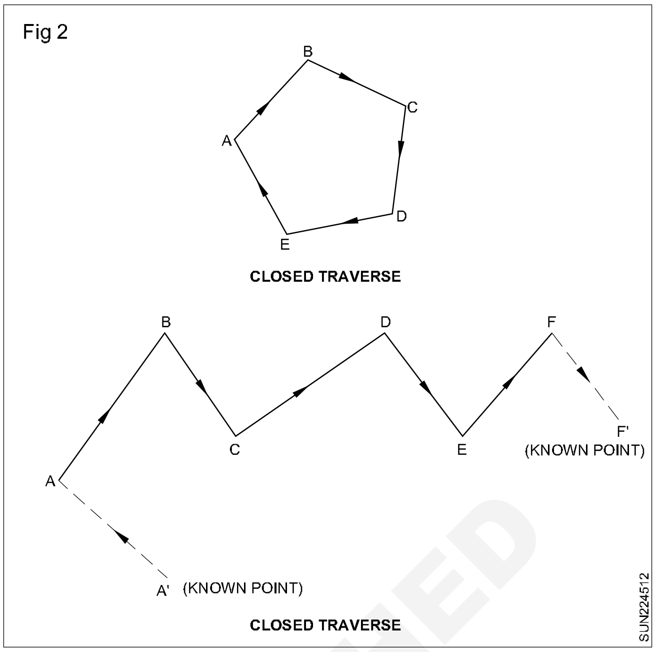
Distances are measured usually by tape or EDM equipment and usually deflection angles are measured at the traverse stations.

Closed traverse

Closed traverse (Figure 2 (a) and (b)) is that type of traverse in which origin point and terminate point are known locations. In such traverse, sum of all internal angles should be equal to (2n-4) times right angles, where n is the number of sides.

This mathematical condition provides computational checks which gives indication of the accuracy of measurements,

Fig 2



Closed traverse provides check for both linear and angular measurements and therefore preferred to all other types of traverse.

Figure 2 (a) shows a closed traverse ABCDEA. The traverse originates and terminates at the same point. From the figure it is clear that this traverse is mathematically and geometrically closed. It is called closed-loop traverse.

Figure 2 (b) shows a closed traverse ABCDEF. The traverse originates and terminates at different points. From the figure it is clear that this traverse is mathematically closed and geometrically open.

Reading a theodolite

Objectives: At the end of this lesson you shall be able to
- **find least count of the main scales**
- **find least count of the instrument**
- **read a thodolite.**

Reading a thodolite : Mainly two verniers are provided in a theodolite for measuring horizontal and vertical angles. For horizontal angles, readings on the main scale (lower plate) and verniers (upper plate) are observed. For vertical angles, the main scale on the vertical circle and the verniers on the T frame are observed.

Two verniers A and B are provided on the horizontal circle and C and D are provided on the vertical circle. The main scale for horizontal circle is graduated from 0º to 360º. Generally each degree on the main scale is divided into three parts, hence the least count or the smallest division of the main scale is,

L.C = (1/n) x smallest division of the main scale, n is the number of dvisions = (1/3)x 60' =20'20 is the L.C of the main scale.

For finding L.C of the instrument above formula is used. Smallest division of the main scale is 20' and n is 60 divisions. Sixtieth division of the vernier coincides with the fifty ninth division of the main scale, hence 60 divisions.

L.C = (1/n) x smallest division of the scale, n is the number of divisions = (1/60) x 20' = 20" 20" is the least count.

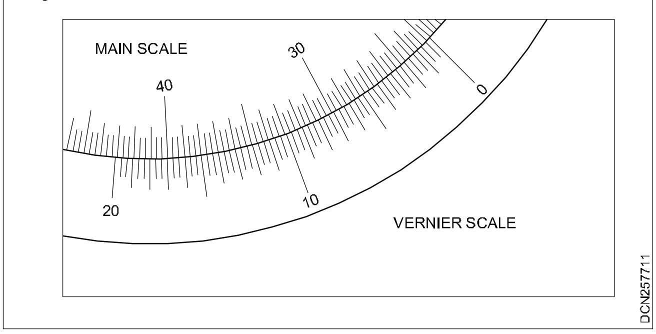
Least count of the instrument is 20"

For minimizing error observation due to instrumental error, reading in both the verniers A and B are taken and the mean of the two readings is used.

Vernier (Fig 1)

Graduations are marked in clockwise direction and figures are engravedat 10^0 interval.

Fig 1



One division on main scale is 20’

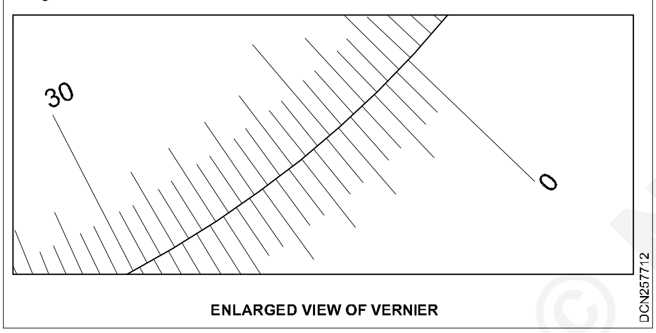
One division on vernier scale is 20”

Reading = M.S.D + (V.S.D x L..C)

From the following enlarged view of figure 1 it is understood that zero of vernier scale is in between 22° 40’00” and 23° 00 00”.

Enlarged view of vernier (Fig 2)

Fig 2



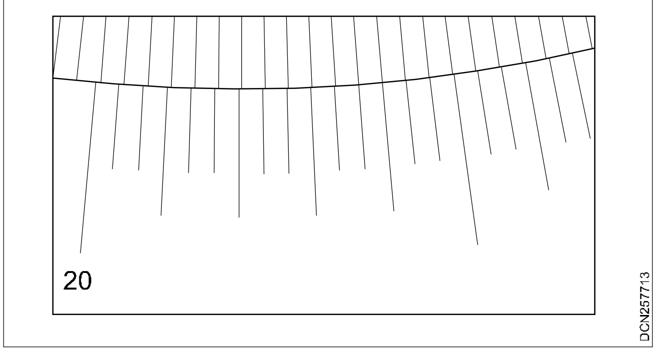
ENLARGED VIEW OF VERNIER

From the following enlarged view of figure 1 it is understood that forty fifth vernier division exactly coincides with a man scale division.

So reading = 22 °40’ 00” + (45 x 20”) = 22°55’00”

Enlarged view of vernier (Fig 3)

Fig 3



Note

1 Read vernier eliminating parallax.

2 No need to count vernier division. Read the vernier division directly and add this to M.S.D

In the above example it is 15’00” (45 x 20” = 900”). Add this value to the M.S.D. = 22°40’00” + 15’ 00” = 22° 55’ 00”

While observing an angle it is noted that zero of vernierr lies between 78° 00’ 00” and 78°20’ 00” and 13th vernier division coincides with the main scale. L. C of instrument is 20”. what is the angular value?

Solution

Angular value	=	78°20’00” + (20” x 13)
	=	78° 00’ 00” + 260”
	=	78° 00’00” + 4’20”
	=	78°04’ 200”

Theodolite - measuring horizontal angle - ordinary method

Objectives: At the end of this lesson you shall be able to
- **explain ordinary method**
- **state advantages of ordinary method**
- **point out things to remember while working.**

Ordinary Method : A single set of observations are made for measuring a horizontal angle between any two points at a station in this method (Fig 1)

Fix two station, P and Q on the ground and set up the instrument at the point “O’. Perform all temporary adjustments. Set vernier A 00º00’00". Sight the left hand station. Loosen the upper clamp, sight the right hand station and observe reading. Change face of the instrument and take another set of readings. The mean of the face left and face right observations is the final required angle. Procedure explained in the given figure and a table is also given to show how to tabulate.

Advantages of ordinary method

1 Errors due to eccentricity of the spindles are eliminated by reading both the verniers.

2 Errors due to eccentricity of the verniers are eliminated by reading both the verniers.

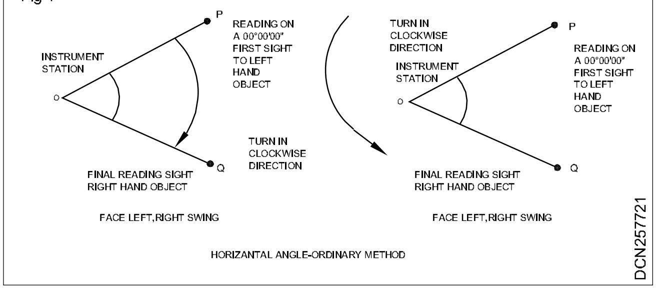
Point to remember

1 Carefully clamp and unclamp screws and tangents.

2 Utmost care should be taken to avoid errors and mistakes while operating theodolite.

3 Usually degree, minutes and seconds are measured at vernier A and Minutes and seconds in Vernier B.

Fig 1



4. Theodolite should swing in clockwise direction (Right swing) for face lit observation and swing in anticlockwise direction (Lect swing) for face right observation.

5. Telescopes cannot move relative to graduated circle when upper screw is clamped and lower screw is unclamped but can rotate in horizontal plane.

6. Telescope moves relative to graduated circle and can rotate in horizontal plane also when upper screw is unclamped and lower screw is clamped.

Theodolite - measuring horizontal angle - repetition method

Objectives: At the end of this lesson you shall be able to
- **explain repetition method**
- **state advantages of repetition method**
- **state errors which are not eliminated.**

Repetition Method : This method is used to measure a horizontal angle accurately. In this method same angle is measured repeatedly in both face observations instead of single observations. Mean of the face left and face right readings after dividing by the number of repetitions, is the final measured value of the angle.

Fix two staions, P and Q on the ground and set up the instrument (Fig) at the point, ‘O’. Perform all temporary adjustments. Set vernier A 00º00’00". Sight the left hand station (Fig 1) chose the upper clamp, sight the right hand station and observer reading. Without changing the reading observed, turn the telescope and sight ‘P’ Measure the angle again, which will read twice the first angle. Repeat the process for required number of repetitions.

Change face of the instrument and repeat above steps (Fig 2). The mean of the face left and face right observations is the final required angle.

Suppose that, for measuring a horizontal angle θ, ‘n’ times repetitions are done. Then angle θ = (n x θ) ÷ n.

Fig 2

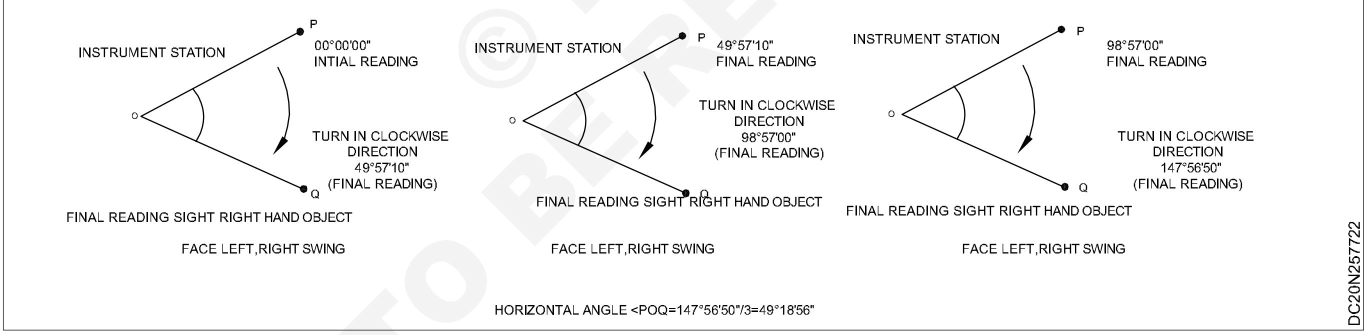
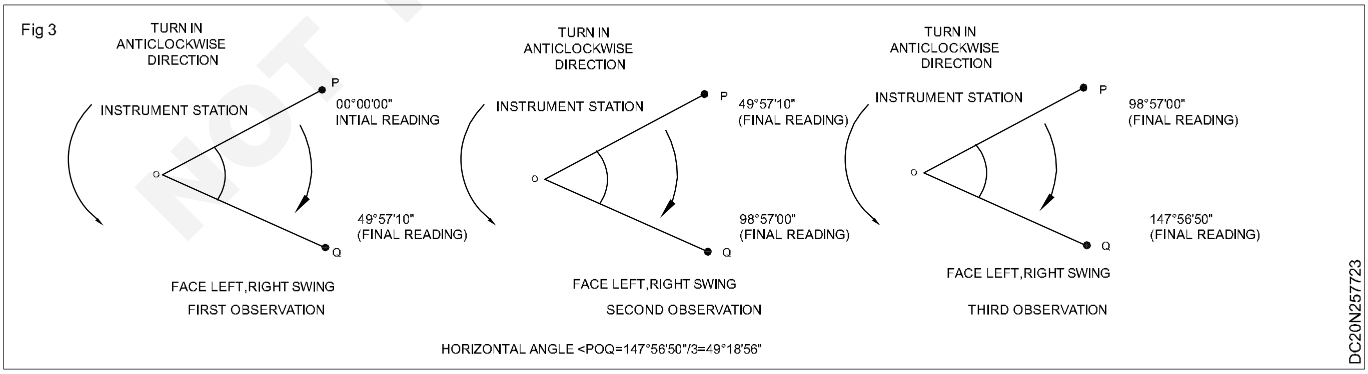


Fig 3



Advantages of repetition Method

1 Error due to imperfect graduations are minimized by reading on different parts of the graduated circle.

2 Errors, due to eccentricity of the spindles are eliminated by reading both the verniers.

3 Errors due to eccentricity of the verniers are eliminated by reading both the verniers.

4 Error due to line of collimation not being perpendicular to the horizontal axis is eliminated by taking both the face left and face right observations.

5 Error due to inaccurate bisection is compensated because many observations are taken.

6 Possible to obtain values lesser than least count of the instrument.

Errors which are not eliminated by this method

1 Slip

2 Displacement of signal

3 Vertically of vertical axis

Points to remember

1 For ordinary works, 3 repetitions are sufficient.

2 For precise work, 5 & 6 repetitions are done.

3 Care should be taken if reading exceeds 360º

4 Carefully clamp and unclamp screws and tangents.

5 Utmost care should be taken to avoid errors and mistakes while operating theodolite.

Face left, right swing observation

Example

Mean of two readings (Fig 2)

$$\angle POQ = \frac{147^\circ 56' 50''}{3} = \angle 49^\circ 18' 56''$$

No. of repetitions = 3

∠147º 56'50" is the angle after 3 repetitions.

Face right, left swing observation

Mean of two readings

$$\angle POQ = \frac{147^\circ 56' 50''}{3} = \angle 49^\circ 18' 56''$$

No. of repetitions = 3

= ∠147º 56'50" is the angle after 3 repetitions.

Means of two observations is the final angle =

$$\frac{\angle 49^\circ 18' 56'' + \angle 49^\circ 18' 56''}{2} = \angle 49^\circ 18' 56''$$

$$\angle POQ = \angle 49^\circ 18' 56''$$

Theodolite - measuring horizontal angle - reiteration method

Objectives: At the end of this lesson you shall be able to
- **explain reiteration method**
- **point out things to remember**
- **check and adjust closing the horizon error.**

Reiteration Method : This method is useful for measuring precisely a number of horizontal angles from a single station point. Suppose from a station 'O', angle' POQ, QOR, ROS and SOP are to be measured. After setting the vernier A, 00º00'00", sight the initial station P. Unlock the upper clamp and swing telescope clockwise (left swing) and successively bisect the stations Q,R, and S and measure angles accurately. Tabulate it correctly. Finally close the horizon by sighting initial station P. When closing horizon (the angle between the last station and first station), the final reading should be same as initial reading. If large discrepancy is found, the whole work should be repeated.

Change face of the instrument and swing telescope anticlockwise (right swing) and bisect the stations. Measures angles accurately and tabulate it.

Determine ∠QOR by deducting ∠POQ from ∠POR. Thus determine the remaining three angles separately for both face observations. Average of the two face observations is required angle. Sum of all the four angles to check whether the sum is 360º. If the error is small it is distributed equally among all the angles and the corrected angles are obtained.

More precision can be obtained by taking 'n' set of readings and averaging the observations.

Points to Remember

1 While bisecting stations after sighting initial station use only upper clamp screw and its tangent.

2 For face left observation, turn telescope clockwise and for face right observation, turn telescope anticlockwise.

3 Carefully tabulate face right observation because last station will bisect first.

4 Mean angles are checked for closing the horizon.

5 Angles are corrected angles after checking and adjusting for horizon closing (if found any discrepancy).

Measuring vertical angle

Objectives: At the end of this lesson you shall be able to
- **define vertical angle**
- **differentiate angle of elevation and angle of depression**
- **explain how to measure vertical angle.**

Measurement of Vertical Angle

A vertical angle is defined as the angle between the line of sight and a horizontal line, at a station in vertical plane.

If the angle measured is above the horizontal line, then it is called angle of elevation. Angle of elevation is a positive angle (+)

If the angle measured is below the horizontal line, then it is called angle depression. Angle of depression is a negative angle (-).

The method of measuring vertical angle varies according to the type of the instrument used. Engineer's transit measures vertical angle with respect to horizontal line. Electronic theodolites can measure vertical angle with respect to horizontal line or with respect to zenith.

Set up the instrument at the station. Perform all the temporary adjustments. The altitude bubble is set to its centre of run for all positions of telescope. To do this follow the given steps.

1 Turn the instrument so that the altitude bubble is parallel to the line joining any two foot screws.

2 Bring the bubble to its centre of its run by turning the levelling screws either inwards or both outwards.

3 Turn the telescope through 90º so that the altitude bubble 1st perpendicular to the line joining the above two levelling screws. Bubble table over the third foot screw.

4 Bring the bubble of the altitude level again to centre of its run by turning the IIIrd screws.

5 Turn back the telescope through 90º so that the altitude level is IInd to the 1st two screws.

6 Repeat above steps until the altitude bubble remains central in both the positions.

7 Bubble will remain central if the instrument is in permanent adjustments.

The object to which the vertical angle is required is bisected using the vertical clamping screw and its tangent screw. The reading on the vertical circle is now read. Change face of the instrument and take another reading. Mean of the readings is the vertical angle.

Point to remember

1 Carefully read Venier C and Vernier D (Fig 1)

2 Signs of angles should be noted down very carefully.

To eliminate or minimise errors due to in adjustments of the instrument, both face readings should be taken.

Angle of elevation, <POP' = + 09º57'10" (Fig 2)

Angle of depression, <POP' = - 09º57'10

Included vertical angle, <POP" = <POP' +<POP"= 19º54'20"

Fig 1

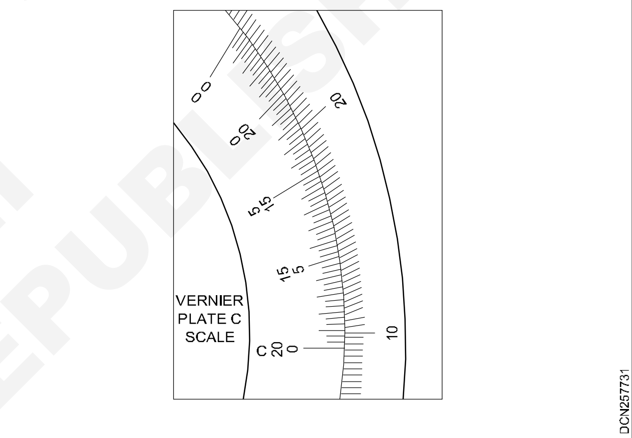


Fig 2

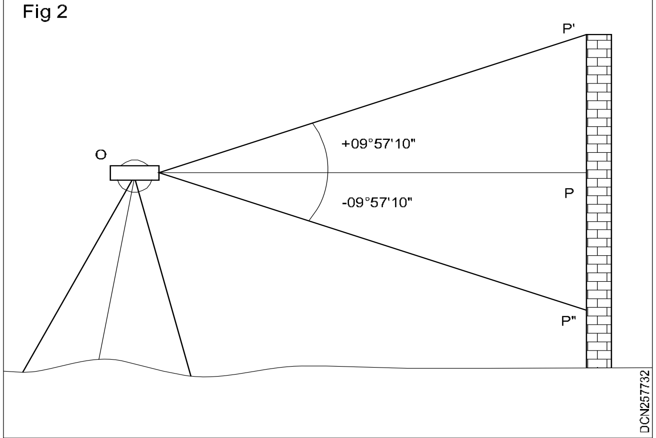


Table for entering readings to measure vertical angle

Instru-ment	Sight To	Face left								Right Swing	Face Right					Left Swing											Average Horizontal Angle			Rough Sketch
		A			B		Mean			No of Repetitions	Horizontal Angle			A			B		Mean			No of Repetitions	Horizontal Angle							
		0	'	"	'	"	0	'	"		0	'	"	0	'	"	'	"	0	'	"		0	'	"	0	'	"		

Measurement of vertical Angle

Instrument at	Sight to	Face Left												Face Right												Average Vertical Angle			Rough Sketch
		C			D		Mean			No. of Repetitions	Vertical Angle			C			D		Mean			No. of Repetitions	Vertical Angle						
		0	'	"	'	"	0	'	'																				
0	P	00	00	00	00	00	00	00	00		00	00	00	00	00	00	00	00	00	00	00		00	00	00	00	00	00	
0	P	+09	57	20	57	00	+09	57	10	1	+09	57	10	+09	57	00	56	40	+09	56	56	1	+09	56	50	+09	57	00	
0	P	-09	57	20	57	00	-09	57	10		-09	57	10	-09	57	00	56	40	-09	56	56		-09	56	50	-09	57	00	

Deflection angle & Direct angle

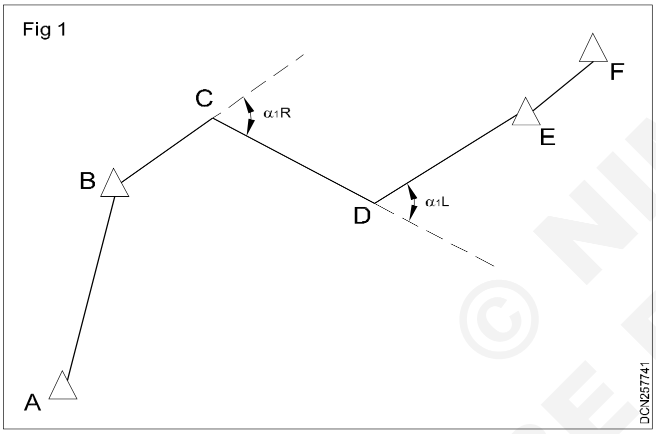
Objectives: At the end of this lesson you shall be able to
- **state deflection angle**
- **differentiate right deflection angle and left deflection angle**
- **state direct angle**
- **differentiate deflection angles and direct angles.**

Theodolite is used for various kind of operations in the field. Measuring deflection angle, direct angle, prolonging a line, running a straight line are some of them. Operations using theodolite is explained in the forthcoming lessons.

Horizontal angle can be measured by any of the 3 methods explained earlier, depending upon the conditions.

Deflection angle : Angle between the preceding line and the succeeding is called deflection angle. The deflection angle vary between 0^0 and 180^0. This type of angles is very useful in open traversing. Such a alignment of highways, railways, canals etc.

Right deflection and left deflection angle (Fig 1)



The angle measured in clockwise direction is called right deflection angle.

The angle measured in anticlockwise direction is called left deflection angle.

The measurement of deflection angles is done by taking a backsight on the previous station with zero reading on one of the verniers. Then the telescope is transited and turned clockwise or anticlockwise as the case may be.

Accuracy of the values can be improved by taking repeated readings. The angular closure is checked by calculating azimuths from known lines (AB and EF in the above figure)

Points to remember

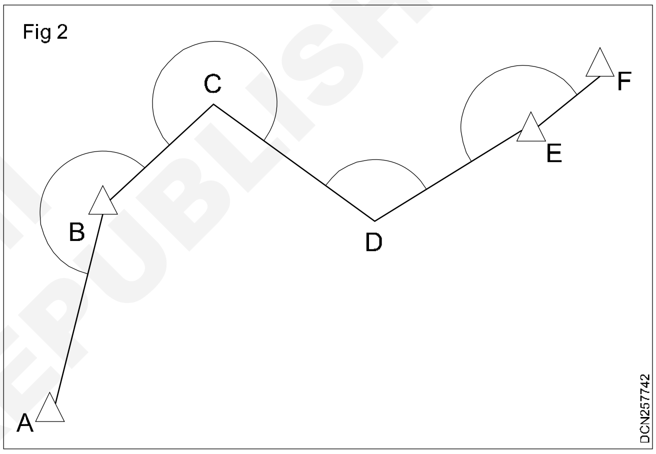
1 Right deflection angle itself is the value of the angle.

2 The angle observed on scale deducted from 360^0 is the value of the left deflection angle.

3 The numerical value of the deflection angle must always be followed by 'R' or 'L' .R is for right deflection angle and L is for left deflection angle.

4 Measure bearing of a traverse line, if there is no known coordinates for the traverse.

Direct Angles (Fig 2)



Angles measured clockwise from a backsight to the previous line are called angles to the right or direct angles. The direct angles vary between 0ˆ and 360ˆ. This type of angles are very useful both in open traverse and closed.

Accuracy of the values can be improved by taking repeated readings. The angular closure is checked by calculating azimuths from known lines (AB and EF in the following figure).

Points to remember

1 Rotation should always be clockwise from the backsight.

2 Measure bearing of a traverse, line, if there is no known coordinates for traverse.

Classification of traverse

Objectives: At the end of this lesson you shall be able to
- **classify traverse based on the instruments used**
- **explain method of traversing**
- **explain how to measure traverse length in theodolite traversing**
- **explain how to measure traverse angle in theodolite traversing.**

Classification of traverse based upon the instruments used : Classification of traverse based upon the instruments employed are:

- Chain traversing
- Compass traversing.

- Plane table traversing
- Theodolite traversing.

Methods of traversing : A traverse can be run by several methods depending upon the instrument. The classification of traverse based upon the instruments employed and the method of running the traverse and explained below.

Chain Traversing : In this method, the entire work is done with a chain or tape and no angle measuring instrument is employed. The directions of lines are fixed by linear measurements only. Directions of lines are fixed by taking chain angles.

Chain angles are generally liable to errors as the accuracy of measurement of the angles, is proportional to the accuracy achieved in measuring the tie distances.

Compass traversing : When a compass is used to fix directions, the traverse is called compass traversing. Method is already explained in compass surveying module.

Plane table traversing : Traversing using plane table is called plane table traversing. Method is already explained in plane table surveying module.

Theodolite Traversing : In the method of traverse, theodolite is commonly used for providing horizontal control systems.

Measurement of theodolite traverse lengths : Depending on accuracy required, the length can be measured by:

- Chaining.
- Taping.
- Tacheometry or,
- EDM equipment.

For greater accuracy, lengths are measured in both directions and average value is taken.

Calculation omitted measurements

Objectives: At the end of this lesson you shall be able to
- **describe omitted measurements**
- **list out and explain the classification of omitted measuremnts.**

In a closed traverse, lengths and bearings of all the traverse lines are measured. However, sometimes it may not be possible to take all the measurements due to obstacles or oversights. But such omitted measurements can be computed indirectly, provided number of unknown measurements is not more than two.

As we know, in a closed traverse, algebraic sum of departures and algebraic sum of latitudes are zero, ie. ΣL and ΣD are equal to zero. From this condition it has been derived that,

Length of a traverse line = $\sqrt{L^2 + D^2}$

Reduced bearing of a traverse line = $\tan^{-1}$ (D/L)

The omitted measurements may be classified in the following cases:

1. Length or bearing or both of a line omitted.
2. Length of a line and bearing of an adjacent line omitted.
3. Lengths of two adjacent lines omitted.
4. Bearings of two adjacent lines omitted.

Length or bearing or both of a line omitted : Let ABCDFA is the traverse planned, Due to a building, lengths and included angles at each station are observed. As we know latitudes and departures of all the sides of the traverse are balanced, provided it is a closed traverse. If not, the residual sum left is the latitude and departure of the closing error. Sum up latitudes and departures of all other sides leaving the side DE. Let it be $\Sigma L'$ and $\Sigma D'$.

Then length of DE = $\sqrt{\left(\Sigma L'^2 + \Sigma D'^2\right)}$

And direction of DE, tan = $\Sigma D'/\Sigma L'$

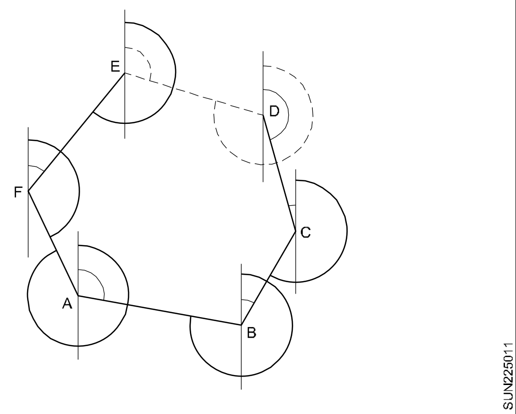
Exercise : Following data were obtained for a closed traverse ABCD which was run in anticlockwise direction.

Line	Length (m)	Bearing	Included Angle
AB	150	30°	<A=110°
BC	120		<B=63°
CD	250		<C=130°
DA	120		<D=53°

Determine the closing error.

Fig 1. Omitted measurements : Length or bearing or both of a line omitted.

Fig 1



Solution : The sum of the observed interior angles of the traverse is <A +<B+<C +<D = 110° +63°+130°+53° = 356°.

Theoretical sum = (2n-4) x 90°, n=4, so (2x4) x 90° = 360°.

Error is 356° -360° = 4°

Correction = $^{+}$4°

Applying the corrections equally to all the angles (4°/4) = $^{+}$1°.

<A = 110° +1°	=	111°
<B = 63° +1°	=	64°
<C =130° +1°	=	131°
<D = 53° +1°	=	54°
		360°

Bearing of AB is 30°

Back bearing of AB is 180°+30° = 210°

<B = 64°

Bearing of BC = 210° +64°= 274°

Back bearing of BC is 274° - 180° = 94°

<C = 131°

Bearing of CD = 94° + 131° = 225°

Back bearing of CD is 225° - 180° = 45°

<D = 54°

Bearing of DA is 45° + 54° = 99°

Line	Length (m)	Bearing	Included Angle	Corrected Angle	FB	RB	Latitude		Departure	
							N (+)	S (-)	E (+)	W (-)
AB	115	30°	<A=110°	<A=111°		30°	N 30°E	99.59		57.5
BC	50		<B=63°	<B=64°	274°	N 86°W	3.48			49.87
CD	150		<C=130°	<C=131°	225°	S 45°W	106.06			106.06
DA	100		<D=53°	<D=54°	99°	N 81°E	15.64		98.76	
							118.71	106.06	156.26	155.93
							$^{+}$12.65		$^{+}$0.33	

Therefore closing error = $\sqrt{(12.65)^2 + (0.33)^2} = 12.65$ m

Length of one line and bearing of an adjacent line omitted : In the traverse ABCDEF, the length of ED and bearing of FE are unknown.

If D and F are joined, we will get a closed traverse ABCDEF in which the length and bearing of DF, L_{df} can be computed using the formula

$$\sqrt{\left(\sum L'^2 + \sum D'^2\right)} \text{ and } \tan = \sum D' / \sum L'$$

From the bearing of DE and DF, compute the angle FDE. In the triangle FDF, L_{fe}, L_{df} and the angle D are known.

< f = 180° - (<d+<e)

$$\frac{EF}{\text{Sin FDE}} = \frac{DE}{\text{Sin DFE}} = \frac{DF}{\text{Sin FED}}$$

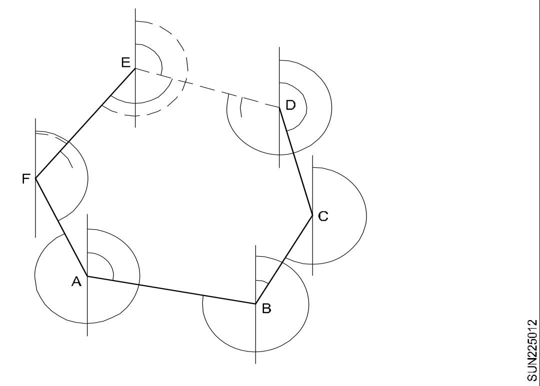
$$\frac{L_{ef}}{\text{Sin FDE}} = \frac{L_{de}}{\text{Sin DFE}} = \frac{L_{df}}{\text{Sin FED}}$$

Therefore < e = sin-1 [(L_{df} x (sin d /L_{ef})]

Lde = (L_{ef} / sin d) x sin f from the known values of included angles and bearings, unknown bearings can be computed.

Length of one line and bearing of an adjacent line omitted. (Fig 2)

Fig 2

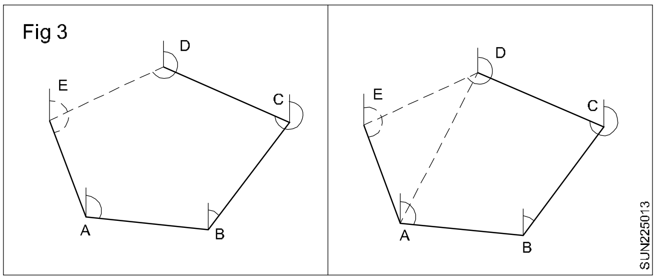


Exercise

Following data shows incomplete observations of a closed traverse ABCDEA. Determine the missing data.

Line	Length(m)	Bearing
AB	400	100°00'00"
BC	600	30°00'00"
CD	580	30°00'00"
DE	-	245°00'00"
EA	592.07	-

Solution (Fig 3, 4)



Line	Length(m)	Bearing	RB
AB	400	100°00'00"	S80°00'00" E
BC	600	30°00'00"	N30°00'00" E
CD	580	30°00'00"	N60°00'00" W
DE	-	245°00'00"	S65°00'00" W
EA	592.07	-	-

Join the line DA and form a closed traverse ABCDA.

Consecutive coordinates of B.

Latitude = 400 x Cos 80°00’00” = +69.459 m

Departure = 400 x Sin 80°00’00” = +393.923 m

Consecutive coordinates of C

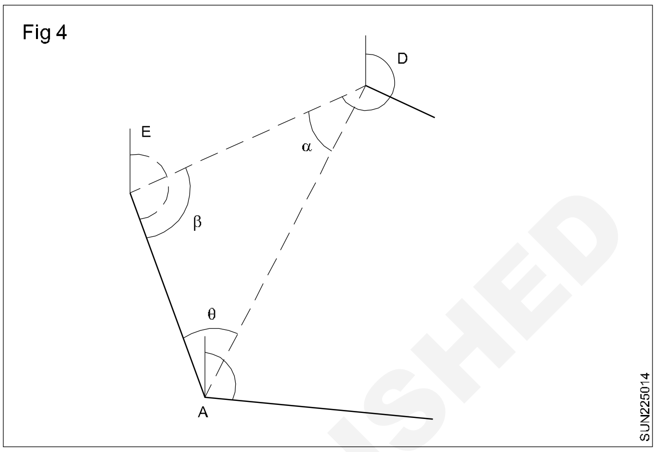
Latitude = 400 x Cos 30°00’00” = +290.615 m

Departure = 600 x Sin 30°00’00” = +300.000 m

Consecutive coordinates of D

Latitude = 580 x Cos 60°00’00” = +290.00 m

Departure = 580 x Sin 60°00’00” = -502.294 m



Line	Length (m)	RB	Latitude (m)		Departure (m)	
			N (+)	S (-)	E (+)	W (-) s
AB	400	S80°00'00"E		69.459	393.923	
BC	600	N30°00'00" E	519.615		300.000	
CD	580	N60°00'00" W	290.000		502.294	
Total			809.615	69.459	693.923	502.294
Σ			+740.156		+191.629	

$\Sigma L = L_{DA} + (+740.156) = 0$

Therefore L_{DA} = 740.156 m

$\Sigma D = D_{DA}$ (+191.629)m

Length of DA = $\sqrt{(+740.156^2 + 191.629^2)}$

= 764.56 m

Bearing of DA = $\tan^{-1}$ (191.629/740.156) = 14°30’55” (S-W quadrant) - Quadrant from the sign of L_{DA} and D_{DA} WCB of DA = 194°30’55’’. Therefore, Bearing of AD = 14°30’55”.

Now in triangle Δ ADE

α = Bearing of DE - Bearing of DA

245°00’00” - 194°30’55” = 50°29’05’’

From triangle Δ ADE, we have,

$\frac{DE}{\sin\theta} = \frac{AD}{\sin\beta} = \frac{AE}{\sin\alpha}$

β= $\sin^{-1}$ (AD/AE) x Sin α = (764.56/592.07) Sin 50°29’05” = 85°00’26”

θ =180°00’00” - (α+β) = 180°00’00” - (50°29’05” + 85°00’26”) = 44°30’29”

DE = AD (Sin θ/ Sinβ) = 764.56 x (Sin 44°30’29” / Sin 85°00’26”) = 538.00 m

Bearing of ED = Bearing of DE - 180°00’00” = 245°00’00” -180°00’00” = 65°00’00”

Bearing of ED = Bearing of ED + < β = 65°00’00” + 85°00’26” = 150°00’26”

Exercise

Following data were collected while running a closed traverse ABCD. Determine the missing data.

Solution (Fig 5,6,7)

Join AC

Line	Length (m)	WCB	RB
AD	40	50°	N50°E
DC	60	110°	S70°E

Fig 5

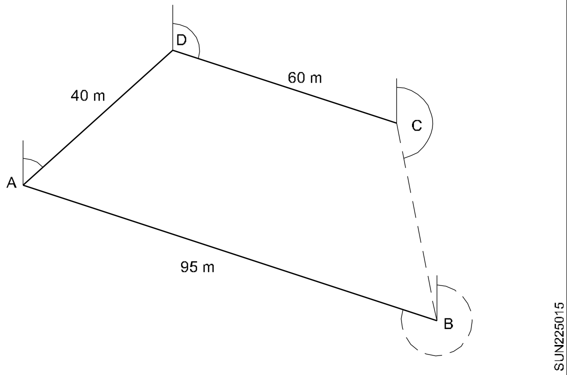


Fig 6

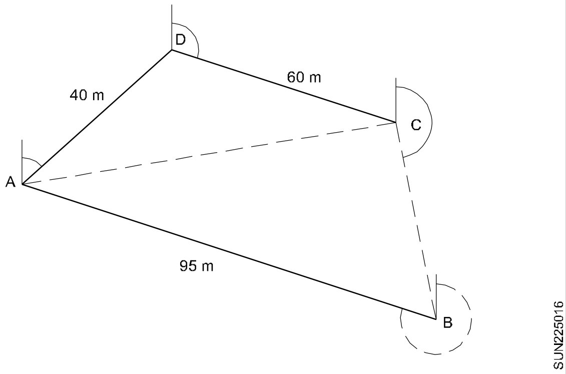
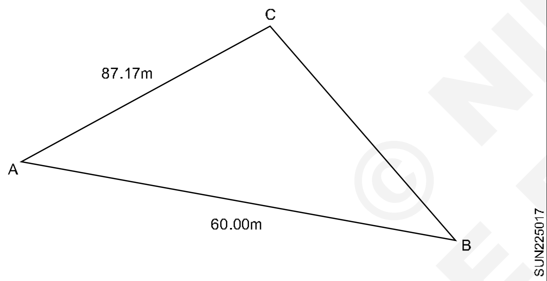


Fig 7



Line	Latitude		Departure	
	N (+)	S(-)	E (+)	W (-)
AD	25.7115	-	30.6417	-
DC	-	20.5212	56.3815	-
Total	25.711	20.5212	87.024	0.000
Σ	+5.1903		+87.024	

$\Sigma L = L_{CA} + (+5.190) = 0$

Therefore $L_{CA} = 5.190$ m

$\Sigma D = D_{CA} (+62.024) = 0$

Therefore $D_{CA} = 87.024$ m

Length of CA = $\sqrt{(-5.190^2 + \text{-}87.024^2)} = 87.17\,\text{m}$

Bearing of CA = tan -1 (87.024/5.190) = 86°35'13" (S-W quadrant) - Quadrant from the sign of LCA and DCA WCB of CA = 266°35'13". Therefore, Bearing of AC = 86°35'13"

$$\frac{AC}{\text{Sin ABC}} = \frac{BC}{\text{Sin CAB}} = \frac{AB}{\text{Sin ACB}}$$

(AC/Sin <B) = (BC/Sin<A) = (AB/Sin <C)

(AC/Sin <B) = (AB/Sin <C)

(87.17/Som<B) = (AB/Sin <C)

<A = Bearing of AB - Bearing of AC

= 108°47'00" - 86°35'13" = 22°11'47"

(87.17/Sin <B) = (60.00/Sin 116°35'13")

<B = Sin^{-1} (60.00/87.17) x Sin 115°13'00")

=38°30'53"

<C=180°00'00" - (22°11'47" + 38°30'53")

= 119°17'20"

Bearing of CB = Bearing of CA - <C = 266°35'13" - 119°17'20" = 147°17'53"

Bearing of BC = 147°17'53 + 180°00'00" = 327°17'53"

(BC/Sin <A) = (AB/Sn <C)

BC = AB (Sin <A/Sin <C)

= 60 x (Sin 22°11'47" /Sin 119°17'20")

=26.12 m

Exercise

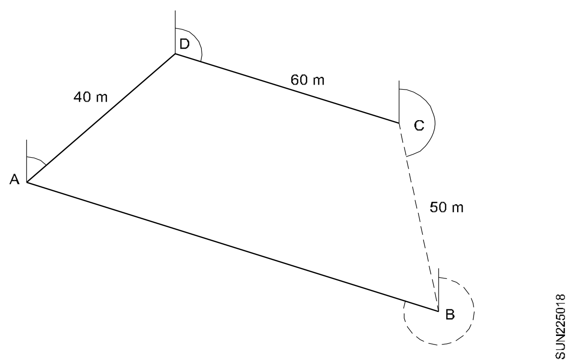
A traverse ABCD was to be run but due to an obstruction between the stations A and B, it was not possible to measure the length and direction of the line aB. Following is the observations made.

Line	Length (m)	WCB
AD	40	50°
DC	60	110°
CB	50	150°

Determine the length of directions of the omitted side.

Solution (Fig 8)

Fig 8



Line	Length (m)	WCB	RB
AD	40	50°	N50°E
DC	60	110°	S70°E
CB	50	150°	S30°E

Consecutive coordinates of D

Latitude of D = 40 x Cos 50° = +25.7115

Departure of D = 40 x Sin 50° = + 30.6417

Consecutive coordinates of C

Latitude of C = 60 x Cos 70° = -20.5212

Departure of C = 60 x Sin 70° = +56.3815

Consecutive coordinates of B

Latitude of B = 50 x Cos 30° = -43.3012

Departure of B = 50 x Sin 30° = +25.0000

Line	Latitude (m)		Departure (m)	
	N (+)	S (-)	E (+)	W (-)
AD	25.7115	-	30.6417	-
DC	-	20.5212	56.3815	-
CB	-	43.3012	25.0000	-
BA	-	-	-	-
Total	25.711	63.822	112.0232	0.000
Σ	-38.111		+112.023	

$\Sigma L = L_{BA} + (-38.111) = 0$

Therefore $L_{BA} = +38.111$ m,or $l_{BA} \times \cos\theta = +38.111$ m

$\Sigma D = D_{BA}\ (+112.023) = 0$

Therefore $D_{BA} = 87.024$ m, or $l_{BA} \times \sin\theta = -87.024$ m

Length of BA = $\sqrt{(-38.111^2 + 112.023^2)} = 118.33$ m

Bearing of BA = tan -1 (112.023/38.111) = 71°12'40" (N-W quadrant) - Quadrant from the sign of L_{BA} and D_{BA} WCB of BA = 288°47'20". Therefore, Bearing of AB = 108°47'20"

Lengths of two adjacent lines omitted

Let us consider that the lengths DE and EF could not be measured.

If D and F are joined, we will get a closed traverse ABCDF in which the length and bearing of DF, Ldf can be computed using the formula $\sqrt{(\Sigma L'^2 + \Sigma D'^2)}$ and $\tan\theta = \Sigma D'/\Sigma L'$.

Consider the triangle DEF, by sine rule

$$\frac{EF}{\text{Sin FDE}} = \frac{DE}{\text{Sin DFE}} = \frac{DF}{\text{Sin FED}}$$

$$\frac{L_{ef}}{\text{Sin FDE}} = \frac{L_{de}}{\text{Sin DFE}} = \frac{L_{df}}{\text{Sin FED}}$$

In the triangle DEF the bearing of all three sides and length of DF are known. From known bearings of sides of the triangle we can compute the included angles of the triangle.

Therefore

$L_{de} = (L_{df}/\text{Sin e}) \times \sin f$

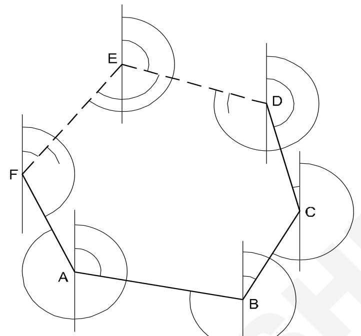
$L_{ef} = (L_{df}/\sin e) \times \sin d$

Lengths of two adjacent lines omitted.

Exercise (Fig 9)

Following data shows incomplete observations of a closed traverse ABCDEA. Determine the missing data.

Fig 9



Line	Length (m)	Bearing
AB	400	100°00'00"
BC	600	30°00'00"
CD	580	30°00'00"
DE	-	245°00'00"
EA	-	150°00'00"

Solution (Fig 10,11,12)

Fig 10

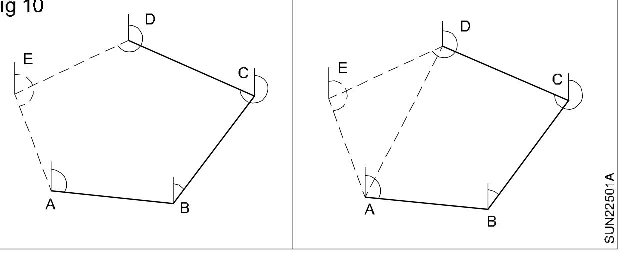
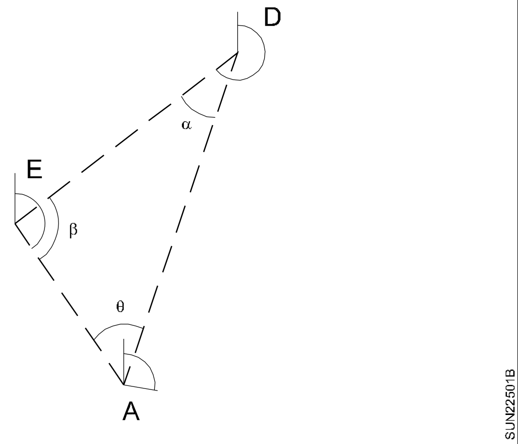


Fig 11



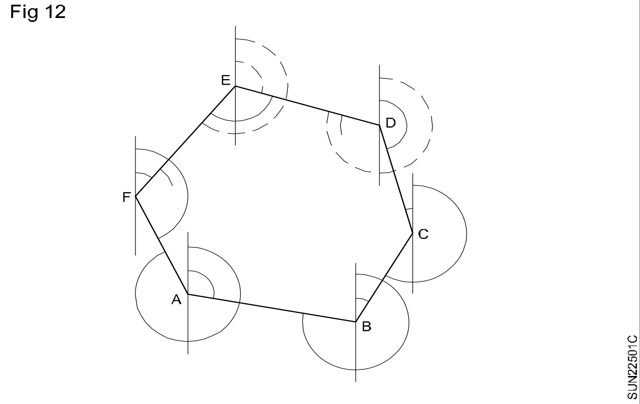


Fig 12

Line	Length (m)	Bearing	RB
AB	400	100°00'00"	S80°00'00" E
BC	600	30°00'00"	N30°00'00"E
CD	580	30°00'00"	N60°00'00" W
DE	-	245°00'00"	S65°00'00" W
EA	-	150°00'00"	S30°00'00" E

Join the line DA and form a closed traverse ABCDA.

Consecutive coordinates of B

Latitude = 400 x Cos 80°00’00” = + 69.459 m

Departure = 400 x Sin 80°00’00” = + 393.923 m

Consecutive coordinates of C

Latitude = 600 x Cos 30°00’00” = +519.615m

Departure = 600 x Sin 30°00’00” = +300.000m

Consecutive coordinates of D

Latitude = 580 x Cos 60°00’00” = +290.00 m

Departure = 580 x Sin 60°00’00” = -502.294 m

$\Sigma L = L_{DA}$ + (+740.156) = 0

Therefore L_{DA} = 740.156 m

$\Sigma D = D_{DA}$ (+191.629)m

Therefore D_{DA} = 191.629 m

Length of DA = $\sqrt{(+740.156^2 + 191.629^2)}$

= 764.56 m

Line	Length (m)	RB	Latitude (m)		Departure (m)	
			N (+)	S (-)	E (+)	W (-) s
AB	400	S80°00'00"E		69.459	393.923	
BC	600	N30°00'00" E	519.615		300.000	
CD	580	N60°00'00" W	290.000			502.294
DE	-	N65°00'00" W		-		-
EA	-	N30°00'00" E		-	-	
Total		809.615	69.459	693.923	502.294	
Σ			+740.156		+191.629	

Bearing of DA = $\tan^{-1}$ (191.629/740.156) = 14°30’55” (S-W quadrant) - Quadrant from the sign of L_{DA} and D_{DA} WCB of DA = 194°30’55’’. Therefore, Bearing of AD = 14°30’55”.

Now in triangle Δ ADE

$\alpha =$ Bearing of DE - Bearing of DA

245°00’00” - 194°30’55” = 50°29’05’’

β= Bearing of EA - Bearing of DE

= 150°00’00” - (245°00’00” - 180°00’00”) = 85°00’00”

θ = Bearing of AD + 360°00’00” - (150°00’00” +180°00’00”) = 44°30’55”

Check, $\alpha + \beta$ + = 50°29’05” +85°00’00” + 44°30’55” = 180°00’00”

From triangle Δ ADE, we have,

$\frac{DE}{\sin\theta} = \frac{AD}{\sin\beta} = \frac{AE}{\sin\alpha} =$ ____

DE = AD (Sin θ/ Sinβ) = 764.56 x (Sin 44°30’55” / Sin 85°00’00”) = 538.08 m

AE = AD (Sin α/ Sinβ) = 764.56 x (Sin 50°29’05” / Sin 85°00’00”) = 592.07 m

Bearings of two adjacent lines omitted

Let the bearings of DE and EF could not measure. To find the bearings of these lines, D and F are joined, we will get a closed traverse ABCDF in which the length and bearing of DF, Ldf can be computed using the formula $\sqrt{(\sum L'^2 + \sum D'^2)}$ and tan $\theta = \Sigma D'/\Sigma L'$.

Now the triangle DEF, the length of all the sides and baring of DF is known. We can determine the area of the triangle DEF using the formula.

$\sqrt{[S(S - L_{ef})(S - L_{df})]}$

Area can also be determined using the formula

A = (1/2) x L_{df} x L_{ef} x Sin f

A = (1/2) x L_{de} x L_{ef} x Sin e

A = (1/2) x L_{df} x L_{de} x Sin d

Equating both equations for finding area, we get

f = $\sin^{-1}$ [(2A) x (L_{df} x L_{ef})] radians
e = $\sin^{-1}$ [(2A) x (L_{de} x L_{ef})] radians
d = Sin-1 [(2A) x (L_{df} x L_{de})] radians

Now, with these included angles and bearings of DE and EF can be computed.

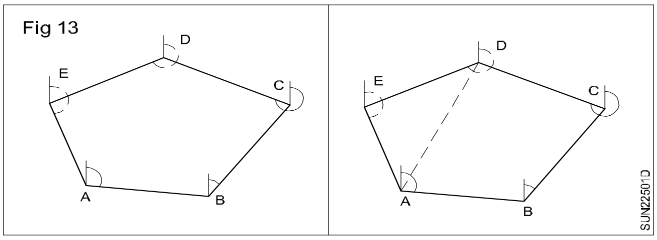
Exercise

Following data shows incomplete observations of a closed traverse ABCDEA, Determine the missing data.

Line	Length (m)	Bearing
AB	400	100°00'00"
BC	600	30°00'00"
CD	580	30°00'00"
DE	538.08	-
EA	592.07	-

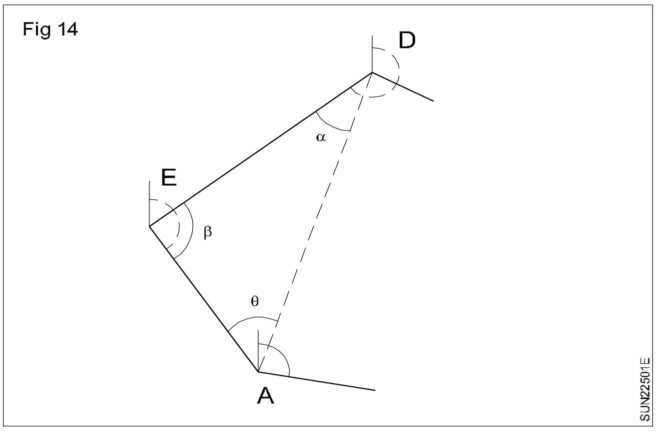
Solution (Fig 13,14)

Fig 13



Line	Length (m)	Bearing	RB
AB	400	100°00'00"	S80°00'00" E
BC	600	30°00'00"	N30°00'00"E
CD	580	30°00'00"	N60°00'00" W
DE	538.08	-	-
EA	592.07	-	-

Fig 14



Join the line DA and form a closed traverse ABCDA.

Consecutive coordinates of B

Latitude = 400 x Cos 80°00'00" = + 69.459 m

Departure = 400 x Sin 80°00'00" = + 393.923 m

Consecutive coordinates of C

Latitude = 600 x Cos 30°00'00" = +519.615m

Departure = 600 x Sin 30°00'00" = +300.000m

Consecutive coordinates of D

Latitude = 580 x Cos 60°00'00" = +290.00 m

Departure = 580 x Sin 60°00'00" = -502.294 m

$\Sigma L = L_{DA}$ + (+ 740.156) = 0

Therefore L_{DA} = -740.156 m

$\Sigma D = D_{DA}$ + (+ 191.629)

Therefore D_{DA} = -191.629 m

Length of DA = $\sqrt{(+740.156^2 + 191.629^2)}$

= 764.56 m

Bearing of DA = $\tan^{-1}$ (191.629/740.156) = 14°30′55″

Line	Length (m)	RB	Latitude (m)		Departure (m)	
			N (+)	S (-)	E (+)	W (-) s
AB	400	S80°00'00"E		69.459	393.923	
BC	600	N30°00'00" E	519.615		300.000	
CD	580	N60°00'00" W	290.000			502.294
Total			809.615	69.459	693.923	502.294
Σ			+740.156		+191.629	

(S - W quadrant) - Quadrant from the sign of L_{DA} and D_{DA} WCB of DA = 194°30′55″. Therefore, Bearing of AB = 14°30′55″

Area of the triangle, A = $\sqrt{S(S-AD)(S-DE)(S-EA)}$

$= \sqrt{947.355 \times 182.795 \times 409.275 \times 355.285}$

= 158684.52 m^2

$\beta = \sin^{-1}$ (2A / (DE x EA))

= $\sin^{-1}$ (2 x 158684.52 / (538.08 x 592.07))

= 85°00′02″

$\theta = \sin^{-1}$ (2A / (AD x EA))

= $\sin^{-1}$ (2 x 158684.52 / (764.56 x 592.07))

44°30′55″

$\alpha = \sin^{-1}$ (2A / (AD x ED))

= $\sin^{-1}$ (2 x 158684.52 / (764.56 x 538.08))

50°29′02″

Bearing of DE = Bearing of DA + <α = 194°30′55″ + 50°29′0.2″ = 244°59′57″

Bearing of ED = 244°59′57″ – 180°00′00″ = 64°59′57″

Bearing of EA = Bearing of ED + <β = 64°59′57″ +85°00′02″ = 149°59′59″

Bearing of AE = Bearing of EA + 180°00′00″ = 329°59′59″