

CIVIL ENGINEERING ASSISTANT

NSQF LEVEL - 4

1st Year

TRADE THEORY

SECTOR: CONSTRUCTION

(As per revised syllabus July 2022 - 1200Hrs)



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 Year

**Trade : Civil Engineering Assistant - 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, 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 Media Development Committee members of various stakeholders 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 **Civil Engineering Assistant - 1st Year - Trade Theory in Construction Sector** under **Yearly Pattern**. 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 Instructional Media Packages IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

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

Jai Hind

ATUL KUMAR TIWARI, I.A.S

Secretary

Ministry of Skill Development & Entrepreneurship,
Government of India.

April 2024

New Delhi - 110 001

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 under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVET/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 organizations to bring out this Instructional Material (**Trade Theory**) for the trade of **Civil Engineering Assistant - 1st Year NSQF Level - 4 (Revised 2022)** under **Construction** Sector for ITIs.

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NIMI records its appreciation of 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 staff who have contributed for the development of this Instructional Material.

NIMI is grateful to all others who have directly or indirectly helped in developing this IMP.

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 **Civil Engineering Assistant 1st Year NSQF Level - 4 (Revised 2022)** 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) syllabus are covered. This manual is divided into ten modules. The ten modules are given below.

Module 1	Safety
Module 2	Basic Engineering Drawing
Module 3	Building Materials - I
Module 4	AutoCAD
Module 5	Building Materials - II
Module 6	Building Construction
Module 7	Survey
Module 8	Carpentry
Module 9	Electrical Wiring
Module 10	Plumbing work

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 **Civil Engineering Assistant 1st Year**, NSQF Level - 4 (Revised 2022) in **Construction** Sector. 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 perceptual 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.

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LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

S.No	Learning Outcome	Ref. Ex.No.
1	Prepare free hand sketches of hand tools used in civil work with proper layout and folding of drawing sheets following safety precaution. (Mapped NOS: PCS/N9446)	1.1.01 - 1.2.13
2	Prepare Symbols, Lettering, Numbering, plane figure applying drawing instruments and practice dimensioning Technique as per BIS. (Mapped NOS: PCS/N9447)	1.2.14 - 1.2.16
3	Construct plain scale, comparative scale, diagonal scale and vernier scale (Mapped NOS: PCS/N9448)	1.2.17
4	Draw orthographic projections of different objects with proper lines and dimensioning. (Mapped NOS: PCS/N9449)	1.2.18 - 1.2.19
5	Draw Isometric, oblique and perspective views of different solid, hollow and cut sections with proper lines and dimensions as per standard conversion. (Mapped NOS: PCS/N9450)	1.2.20
6	Draw component parts of a single storied residential building with suitable symbols and scales. (Mapped NOS: PCS/N9451)	1.3.21
7	Create objects on CAD workspace using Toolbars, Commands, Menus, formatting layer and style. (Mapped NOS: PCS/N9452)	1.4.22 - 1.4.28
8	Identify different types of building materials i.e. Stones, Bricks, Lime, Pozzolanic, Cement, Sand, Clay Products, Mortar their characteristic, types, use & function. (Mapped NOS: PCS/N9453)	1.5.29 - 1.5.36
9	Mark different types of Foundation and Set out Foundation trenches. (Mapped NOS: PCS/N9454)	1.6.37 - 1.6.39
10	Demonstrate different types of brick masonry and Tools used in different bonds. Perform construction of wall - header bond, stretcher bond, English bond, Flemish bond. (Mapped NOS: PCS/N9455)	1.6.40 - 1.6.41
11	Perform different types of Plastering & Pointing, rendering & wall cladding. (Mapped NOS: PCS/N9456)	1.6.42 - 1.6.44
12	Identify different types of Protective materials i.e. Paint, Varnish and their application. (Mapped NOS: PCS/N9457)	1.6.45 - 1.6.48
13	Demonstrate Damp Proof Course in different position. (Mapped NOS: PCS/N9458)	1.6.49
14	Prepare different types of Flooring (Mapped NOS: PCS/N9459)	1.6.50 - 1.6.51
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18	Prepare topography map by contours with levelling instruments. (Mapped NOS: PCS/N9463)	1.7.66 - 1.7.81
19	Perform a site survey with Theodolite and prepare site plan. (Mapped NOS: PCS/N9464)	1.7.82 - 1.7.88
20	Perform a site survey with Total Station and prepare site plan. (Mapped NOS: PCS/N9465)	1.7.89 - 1.7.98

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

S.No	Learning Outcome	Ref. Ex.No.
21	Identify timber and perform sawing and planing using hand and power tools. (Mapped NOS: MIN/ N0454)	1.8.99 - 1.8.103
22	Demonstrate surface finish with exact sizing by planing operation. (Mapped NOS: MIN/ N0454)	1.8.104 - 1.8.108
23	Prepare different wooden Joints. (Range of skill - framing joint, Housing joints, broadening joints, Lengthening joints). (Mapped NOS: MIN/ N0454)	1.8.109 - 1.8.112
24	Make small wooden job as per drawing with schedule sizes of timber or alternatives of timber i.e. FRP, MDF, FOAM using various hardware. (Mapped NOS: PCS/N9466) ‘	1.8.113 - 1.8.115
25	Make different types of doors and windows with fixing of component. (Mapped NOS: PCS/N9467)	1.8.116 - 1.8.117
26	Demonstrate joining of electrical wire and carry out soldering, crimping observing related safety precautions. (Mapped NOS: MIN/N3102)	1.9.118 - 1.9.123
27	Demonstrate Electrical wiring with fixing of accessories conforming ISI rules (Range of skills -different types of Electrical wiring, joining of Fuses, fixing of MCB, connection of lamp with switch and different fitting, etc.). (Mapped NOS: MIN/N3102)	1.9.124 - 1.9.129
28	Demonstrate installation of electrical appliances, Earthing and estimate costing of wiring. (Mapped NOS: MIN/N3102, MIN/N3104, MIN/N3102)	1.9.130 - 1.9.132
29	Identify different type of transformers and test and use. (Mapped NOS: MIN/N3101, MIN/N3102, MIN/N3103)	1.9.133
30	Prepare a Simple pipe connection demonstrating cutting, joining of pipe with different method using different types of fittings. (Mapped NOS: MIN/ N3208)	1.10.134
31	Prepare layout of soil pipe and waste pipe with different types of sanitary fittings. (Mapped NOS: PCS/N9468)	1.10.135 - 1.10.141
32	Prepare a water supply system in residential buildings using different types of valves, fittings and appliances. (Mapped NOS: PCS/N9469)	1.10.142 - 1.10.146
33	Create objects on 3D Modelling concept in CAD (Mapped NOS: PCS/N9470)	1.10.147

SYLLABUS

1st Year

Duration: Two years

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
Professional Skill 18 Hrs; Professional Knowledge 04 Hrs	Prepare free hand sketches of hand tools used in civil work with proper layout and folding of drawing sheets following safety precaution. (Mapped NOS: PCS/ N9446)	1. Importance of trade training, demonstrate tools & equipments used in the trade. (1 hrs) 2. Importance of housekeeping & good shop floor practices. (1 hrs) 3. Occupational Safety & Health :Introduction to safety equipments and their uses. Introduction of first aid. Health, Safety and Environment guidelines, legislations & regulations as applicable. (2 hrs) 4. Disposal procedure of waste materials of the trade. (1 hrs) 5. Personal protective Equipments(PPE):-Basic injury prevention, Basic first aid. (1 hrs) 6. Hazard identification and avoidance, safety signs for Danger, Warning, caution & personal safety message. (1 hrs) 7. Preventive measures for electrical accidents&steps to be taken in such accidents. (2 hrs) 8. Use of Fire extinguishers. (1 hrs.) 9. Awareness about the job sheets made by the ex. trainees. (1 hrs) 10. Use of drawing instruments and equipment with care. (1 hrs) 11. Method of fixing of drawing sheet on the drawing board. (1 hrs) 12. Layout of different size of Drawing sheets and folding of sheets. (2 hrs) 13. Draw free hand sketch of hand tools used in civil work.(3 hrs) pneumatic cylinder.(4 hrs)	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. (02 hrs) • 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. (02 hrs)
Professional Skill 15 Hrs; Professional Knowledge 06 Hrs	Prepare Symbols, Lettering, Numbering, plane figure applying drawing instruments and practice dimensioning Technique as per BIS. (Mapped NOS: PCS/ N9447)	14. Symbols & conventional representation for materials in sections as per IS 962-1989, SP46:2003 for building drawings. (04 hrs) 15. Draw types of Lines, lettering and numbering as per IS 962- 1989, SP- 46:2003. (05 hrs) 16. Construction of plain geometrical figures. (06 hrs)	• 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. (06 hrs)

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
Professional Skill 20 Hrs; Professional Knowledge 04Hrs	Construct plain scale, comparative scale, diagonal scale and vernier scale (Mapped NOS: PCS/N9448)	17. Construction of scales – Plain, comparative, diagonal, vernier & scale of cords. (20 hrs)	Knowledge of different types of scale. Principle of R.F. (04 hrs)
Professional Skill 22 Hrs; Professional Knowledge 10Hrs	Draw orthographic projections of different objects with proper lines and dimensioning. (Mapped NOS: PCS/N9449)	Drawing of :- 18. Construction of solid geometrical figures. (10 hrs) 19. Three views in Orthographic Projection of Solid objects & section of solids. (12 hrs)	Different types of projection views: Orthographic, Isometric, Oblique and Perspective. (10 hrs)
Professional Skill 28 Hrs; Professional Knowledge 06 Hrs	Draw Isometric, oblique and perspective views of different solid, hollow and cut sections with proper lines and dimensions as per standard conversion. (Mapped NOS: PCS/N9450)	20. Isometric, oblique and perspective views of geometrical solids, hollow and cut sections. (28 hrs)	Theory of perspective view (06 hrs)
Professional Skill 28 Hrs; Professional Knowledge 04 Hrs	Draw component parts of a single storied residential building with suitable symbols and scales. (Mapped NOS: PCS/N9451)	Drawing of :- 21. Component parts of a single storied residential building. (in sectional details) Showing Foundation, Plinth, Doors, Windows, Brick work, Roof, Lintel and Chajjah, Arches, etc. (28 hrs)	Building materials:- - Timber:- Types, Structure, disease & defects, characteristic, seasoning, preservation and utility. - Alternative material to Timber - Plywood, Block board, Particle board, Fire proof reinforced plastic (FRP), Medium density fireboard (MDF) etc. - Tar, bitumen, asphalt: Properties, application and uses.(04 hrs)]
Professional Skill 114 Hrs; Professional Knowledge 04 Hrs	Create objects on CAD workspace using Toolbars, Commands, Menus, formatting layer and style. (Mapped NOS: PCS/N9452)	22. Function of keys and practice of basic commands. (20 hrs) 23. Use of elementary commands by CAD toolbar. (14 hrs) 24. Creation of objects in different layers on CAD workspace. (14 hrs) 25. Plotting of drawing from CAD. (14 hrs) 26. 2D drafting of flash door, panel door, window, hand railing, wash basin, sewerage pipe joints, etc. (20 hrs) 27. Preparing Library folder by creating blocks of the above items. (12 hrs) 28. Study and prepare bar bending schedule(20 hrs)	Computer aided drafting:- - Operating system, Hardware & software. - Introduction of CAD. - Its Graphical User Interface. - Method of Installation. - Basic commands of CAD. - Knowledge of Tool icons and set of Toolbars. Knowledge of shortcut keyboard commands. (04 hrs)

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
Professional Skill 28 Hrs; Professional Knowledge 04 Hrs	Identify different types of building materials i.e. Stones, Bricks, Lime, Pozzolan, Cement, Sand, Clay Products, Mortar their characteristic, types, use & function. (Mapped NOS: PCS/N9453)	29. Identify different types of bricks, uses and hollow bricks. Standard size of bricks available at local market. (04 hrs) 30. Identify different types of stones, types and uses. (04 hrs) 31. Identify different types of tiles, types and uses. (03 hrs) 32. Identify different types of cement, types and uses, field test of cement. Etc. (03 hrs) 33. Identify different types of sand and aggregates, types and uses. (03 hrs) 34. Identify different types of lime, types and uses. (03 hrs) 35. Identify different types of steel, types and uses. (04 hrs) 36. Identify different types of timber, earthen ware, types and uses. (04 hrs)	Materials:- - Stones :- characteristics, types & uses. - Bricks :- Manufacturing, characteristics of good bricks, types, uses and hollow bricks. - Lime :- characteristics, types, manufacturing & its uses. - Pozzolan :- characteristics, types & uses. Cement :- Manufacturing, characteristics, types, uses and test of good cement. Building materials:- - Sand:- characteristics, types & uses. - Clay Products :- types, earthenware, stoneware, porcelain, terracotta, glazing. Mortar & Concrete: Types, uses, preparation, proportion, admixtures and applications. (06 hrs)
Professional Skill 28 Hrs; Professional Knowledge 10 Hrs	Mark different types of Foundation and Set out Foundation trenches. (Mapped NOS: PCS/N9454)	37. Setting out a building: Obtaining first, second, third & fourth lines, marking diagonals, setting out cross walls & offsets. (13 hrs) 38. Marking excavation lines & fixing of plinth & floor levels. (05 hrs) 39. Set out foundation trench. (10 hrs)	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 – (Spread Footing, Grillage foundation, Pile foundation, Raft foundation, Well foundation, Special foundation) - Drawing of footing foundation setting out of building on ground excavation - Simple machine foundation. (10 hrs)
Professional Skill 12Hrs; Professional Knowledge 06 Hrs	Demonstrate different types of brick masonry and Tools used in different bonds. Perform construction of wall - header bond, stretcher bond, English bond, Flemish bond. (Mapped NOS: PCS/N9455)	40. Demonstrate the use of brick masonry tools. (02 hrs) 41. Perform construction of wall header bond, stretcher bond, English bond, Flemish bond (10hrs)	Building Construction:- - Sequence of construction of a building. - Name of different parts of building. - Brick masonry:- - Terms, use and classification.. - Strength of walls. - Strength of masonry. - principles of construction of bonds. Tools and equipments used.(06 hrs)

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
Professional Skill 24 Hrs; Professional Knowledge 06 Hrs	Perform different types of Plastering & Pointing, rendering & wall cladding. (Mapped NOS: PCS/N9456)	42. Make scaffolding and prepare surface for plastering. (04 hrs) 43. Perform plastering operation at different surface - Plaster in two coats -External finishes— sand finish, textured finish. (14 hrs) 44. Perform rendering & wall cladding. (06 hrs)	Plastering : Types, thickness in different position, materials, tools used, defects and remedies, surface preparation for rendering & wall cladding. Special materials used in plastering. Types of plaster finishes.(06 hrs)
Professional Skill 24 Hrs; Professional Knowledge 06 Hrs	Identify different types of Protective materials i.e. Paint, Varnish and their application. (Mapped NOS: PCS/N9457)	45. Perform application of cement paint on different surfaces (07hrs) 46. Perform application of plastic emulsion on different surfaces (06 hrs) 47. Perform application of enamel paint on different surfaces(05 hrs) 48. Perform application Process of varnishing on different surfaces (06 hrs)	Protective materials:- • Paints:- characteristic, types, uses. • Varnishes :- characteristics and uses.(06 hrs)
Professional Skill 20 Hrs; Professional Knowledge 06 Hrs	Demonstrate Damp Proof Course in different position. (Mapped NOS: PCS/N9458)	49. Perform Laying of D.P.C with proper methods and Materials. (20 hrs)	Treatments of building structures:- • DPC Sources and effects of dampness • Method of prevention of dampness in building • Damp proofing materials – properties, function and types. (06 hrs)
Professional Skill 28 Hrs; Professional Knowledge 06 Hrs	Prepare different types of Flooring (Mapped NOS: PCS/N9459)	Flooring practice: 50. Determination and Formation of slope/level, laying of Base Layers, laying of Topping,application of slurry for finishing, setting out of skirting, formation of spots for skirting. (18 hrs) 51. Use of screeds, formation of curve at the junction of skirting & floor. (10 hrs)	• Floors –Types of flooring. • Flooring- materials used types. prepare method of laying, grinding & polishing of floor and prepare a survey report on materials used in flooring, site visit to check the practical techniques of flooring.(06 hrs)
Professional Skill 38 Hrs; Professional Knowledge 06 Hrs	Perform site survey with Chain/Tape and prepare the site Plan. (Mapped NOS: PCS/N9460)	52. Practice of folding & unfolding of chain. (4 hrs) 53. Ranging (direct/ indirect) & distance measure with chain/ tape. (7 hrs) 54. Offset taking & entering field book. (4 hrs) 55. Chaining on sloping ground. (6 hrs) 56. Conduct a chain survey of a small area with all details and plotting the map. (9 hrs) 57. Calculating the area of site. (3 hrs) 58. Prepare a site plan by the help of chain / tape. (5 hrs)	linear & Angular measurement by instrument i.e. Chain, tape, compass etc. • Introduction, , types of surveying, use, application principal. • Main divisions (plane & geodetic). Uses of Chain/ tape, testing of a chain & correction. Ranging (direct & indirect), Principle of chain survey, application. Terms used in chain survey, types of offsets, limit of offset, field book, types of field book, entry of field book,

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
			method of chaining in slopping ground. Field procedure of chain survey errors in chain survey, plotting procedure. Calculation of area (regular & irregular figure) - Knowledge of site plan. - Knowledge of Mouza Map. (06 hrs)
Professional Skill 15 Hrs; Professional Knowledge 06 Hrs	Perform the site survey using Prismatic Compass. (Mapped NOS: PCS/N9461)	59. Temporary adjustment of prismatic compass. (03 hrs) 60. Measure fore & back bearing, R.B., W.C.B. of a line. (02hrs)] 61. Measure true bearing of a line. (02hrs) 62. Prepare a closed & open traverse using prismatic compass measure the bearings, entry into field book, calculation of correct bearing and adjust. (Local attraction), determine the closing error and adjust. Plotting the same. (08 hrs)	Surveying:- Compass survey:- - Basic terms used in compass survey. - Instrument & its setting up. - Conversion of bearing web to R.B. - Calculation of included angle from bearing local attraction, magnetic declination and true bearing, closing error. - Adjustment of closing error, precaution in using prismatic compass. (06 hrs)
Professional Skill 14 Hrs; Professional Knowledge 06 Hrs	Perform site survey with Plane Table and prepare a map. (Mapped NOS: PCS/N9462)	63. Demonstration of instrument used for plane table surveying & their uses (alidade, U-fork, trough compass) Set up the plane table. (03 hrs) - Centering - Levelling - Orientation 64. Practice the method of plane tabling (07 hrs) - Radiation - Intersection - Resection - Traversing 65. Determination of height by telescopic alidade. (04 hrs)	Plane table survey:- - Plane table survey, principle, merits & demerits - Instrument used in plane table survey setting up the plane table. (centering, levelling, orientation) - Methods of plane table survey (radiation, intersection, resection, traversing) - Error in plane table survey. (06 hrs)
Professional Skill 53 Hrs; Professional Knowledge 06 Hrs	Prepare topography map by contours with levelling instruments. (Mapped NOS: PCS/N9463)	Levelling:- (53 hrs) 66. Handling of levelling instruments & their settings. (3) 67. Temporary adjustment of a level. 68. Simple levelling. (3) 69. Differential levelling (Fly levelling). (3) 70. Carry out Levelling field book. (3) 71. Equate Reduction of levels Height of collimation and Rise and Fall method – Comparison of methods. (3) 72. Solve problems on reduction of levels. (3).	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 adjustment, procedure in setting up.

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
		73. Calculate Missing data and fill up calculations & Arithmetical check in various problems and its solution..(4) 74. Practice levelling with different instruments. .(3) 75. Check levelling..(4) 76. Profile levelling or Longitudinal , plotting the profile. .(4) 77. Surveying of a building site with chain and Levelling Instrument with a view to computing earth work..(4) 78. Contour - Direct and Indirect methods..(3) 79. Make Topography map, contours map..(3) 80. Solve trigonometric problems..(3) 81. Prepare a road project in a certain alignment..(4)	- Level & horizontal surface. Datum Benchmark, Focussing & parallax - Deduction of levels / Reduced Level. - Types of levelling, Application to chain and Levelling Instrument to Building construction. - Contouring ; -Definition, Characteristics, Methods. - Direct and Indirect methods - Interpolation of Contour, Contour gradient , Uses of Contour plan and Map. - Knowledge on road project. (06 hrs)
Professional Skill 12 Hrs; Professional Knowledge 06 Hrs	Perform a site survey with Theodolite and prepare site plan. (Mapped NOS: PCS/ N9464)	Theodolite survey:- (12hrs) 82. Field work of theodolite..(1) 83. Measure Horizontal angle. Vertical angle, magnetic bearing of a line..(2) 84. Levelling with a theodolite..(2) 85. Calculation of area from traverse..(2) 86. Determination of Heights..(2) 87. Calculation of departure, latitude, northing and easting. (2) 88. Setting out work-Building work, etc. (1)	- Introduction and Types of Theodolite, - parts of Theodolite, - Terms used in Theodolite survey. - Temporary adjustment of Theodolite, - Angle measurement process. Reading of angles, field book entry of measured angles. - Permanent adjustment of Theodolite.(06 hrs)
Professional Skill 14 Hrs; Professional Knowledge 06 Hrs	Perform a site survey with Total Station and prepare site plan. (Mapped NOS: PCS/ N9465)	89. Application of survey using Total Station. (1 hrs) 90. Field procedure for co ordinate measurement. (1 hrs) 91. Field procedure to run open traverse and closed traverse. (2 hrs) 92. Transfer or establish Bench Mark. (1 hrs) 93. Perform stakeout / demarcation of building layout /plot layout/ roads/ alignment. (1 hrs) 94. Measure remote distance and elevation. (1 hrs) 95. Calculate surface area on field/site. (1 hrs) 96. Calculate volume of field/site. (1 hrs) 97. Procedure for down load and up load data. (1 hrs) 98. Simple survey map using Auto CAD. (4 hrs)	Total Station:- - Introduction. - components parts, accessories used. - characteristics, features. - advantages and disadvantages. - principle of EMD. - Working and need. - Setting and measurement. - Electronic, display & Data reading. - Rectangular and polar coordinate system. - Terminology of open and closed traverse. (06 hrs)

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
Professional Skill 26 Hrs; Professional Knowledge 06 Hrs	Identify timber and perform sawing and planning using hand and power tools. (Mapped NOS: MIN/ N0454)	99. Identify different wooden sample piece i.e.- soft wood & hard wood, wooden grains etc. & their applications Annual ring, knots, shakes & chicks etc.). (03hrs) 100. Demonstrate application of hand tools, measuring tools, and work holding devices. (03 hrs) 101. Demonstrate use of different power tools, viz. saws, drills, etc. (03hrs) 102. Perform sawing, planning, Moulding, Rebating, Chamfering, etc. using different types of saws, and plains. (14 hrs) 103. Sharpen and set different type saw blade and planer blade/ cutter. (03hrs)	- Common Indian timbers - Defects in timber, diseases of timber, knots, shakes, grains etc. - carpentry hand tools, measuring tools and uses. - work holding devices, power tools, viz. saws, drills, etc. - Description of Carpentry Joinery, Planing, Moulding, Rebating, Chamfering, Sawing, etc. (06 hrs)
Professional Skill 20 Hrs; Professional Knowledge 06 Hrs	Demonstrate surface finish with exact sizing by planning operation. (Mapped NOS: MIN/ N0454)	104. Planning face, face edge, etc. (5hrs) 105. Demonstrate the use of marking, mortise gauge etc. (3 hrs) 106. Test the accuracy of flatness and twist-ness of the surface by using try square. (4 hrs) 107. Demonstrate the use of winding strips, cross planning, edge planning. (4hrs) 108. Demonstrate portable power planer machine and its function. (4 hrs)	- Type of different planes and their proper uses in wood work - Description, function and its size, setting, knowledge of sharpening and uses etc. - knowledge of using marking gauges. - Important instruments necessary for checking flatness and twistness of surface - Sharpening and grinding angle of cutter. - Portable power planer - useful in modern wood work and new technology design. (06 hrs)
Professional Skill 28 Hrs; Professional Knowledge 08 Hrs	Prepare different wooden Joints. (Range of skill - framing joint, Housing joints, broadening joints, Lengthening joints). (Mapped NOS: MIN/ N0454)	Prepare different wooden joints by using different tools - 109. Make framing joint - Mortise and tenon Joint (Single and double, Plain hunched, Mitre corner) (08hrs) 110. Make Housing joints - Full housing, Bridle, Stopped housing (04 hrs) 111. Make broadening joints - Simple butt joint, Riveted butt joint, etc. (08 hrs) 112. Lengthening joints: End half lap joint, End over lap joint, End bends lap joint, slopping scarf, racking scared, half lapping scarf, table scarf joint etc. (08 hrs)	- Description of different types joint. - Uses of joint :- Framing joint angle joint and lengthening joint, housing joint, broadening joint etc. - Wood products - Industrial forms of timber - Veneer - Laminated sheet - Fibre board - Hard board - Plywood (08 hrs)

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
Professional Skill 20 Hrs; Professional Knowledge 06 Hrs	Make small wooden job as per drawing with schedule sizes of timber or alternatives of timber i.e. FRP, MDF, FOAM using various hardware. (Mapped NOS: PCS/N9466)	Make small wall bracket 113. Make joint on hard wood to make small frame. (7 hrs) 114. Stopped Tenon & Mortise joint on hard wood in the frame to set the selves. (6 hrs) 115. Make selves by six pieces of hard wood with single lapped half lap dovetail joint with frame (two nos. of selves). (07hrs)	- Calculation of timber required for Wall Bracket - List out the sequence of operation of the job (06 hrs)
Professional Skill 28 Hrs; Professional Knowledge 06 Hrs	Make different types of doors and windows with fixing of component. (Mapped NOS: PCS/N9467)	Making of :- 116. Different Types doors including panelled, glazed and flush door. (20 hrs) 117. Different types windows and ventilators. (08 hrs)	- Doors –Parts, Location, standard sizes, types. - Windows-types. Ventilators-purpose-types. (06 hrs)
Professional Skill 28 Hrs; Professional Knowledge 04 Hrs	Demonstrate joining of electrical wire and carry out soldering, crimping observing related safety precautions. (Mapped NOS: MIN/N3102)	118. Prepare terminations of cable ends (02 hrs) 119. Practice on skinning, twisting and crimping. (04 Hrs) 120. Identify various types of cables and measure conductor size using SWG and micrometer. (02 Hrs) 121. Make simple twist, married, Tee and western union joints. (08 Hrs) 122. Make britannia straight, britannia Tee and rat tail joints. (08 Hrs) 123. Practice in Soldering of joints / lugs. (04 Hrs)	Electrical Wiring:- - Safety precaution and elementary first aid. - Artificial respiration and treatment of electrical shock - Elementary electricity and its units. - General ideas of supply system. - Wireman's tools kit. Wiring materials. Electrical fittings. - System of wirings. Wiring installation for domestic lightings. - Conductor, insulator, semi-conductor, cable joints, measurement of cable (04 hrs)
Professional Skill 28 Hrs; Professional Knowledge 06 Hrs	Demonstrate Electrical wiring with fixing of accessories conforming ISI rules (Range of skills - different types of Electrical wiring, joining of Fuses, fixing of MCB, connection of lamp with switch and different fitting, etc.). (Mapped NOS: MIN/N3102)	124. Demonstrate different electrical wiring system with fixing of different accessories. (03 hrs) 125. Make electrical Fuse joints, fixing MCB. (3 hrs) 126. Connect lamps with switches. (06 hrs) 127. Stair case circuit wiring. (4 hrs) 128. Godown wiring. (6 hrs) 129. Hospital wiring. (6 hrs).	- Types of Fuses, MCB soldering, ELCB, RCCB, ABCB, MCCB AC and DC, AC fundamentals, poly phase - types of electrical wiring - Different Electrical wiring accessories, - ISI rules of wiring - Illumination (06 hrs)
Professional Skill 28 Hrs; Professional Knowledge 04 Hrs	Demonstrate installation of electrical appliances, Earthing and estimate costing of wiring. (Mapped NOS: MIN/N3102, MIN/N3104, MIN/N3102)	130. Install earthing in different position. (10 hrs) 131. Install and connect electrical appliances and take reading with Voltmeter. (10 hrs) 132. Prepare materials list and costing of wiring. (04 hrs)	- Earthing, types of earthing Earthing Pit. - Different electrical appliance, accessories, Voltmeter. - Estimation and costing of wiring.(02 hrs)

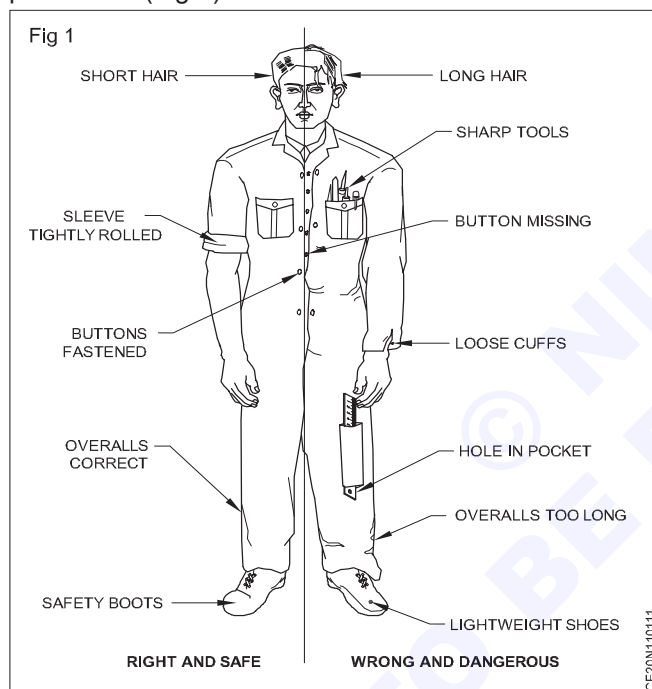
Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
	Identify different type of transformers and test and use. (Mapped NOS: MIN/N3101, MIN/N3102, MIN/N3103)	133. Identify transformer, test and use. (04 hrs)	Explanation and working of different type of transformers and its classification. (02 hrs)
Professional Skill 18 Hrs; Professional Knowledge 10Hrs	Prepare a Simple pipe connection demonstrating cutting, joining of pipe with different method using different types of fittings. (Mapped NOS: MIN/N3208)	133. Perform Simple pipe connection using G.I. Pipes, socket, elbow, tee, reducing elbow, G.I. union, cap plug, reducer, Three face elbow, reducing socket, plug, G.I. nipple etc. (18 hrs)	Plumbing tools, materials used in plumbing. (02 hrs) Different types of pipes, fittings and Joints - GI, PVC, AC, SW, CI, lead, steel - Properties and use in plumbing work (04 hrs) Method of cutting and joining of pipes. Drills - types and uses. Tap and Dies - types and uses, calculation of Tap drill size. (04 hrs)
Professional Skill 33 Hrs; Professional Knowledge 12 Hrs	Prepare layout of soil pipe and waste pipe with different types of sanitary fittings. (Mapped NOS: PCS/N9468)	135. Layout of soil pipe and waste pipe to the sanitary fitting using different types of fitting viz. Door junction, door Bend, H.R. bend, Plain Bend, Double door junction, inverter junction, cowel, floor trap, Gully trap, P-trap etc. (7 hrs) 136. Fitting of I.W.C with high level cistern. (06 hrs) 137. Fitting of washbasin (04 hrs) 138. Fitting of E.W.C. with low level cistern. (04 hrs) 139. Fitting of kitchen sink. (04 hrs) 140. Fitting of bath tub. (04 hrs) 141. Fitting of urinal pot with auto cistern. (04 hrs)	Sanitary Technical terms - sewer, sewage, sullage etc. - Soil pipe and waste pipe fitting Different types of water closets Different types of urinal port Kitchen sinks, Bath tub, Wash basin. (12 hrs)
Professional Skill 28 Hrs; Professional Knowledge 14 Hrs	Prepare a water supply system in residential buildings using different types of valves, fittings and appliances. (Mapped NOS: PCS/N9469)	142. Install water meter. (04 hrs) 143. Remove air lock. (03 hrs) 144. Determination of pH by pH meter. Analysis and treatment of Effluent water. (05 hrs) 145. Recondition taps, valves & flushing tank, test for correct functioning. (03 hrs) 146. Prepare a water supply pipe line system in residential buildings using different types of valves, fittings and appliances. (05 hrs) 147. Prepare different objects on 3D Modelling concept in CAD. (08 hrs)	Water meter • Installation of water meter • Removal of air lock Purification of water • Mineral matter, Hardness, Causes of Scale formation & their Removal. Water Purification: Treatment plants for different groundwater contaminants, Treatment plants for surface water. (07 hrs) Types of damages in taps, valve, water meter and tanks - Method of rectification Water supply - Sources of water Storage of water Distribution of water Different types of valves used in Plumbing, Types of tanks R.C.C., P.V.C. Iron tanks etc. (07 hrs)

Safety, familiarisation about industrial training institute, soft skills, first aid, 5S concept and PPE

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 work 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 accidents are avoidable. A good craftsman, 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)



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 clear.

Move with care in the workshop, do not run.

Don't leave the machine which is in motion.

Don't touch or handle any equipment machine unless authorised 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

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 authorised 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, bolts 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 in 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.

Familiarisation about industrial training institute in India

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

- **state what is ITI and brief the objectives of ITI**
- **describe the organizational chart**
- **list out the infrastructure available in ITI**
- **explain the job opportunities and carrier development after completion of courses**
- **brief the examination pattern and soft skills.**

Introduction to ITI

Industrial Training Institutes (ITI) and Industrial Training Centers (ITC) comes under Craftsman training Scheme (CTS) to provide Vocational training in various trades functioning under Directorate General of Training (DGT), Ministry of Skill Development and Entrepreneurship, Government of India.

ITIs and ITCs are one and the same; ITIs are governed by the state/union government, whereas, the ITCs are self-financing institutions to provide same training courses as ITI's. Trade test for ITI and ITC trainees are common and the National Trade Certificate issued by the National Council for Vocational Training (NCVT) is of the same standard.

The objectives of an ITI

The objective of an ITI is to ensuring a steady flow of skilled workers and to reduce unemployment among the educated youth by training & equipping for suitable industrial employment as well as for self-employment.

The institute imparts training in engineering and non- engineering two years/ one-year trade courses approved by the Government of India in consultation with the National Council for Vocational Training, New Delhi.

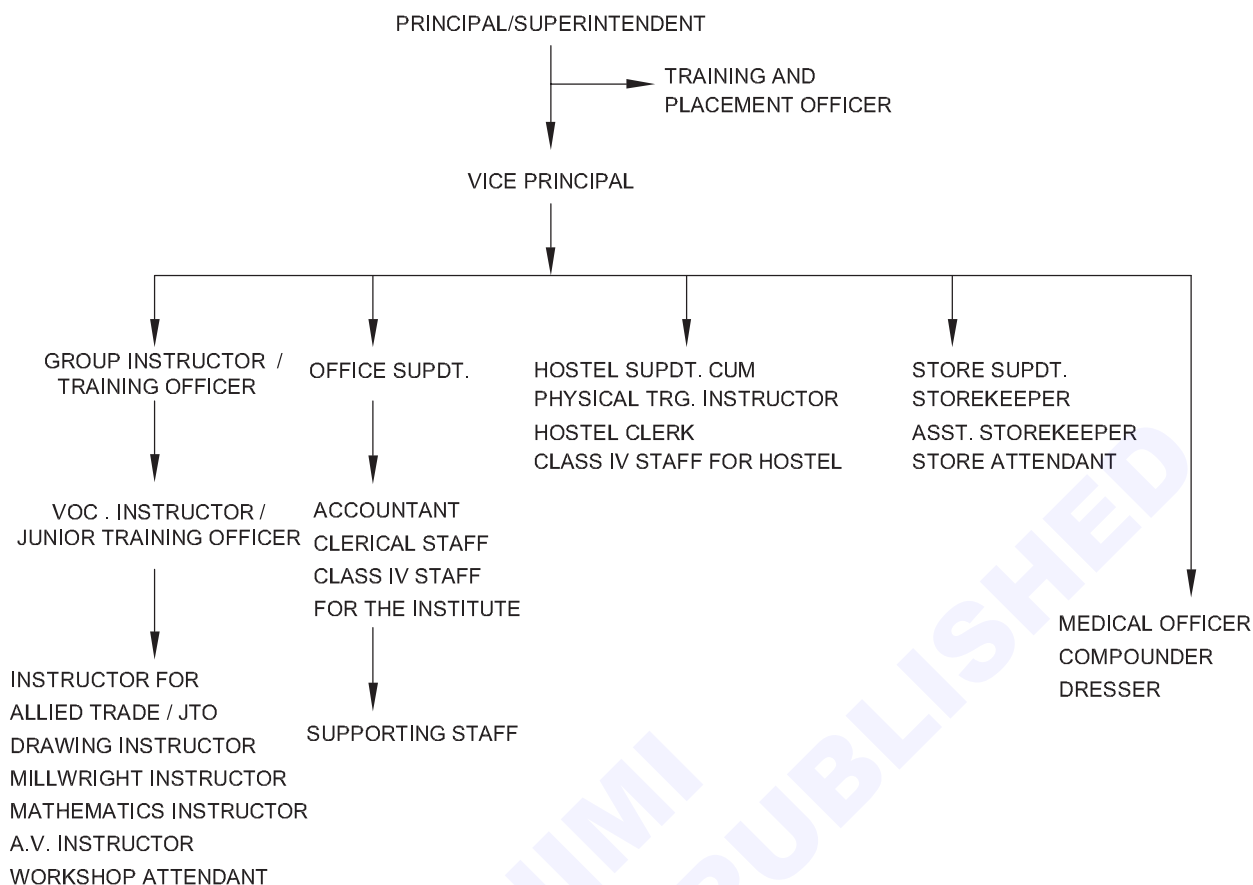
Structure of ITI

The structure of industrial training institute is shown in the following chart 1. It may vary from state to state. It explain the information /order flow from higher superior officials to the ground level officials. The working hours may differ from state to state. The trade master is the overall in-charge for the particular trade. The trainee has to report to trade master.

In every ITI there is a store and the in-charge of the store is storekeeper for inward and outward movement of tools, equipment and consumables. The instructor will indent the training requirement for the training purposes.

Fig 1

ORGANISATIONAL CHART OF ITI



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Infrastructure available in ITI's

To provide 100% practical training to the trainees, tools, equipments, machineries and classroom facilities are available in ITI's. Continuous learning process/ programs are conducted in regular intervals as per the instructions given by the DGT.

The following facilities are available in ITI's

- Hostel facilities
- Libraries
- Soft skills lab/ computer labs
- High end classrooms /smart class.
- Stores
- Sports
- WI-FI enabled campus.
- Industrial visit's/ Industrialist guest lecture
- Internship training on the job training
- Apprentice programs
- Campus interview etc

CTS Admission Process

Online counseling is conducted. Statewide selection is made on merit basis duly following rules of reservation. The candidates exercise the option of choosing the ITI and trade of their choice.

Students between the age of 14 - 40 are admitted in Industrial Training Institutes. Admission is made during the month of August every year.

Craftsman Training Scheme Exam System

Final Trade Test is conducted on All India basis and the question papers are issued to all Trade Testing Centres on the same day by the NCVT. Passed-out candidates are issued with National Trade Certificate (NTC) under the seal and authority of NCVT by DGT, New Delhi

Job area after completion of training

This highlights the employability aspect on completion of training. The trainee should be aware of various prospects available in present market scenario along with scope for self-employment. For example, a trainee with NTC engineering trade may opt for various jobs available in different industries in India and abroad.

After successful completion of training in any one of the engineering trade one can seek appointment in engineering workshop /Factories (Public Sector, Private Sector and Government Industries) in India and abroad as technician / Skilled worker.

Self-employment

One can start his own factory / ancillary unit or design products manufacture and become an entrepreneur.

Further learning scope

- Apprentice training in designated trade.
- Craft Instructor certificate course.
- Diploma in relevant Engineering.

Skill competition

All India Skill Competition for Craftsmen scheme at national level was introduced to foster a healthy competition among the trainees of ITIs / ITCs

India skill competition is organized by National Skill Development Corporation., India skill competition the country's biggest skill competition is designed to demonstrate the highest standards of skilling and offers a platform to young people to show their talent at national level and international levels.

The competition is now held every year in 15 trades viz. Instrument Mechanic, Electronic Mechanic, Welder, Fitter, Turner, Machinist, Mechanic Motor Vehicle, Foundry man, Electrician, Cutting & Sewing, Computer Operator & Programming Assistant, Draughtsman (Civil), Draughtsman (Mechanical), Civil Engineering Assistant, Mechanic Diesel and Mechanic Refrigeration & Air- Conditioning.

The best trainee of each of the above trades at the State level competition competes at the All India Skill Competition.

Awards

The best Craftsmen in each of the above 15 trades at the All India level are awarded merit certificates and a cash prize of Rs.50,000/- each. ITIs whose

trainee stands first in the competition at the All India Skill Competition is awarded a merit certificate and is declared as the best ITI.

Various job available in different industries in India and abroad

After successful completion of ITI training in any one of the engineering facile one can see appointment in engineering workshop/factories (Public sector, private sector and Government industries) In India and Abroad as technician/skilled worker.

Opportunity of job after training

After completion of training there are so many companies & industries AND departments in public sector and private sector which provides the job opportunity for the trade of civil engineering assistant.

The name of some public sectors are given below.

- Central public works department
- Central architect department
- Military Engineering Service
- National highways department
- Central geological department
- Survey of India
- Railways
- State P.W.D.
- Municipal councils
- Private building construction companies

Approach on soft skills

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

- state the concept of soft skill
- list the important common soft skills.

Concept

Soft skills - refer to the cluster of personality traits, social graces, facility with language, personal habits, friendliness, and optimism that mark people to varying degrees. The same can also be defined as ability to interact, communicate positively and productively with others. sometimes called "character skills".

More and more business is considering soft skills as important job criteria. Soft skills are used in personal and professional life. Hard skills/technical skills not considered without soft skills.

Common soft skills

Strong work ethic
Positive attitude

Good communication skills

Interpersonal skills

Time management abilities

Problem-solving Skills

Team work

Initiative, Motivation

Self-confidence

Loyalty

Ability to accept and learn from criticism

Flexibility, adaptability

Working well under pressure

First-aid

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

- state what is first aid
- list the important guide lines for the first aid
- explain the ABC of the first aid
- brief how to give first-aid for a victim who need first aid.

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.

Golden hours: India have best of technology made available in hospitals to treat devastating medical problem 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.

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, gasses, 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.

Remember A-B-Cs

The ABCs of first aid refer to the three critical things the first aiders need to look for.

- Airway - Does the person have an unobstructed airway?
- Breathing - Is the person breathing?
- Circulation - Does the person show a pulse at major pulse points (wrist, carotid artery, groin)

Avoid moving the victim: Avoid moving the victim unless they are in immediate danger. Moving a victim will often make injuries worse, especially in the case of spinal cord injuries.

Call emergency services: Call for help or tell someone else to call for help as soon as possible. If alone in at the accident scene, try to establish breathing before calling for help, and do not leave the victim alone unattended.

Determine responsiveness: If a person is unconscious, try to rouse them by gently shaking and speaking to them.

If the person remains unresponsive, carefully roll them on 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. (Fig 1)

Fig 1



Look, listen and feel for signs of breathing

Look for the victim's chest to raise 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 colour and check their pulse (the carotid artery is a good option; it is located on either side of the neck, below the jaw bone). If the victim does not have a pulse, start CPR

- If you are trained.

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.

- **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 from 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 colour 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.

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

Unconsciousness (COMA): 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.

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)
- Extreme of body temperature (Heat, Cold)
- Cardiac arrest (Heart attack)
- Stroke (Cerebro-vascular accident)
- Blood loss (Hemorrhage)
- Dehydration (Diarrhea & vomiting)
- Diabetes (Low or high sugar)
- Blood pressure (Very low or very 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:

- 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 (palpitation)
- Stupor

First aid

- Call EMERGENCY number.
- 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.

DO NOT

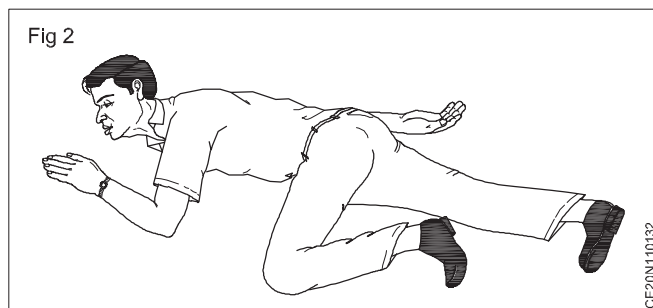
- Do not give an unconscious person any food or drink.
- Do not leave the person alone.
- Do not place a pillow under the head of an unconscious person.
- Do not slap an unconscious person's face or splash water on the face to try to revive him.

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. Never give anything by mouth to an unconscious casualty.

How to diagnose an unconscious injured person?

- Consider alcohol: look for signs of drinking, like empty bottles or the smell of alcohol.

- **Consider epilepsy:** are there signs of a violent seizure, such as saliva around the mouth or a generally disheveled scene?
- **Think insulin:** might the person be suffering from insulin shock (see 'How to diagnose and treat insulin shock')?



- **Think about drugs:** was there an overdose? Or might the person have under dosed - that is not taken enough of a prescribed medication?

- **Consider trauma:** is the person physically injured?
- **Look for signs of infection:** redness and/ or red streaks around a wound.
- **Look around for signs of Poison:** an empty bottle of pills or a snakebite wound.
- **Consider the possibility of psychological trauma:** might the person have a psychological disorder of some sort?
- Consider stroke, particularly for elderly people.
- Treat according to what you diagnose.

Shock: A severe loss of body fluid will lead to a drop in blood pressure. Eventually the blood's circulation will deteriorate and the remaining blood flow will be directed to the vital organs such as the brain. Blood will therefore be directed away from the outer area of the body, so the victim will appear pale and the skin will feel ice cold.

Personal Protective Equipment (PPE)

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

- state what is personal protective equipment and its purpose
- name the two categories of personal protective equipment
- list the most common type of personal protective equipment
- list the conditions for selection of personal protective equipment.

Personal protective equipment

Personal protective equipment, commonly referred to as "PPE", is equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses. 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.

Categories of PPE- Small's

Depending upon the nature of hazard, the PPE is broadly divided into the following two categories.

Non- respiratory: Those used for protection against injury from outside the body, i.e. for protecting the head, eye, face, hand, arm, foot, leg and other body parts

Respiratory: Those used for protection from harm due to inhalation of contaminated air.

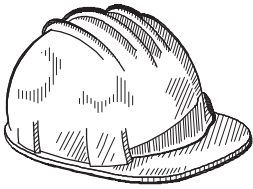
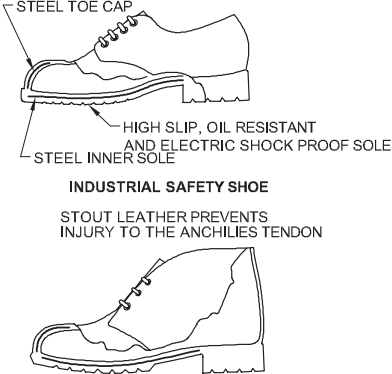
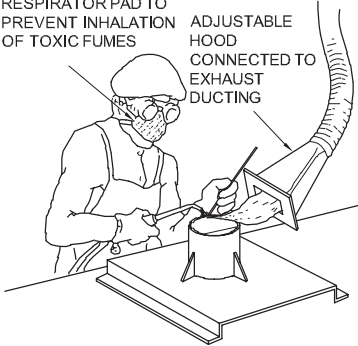
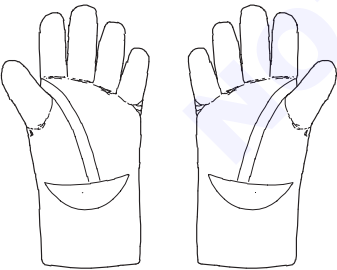
They are to meet the applicable BIS (Bureau of Indian Standards) standards for different types of PPE.

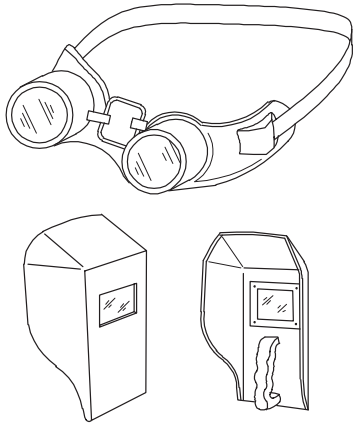
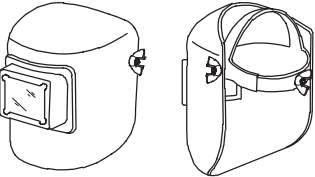
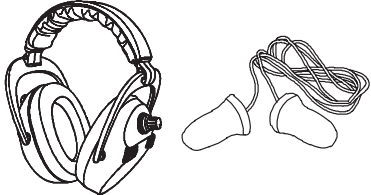
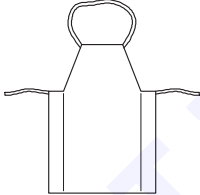
The guidelines on 'Personal Protective Equipment' is issued to facilitate the plant management in maintaining an effective programmer with respect to protection of persons against hazards, which cannot be eliminated or controlled by engineering methods listed in table 1.

Table 1

No	Title
PPE1	Helmet
PPE2	Safety footwear
PPE3	Respiratory protective equipment
PPE4	Arms and hands protection
PPE5	Eyes and face protection
PPE6	Protective clothing and coverall
PPE7	Ears protection
PPE8	Safety belt harness

Personal protective equipment's and their uses and hazards are listed in Table 2

Types of protection	Hazards	PPE to be used
Head protection (Fig 1) HELMET 	1 Falling objects 2 Striking against objects 3 Spatter	Helmets
Foot protection (Fig 2)  INDUSTRIAL SAFETY SHOE INDUSTRIAL SAFETY BOOT	1 Hot spatter	Leather leg guards
Nose (Fig 3) 	1 Dust particles 2 Fumes/gases/ vapors	Nose mask
Hand Protection (Fig 4)  GLOVES	1 Heat burn due to direct contact 2 Blows spark moderate heat 3 Electric shock	Hand gloves

Eye protection (Fig 5 & Fig 6)  HAND SCREEN	1 Flying dust particles 2 UV rays, IR rays heat and High amount of visible	Goggles Face shield radiation Hand shield Head shield
Face protection (Fig 7)  WELDING HELMET	1 Spark generated during Welding, grinding 2 Welding spatter striking 3 Face protection from UV rays	Face shield Head shield with or without ear muff Helmets with welders Screen for welders
Ear protection (Fig 8) EAR MUFFS EAR PLUG 	1 High noise level	Ear plug Ear muff
Body protection (Fig 9 & 10)  APRON LEATHER APRONS  CAP WITH SLEEVES HAND GLOVES APRON LEG GUARDS	1 Hot particles	Leather aprons

Quality of PPE's: PPE must meet the following criteria with regard to its quality-provide absolute full protection against possible hazard and PPE's be so designed and manufactured out of materials that it can withstand the hazards against which it is intended to be used.

Selection of PPE's requires certain conditions

- Nature and severity of the hazard
- Type of contaminant, its concentration and location of contaminated area with respect to the source of reparable air
- Expected activity of workman and duration of work, comfort of workman when using PPE
- Operating characteristics and limitation of PPE
- Ease of maintenance and cleaning
- Conformity to Indian / International standards and availability of test certificate.

Proper use of PPEs: Having selected the proper type of PPE, it is essential that the workman wears it. Often the workman avoids using PPE. The following factors influence the solution to this problem.

- The extent to which the workman understands the necessity of using PPE
- The ease and comfort with which PPE can be worn with least interference in normal work procedures
- The available economic, social and disciplinary sanctions which can be used to influence the attitude of the workman
- The best solution to this problem is to make wearing of PPE' mandatory for every employee.
- In other places, education and supervision need to be intensified. When a group of workmen are issued PPE for the first time.

Introduction to 5S concept & its application

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

- list the benefits of a shop floor maintenance
- state what is 5S
- list the benefits of 5S.

Benefits of a shop floor maintenance

Some of the benefits which may be derived from the utilization of a good Shop Floor Maintenance are as follows:

- Improved Productivity
- Improved operator efficiencies.
- Improved support operations such as replenishment moves and transportation of work in process and finished goods
- Reduction of scrap
- Better control of your manufacturing process
- More timely information to assist shop floor supervisors in managing their assigned production responsibilities.
- Reduction of down time due to better machine and tool monitoring.
- Better control of Work in Progress inventory, what is and where it is improved on time schedule performance.

5S Concept

5S is a Japanese methodology for workplace organisation. In Japanese it stands for seiri (SORT), seitan (SET), seiso (SHINE), seiketsu (STANDARDIZE), and shitsuke (SUSTAIN).

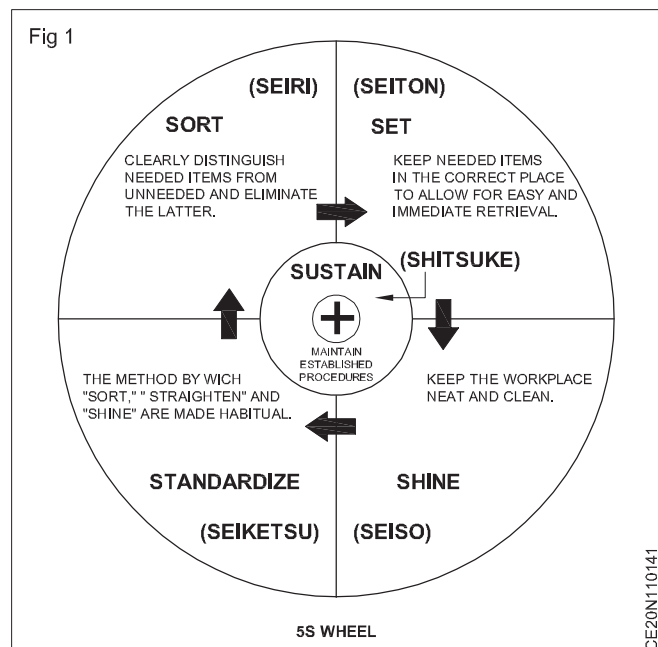
The list describes how to organize a work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order.

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

- Increase in productivity
- Increase in quality
- Reduction in cost



Response to emergencies - Power failure, fire and system failure

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

- state the reason of emergency power failure
- state the cause of system failure
- state the fire safety and immediate actions.

1 If there is a power failure, start the emergency generator. This provides power to close the shutter, which is the first priority. The generator will also keep the UPSs and the cryogenic compressors running,

- Get a flash light.
- Look out for power transfer switch and switch over to normal power to emergency power by pressing the latch.
- Check the fuel valves open or not - Open the valves.
- Check to see that the main breaker switch on the generator is in OFF position.
- Move the starter switch of the generator to run position. The engine will start at once.
- Allow few minutes to warm up the engine.
- Check all the gauges, pressure, temperature, voltage and frequency.
- Check the "AC line" and "Ready" green light on the front panel.

2 System failure

- If the bug or virus, invades the system. The system failure happens.

- Several varieties of bugs are there

1 Assassin bug

2 Lightening bug

3 Brain bug

For more details, refer instruction manual for "System failure".

3 Fire failure

When fire alarm sounds in your buildings

- 1 Evacuate to outside immediately.
- 2 Never go back
- 3 Make way for fire fighters and their trucks to come
- 4 Never use an elevator
- 5 Do not panic

Reporting emergency

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

- explain and report an emergency.

Report an emergency

Reporting an emergency is one of those things that seems simple enough, until actually when put to use in emergency situations. A sense of shock prevails at the accident sites. Large crowd gather around only with inquisitive nature, but not to extend helping hands to the victims. This is common in road side injuries. No passerby would like to get involved to assist the victims. The first aiders need to adapt multitask strategy to control the crowd around, communicate to the rescue team, call ambulance etc, all to be done simultaneously. The mobile phones help to a greater deal for such emergencies. Few guidelines are given below to approach the problems.

Assess the urgency of the situation. Before you report an emergency, make sure that the situation is genuinely urgent. Call for emergency services if you believe that a situation is life-threatening or otherwise extremely disruptive.

- 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, missing, report that as well.
- A life - threatening medical emergency, explain how the incident occurred and what symptoms the person currently displays.

Call emergency service

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

Report your location

The first thing the emergency dispatcher will ask where you are located, so that 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 like landmark etc.

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.**

Refer Exercise no 1.1.01-08

Overview of the subject to be taught in each year

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

- **state the subject to be learned in each year.**

Overview of the subject to be taught for each year: 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.

Subject to be taught in the trade of Civil Engineering Assistant for each year

Ist Year

- Importance of safety
- First Aid and introduction to 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 and perspective
- Simple problems on projection of points, lines surfaces and solids.
- Drawing of sketches from models (Plan, sections and elevation)
- Read and use of plain, diagonal, comparative, diagonal, vernier and scale of chords and B.I.S.
- Different and type of building materials, timber, stones, bricks, lime, pozzolanic, cement, sand, clay products, mortar and concrete
- To have the knowledge to computer aided data and keyboard commands

- Various types of foundation and construction, Different types of plastering, Chain surveying and preparation of site plan
- Observe the bearings of lines, Traverse survey using compass, Compass surveys, plane, table survey
- 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 and total station
- Different type of doors and windows, Different type of carpentry joints and calculation of timber
- Electrical wiring system materials and fittings, Plumbing tools, materials and fittings.

IInd Year

- Different types of cement and properties, Different types aggregate and characteristics, Water quality and requirements
- Admixture terms, functions and classification, Preparation of concrete and processes, Classification of concrete and properties
- Different types of scaffolding and applications, Different materials for form work and importance
- Bar bending technical forms symbols and uses, Bar bending tools and vein for cement
- Different operation of bar bending, Various types of stairs and construction details, Concept of lift and escalator
- Different types and use of pile foundation, Building construction, types and use parks, orientation and ventilation, Different types of building plans
- Estimating and costing importance, Calculation of quantities of items

Various types of repairing works

- Anti-termite type
- House plumbing and drainage
- Different types of adhesive and filler
- Construction equipment
- Construction management

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
- 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

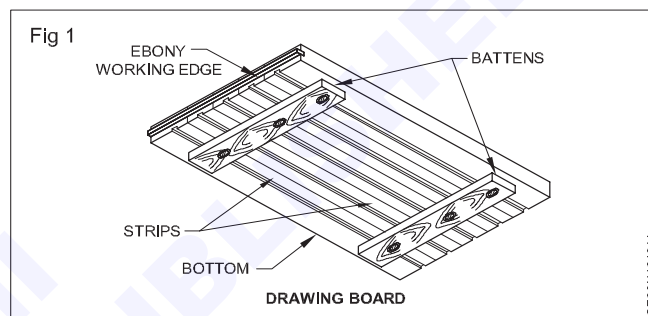
- Drawing papers
- Drawing pencils
- Rubber/ Eraser
- Drawing papers fasteners (Drawing pins, Cello tape)
- Tracing paper or tracing film

Drawing board

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

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

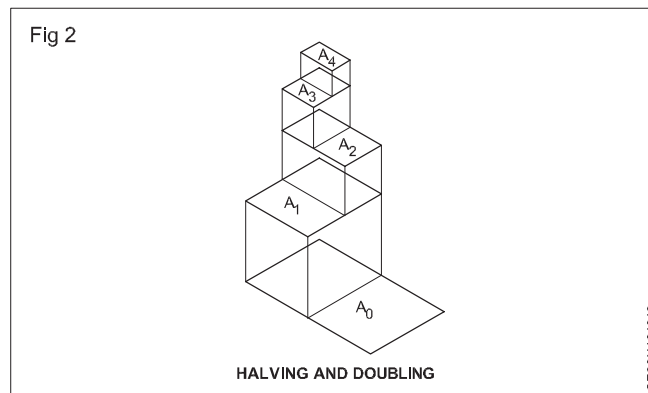


The following precaution may be taken in handling the drawing boards:

- 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)

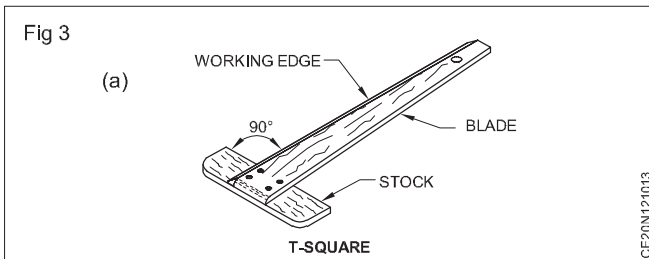


Designation	Trimmed size (mm)	Untrimmed size (mm)
A0	841 x 1189	880 x 1230
A1	594 x 841	625 x 880
A2	420 x 594	450 x 625

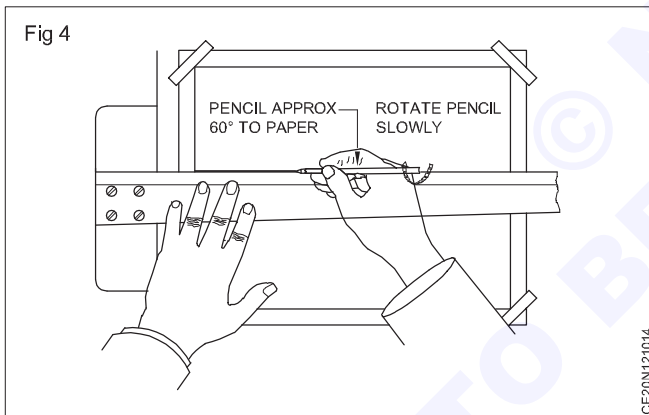
A3	297 x 420	330 x 450
A4	210 x 297	240 x 330
A5	148 x 210	165 x 240

- 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.



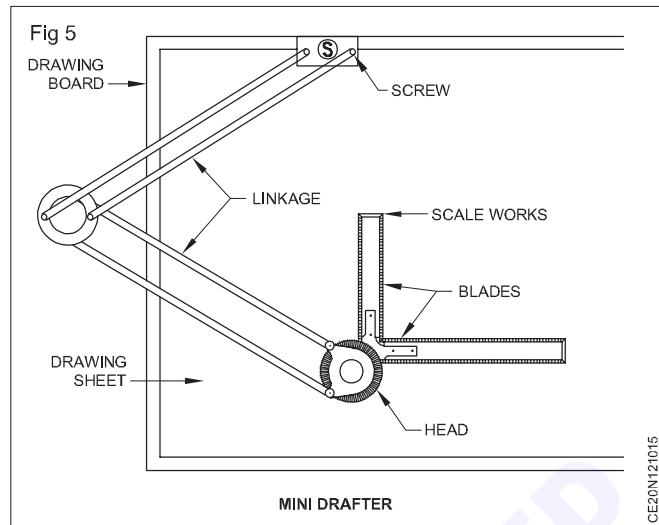
The following precautions may be taken in handling the T-square: (Fig 4)



- 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.

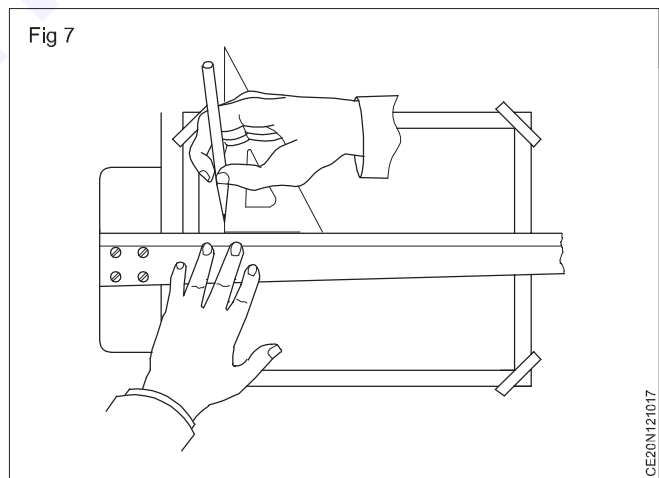
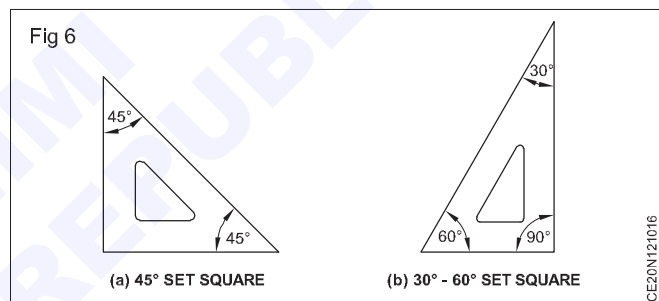
T-square is used to draw only horizontal lines. Do not use lower edge of the T-square to draw horizontal lines. While drawing horizontal lines, the pencil should be slightly inclined towards the right. Vertical and inclined lines are drawn with the help of set squares.

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.

Set-square (Fig 6 and Fig 7)



It is made of transparent celluloid plastic in triangular shape. They are available in two types, 300-600 and 450-450.

Engineer's scales (Table)

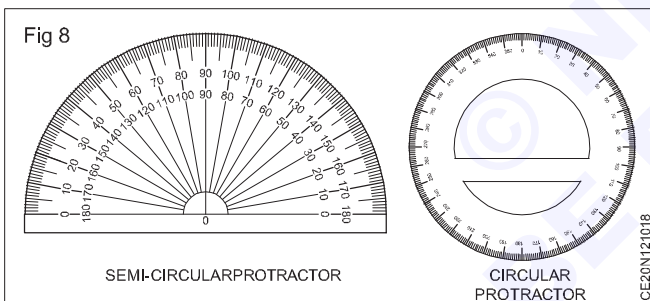
It is used to make full size, reduced size or enlarged size drawings conveniently, depending upon the size of the object and that of the drawing sheet. They are made of cardboard, plastic and as recommended by Bureau of Indian Standards, are available in set of eight scales. They are designated from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

Table

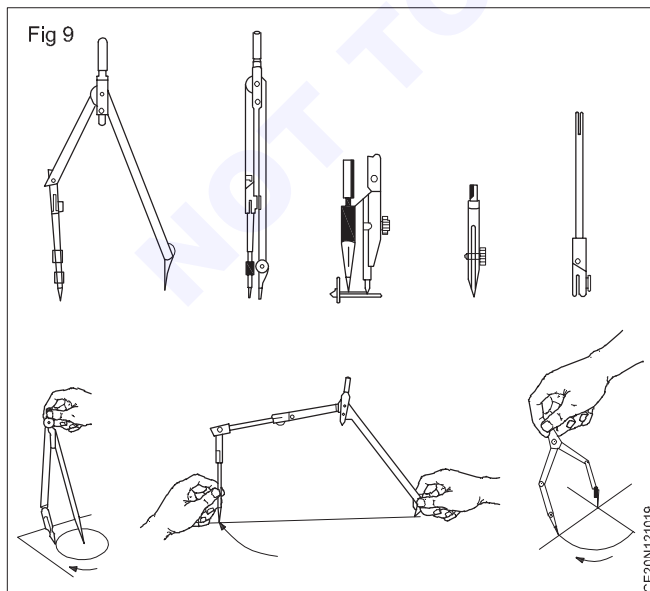
Designation	Description	Scales
M1	Full size	1:1
	50 cm to a metre	1:2
M2	40 cm to a metre	1:2.5
	20 cm to a metre	1:5
M3	10 cm to a metre	1:10
	05 cm to a metre	1:20
M4	02 cm to a metre	1:50
	01 cm to a metre	1:100
M5	5 mm to a metre	1:200
	2 mm to a metre	1:500
M6	3.3 mm to a metre	1:300
	1.66 mm to 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.



Compass (Fig 9)



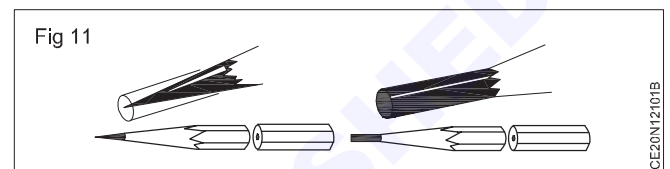
It is used for drawing circles both in pencil and in ink. It consists of two legs hinged at one end. One leg is attached with a steel needle by means of a screw while the other leg is provided with a socket to accommodate interchangeable attachments.

Dividers (Fig 10)

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

- 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 from the scale to the drawings.

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.

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

- 1 Cylindrical
- 2 Conical
- 3 Wedge (Chisel edge)
- 4 Bevel

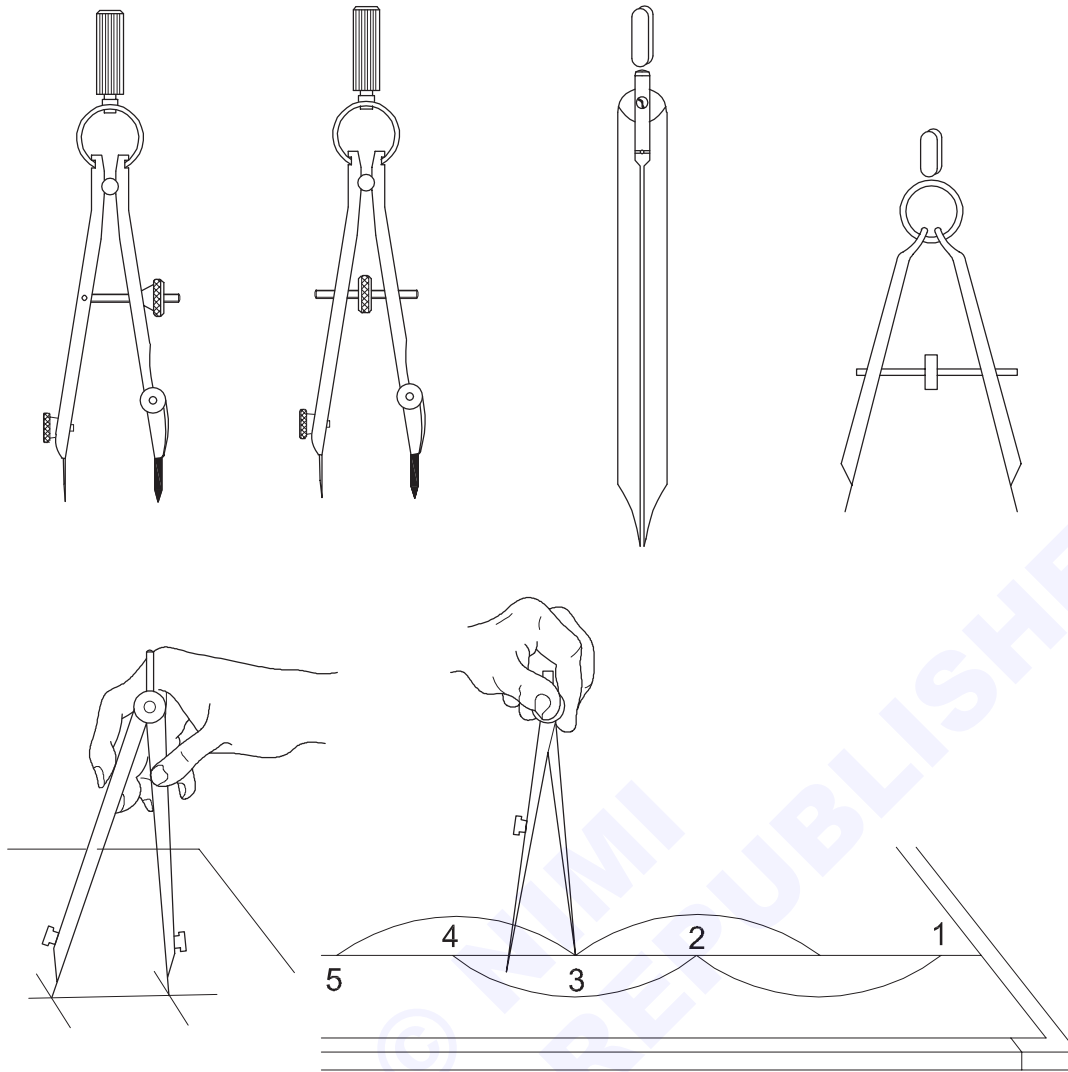
Mechanical clutch pencil is very common in use. This is very simple, easy to use, requires no sharpening time and even cheaper in long run. Hence, this type of pencil is preferred by professional draughtsman. Students using these types of pencils will save a lot of time.

- 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 sloping 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

Fig 10



CE20N12101A

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.

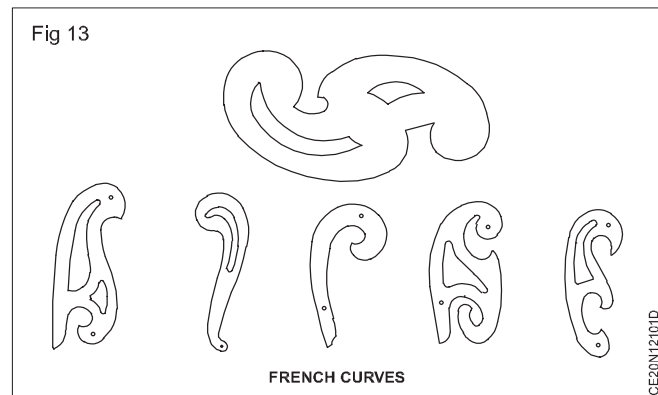
- Thumb pins
- Cello tapes
- Fold back gap spring clips.

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.

French curves (Fig 13)

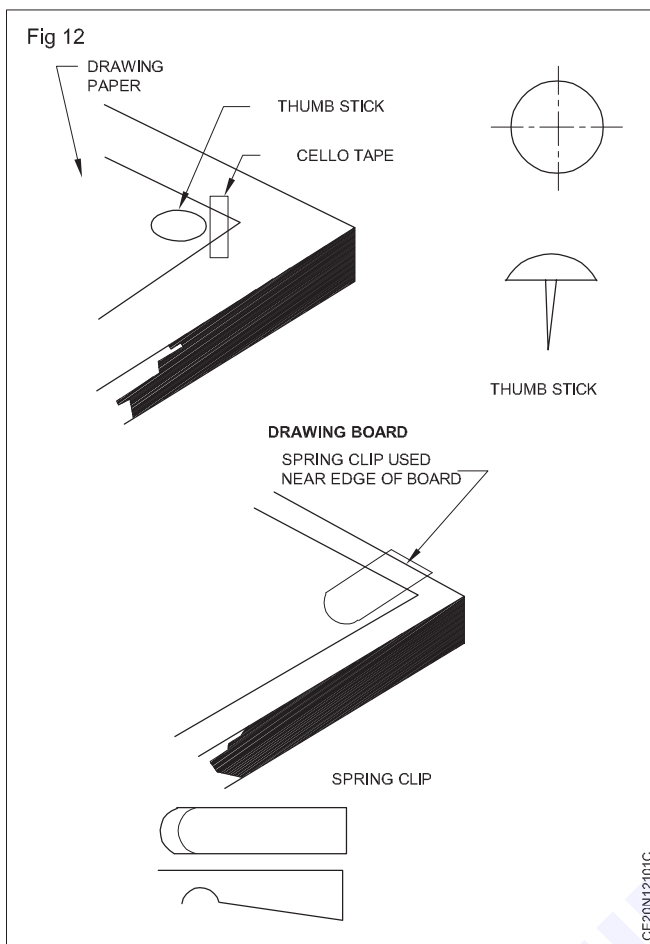
Fig 13



CE20N12101D

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.

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

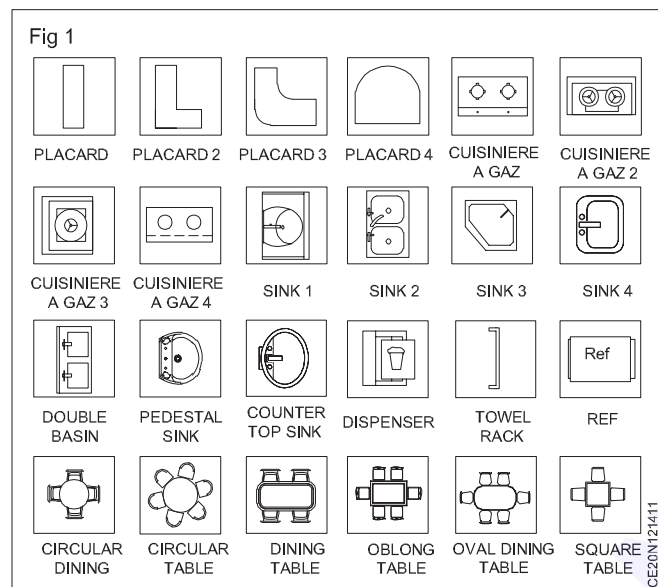
Symbols for architectural & building drawings (IS 962 - 1989) and B.I.S

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.

Home floor- bath kitchen

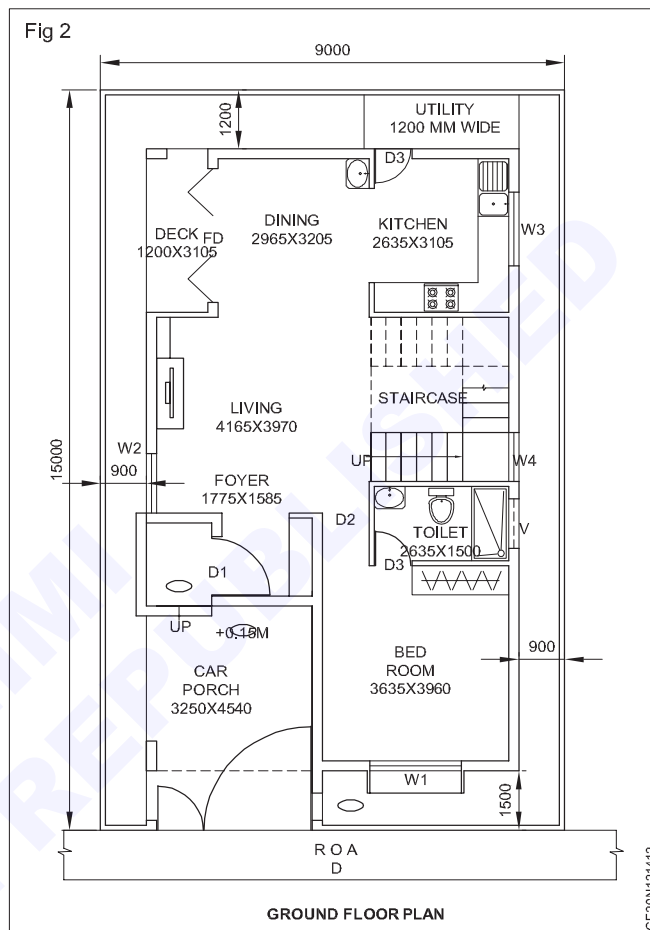
Free download building plan software and view all examples

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

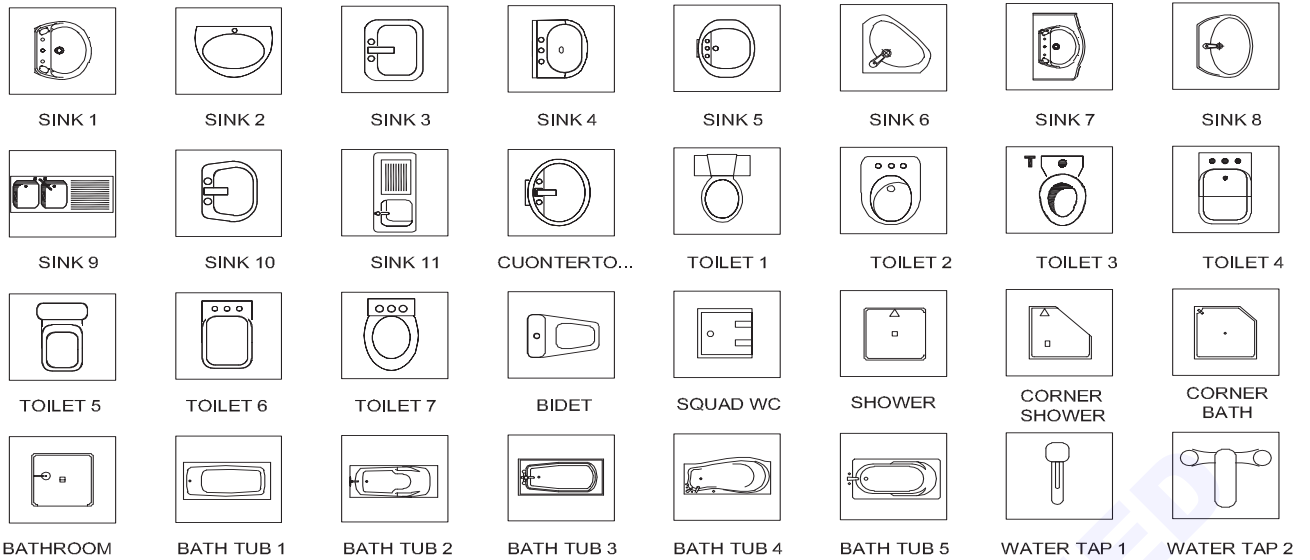
How to use appliances symbols for building plan: One of the obligatory documents that is included to design project of home, apartment, office center,



or any other premise is the plan of arrangement of different appliances and home appliances. Creating 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 indispensable 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.

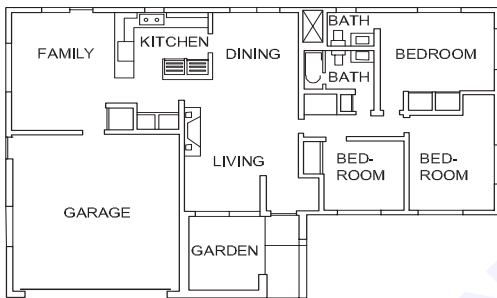
Hatching pattern can be used as a means to broadly indicate the material of the part / object to differentiate difference material in sectional views BIS laid out standards ((IS:11663) on conventional representations of the materials.

Fig 3



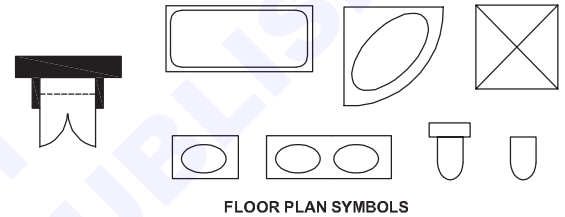
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Fig 4



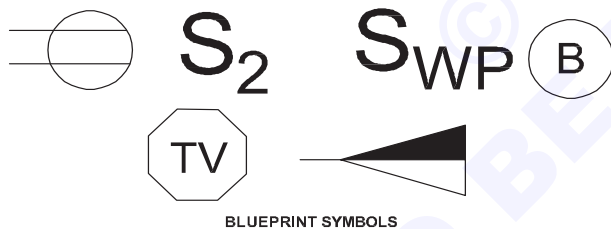
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Fig 6



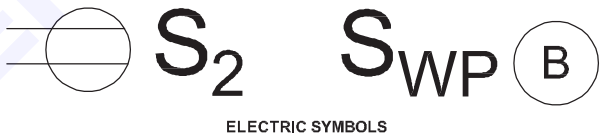
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Fig 5



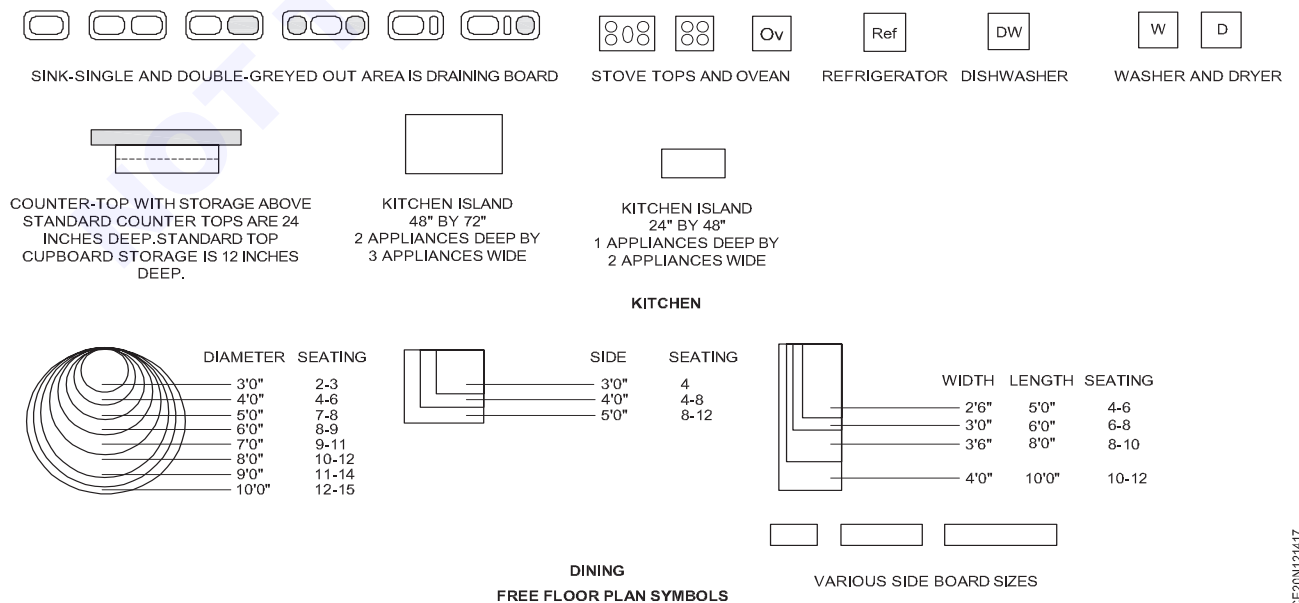
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Fig 8

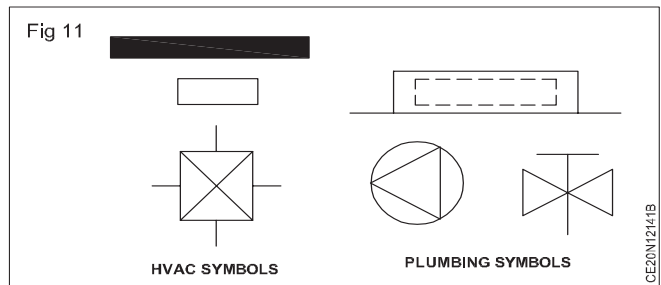
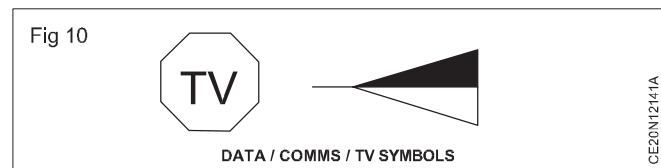
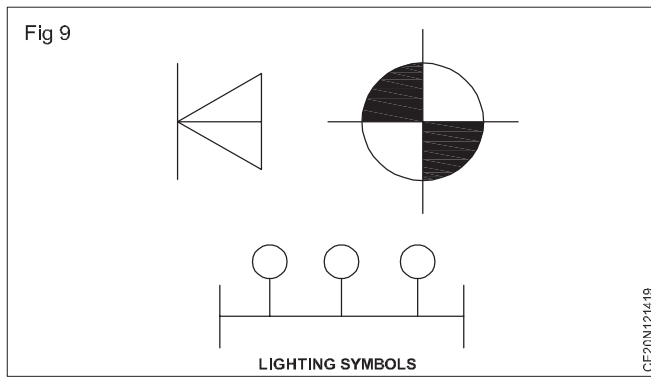


CE20N121418

Fig 7



CE20N121417



Standard and standardisation

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

- state what is meant by standardisation and standard
- state the names of various standard organisation.

Standardisation can be defined as the process of formulating and applying rules for an orderly approach to specific activity for the benefit of the user and the manufacturer, and in particular for the promotion of optimum overall economy taking due account of functional conditions and safety requirement. It is based on the consolidated results of science, technique and experience. It determines not only the basis for the present but also for future development, and to keep pace with progress.

The materials/tools/equipment produced in any country should be of certain standard. To meet this requirement, the international organisation for standardization(ISO) is started and specifies the units of measurement, technology and symbols, products and processes, safety of persons and goods through a number of booklets coded with ISO number.

Standard can be defined as a formulation established verbally, in writing or by any other graphical method or by means of a model, sample or other physical means of representation to serve during a certain period of time for defining designating or specifying certain features of a unit or basis of measurement, physical object, an action, process, method, practice, capacity, function, duty, right of responsibility, a behaviour, an attitude a concept or a conception.

To sell Indian goods in the local and international market certain standardization methods are essential. The standard is specified by the Bureau of Indian Standard BIS(ISI) for various goods through their booklets. The BIS only certifies a good often the product meets the specification and passes necessary tests. The manufacturer allows to use the BIS(ISI) mark on the product only after BIS certification. These are a number of organisation for standardisation throughout the world in different countries.

The standard organisation and the respective countries are given below:

BIS	-	Bureau of Indian Standard (ISI) - India
ISO	-	International standard Organisation

JIS	-	Japanese Industrial Standard - Japan
BSI	-	British Standards Institution BS(S) - Britain
DIN	-	Deutsche Industrie Normen - Germany
GOST	-	Russian
ASA	-	American standards association - America

Advantages of BIS(ISI) certification marks scheme:

A number of advantages accrue to different sectors of economy from the BIS(ISI) certification marks scheme.

To manufacturers

- Streamlining of production processes and introduction of quality control system. Independent audit of quality control system by BIS
- Reaping of production economics accruing from standardization
- Better image of products in the market, both internal and overseas
- Winning for whole-salers, retailers and stockists consumer confidence and goodwill
- Preference for ISI-marked products by organised purchasers, agencies of Central and State Governments, local bodies, public and private sector undertakings etc. Some organised purchasers offer even higher price for ISI-marked goods.
- Financial incentives offered by the Industrial Development Bank of India (IDBI) and nationalised banks.

To consumers

- Conformity with Indian Standards by an independent technical, National Organisation
- Help in choosing a standard product
- Free replacement of ISI-marked products in case of their being found to be of substandard quality
- Protection from exploitation and deception
- Assurance of safety against hazards to life and property

Layout of drawing sheet, line, lettering and dimensioning

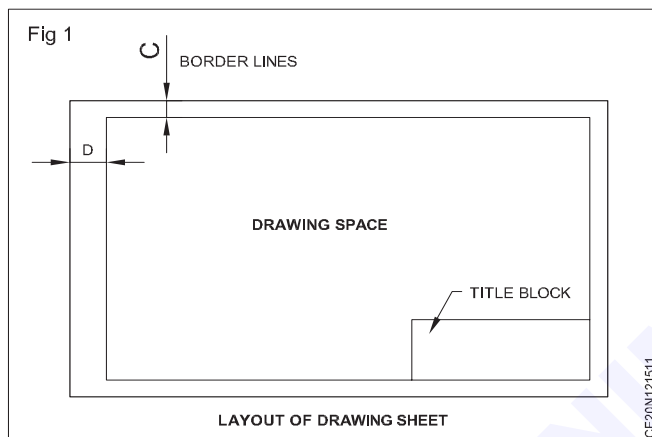
Objectives: At the end of this lesson you shall be able to

- state the system of layout of drawing sheet and explain the title block
- list the different layout for designated drawing sheet.

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)



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

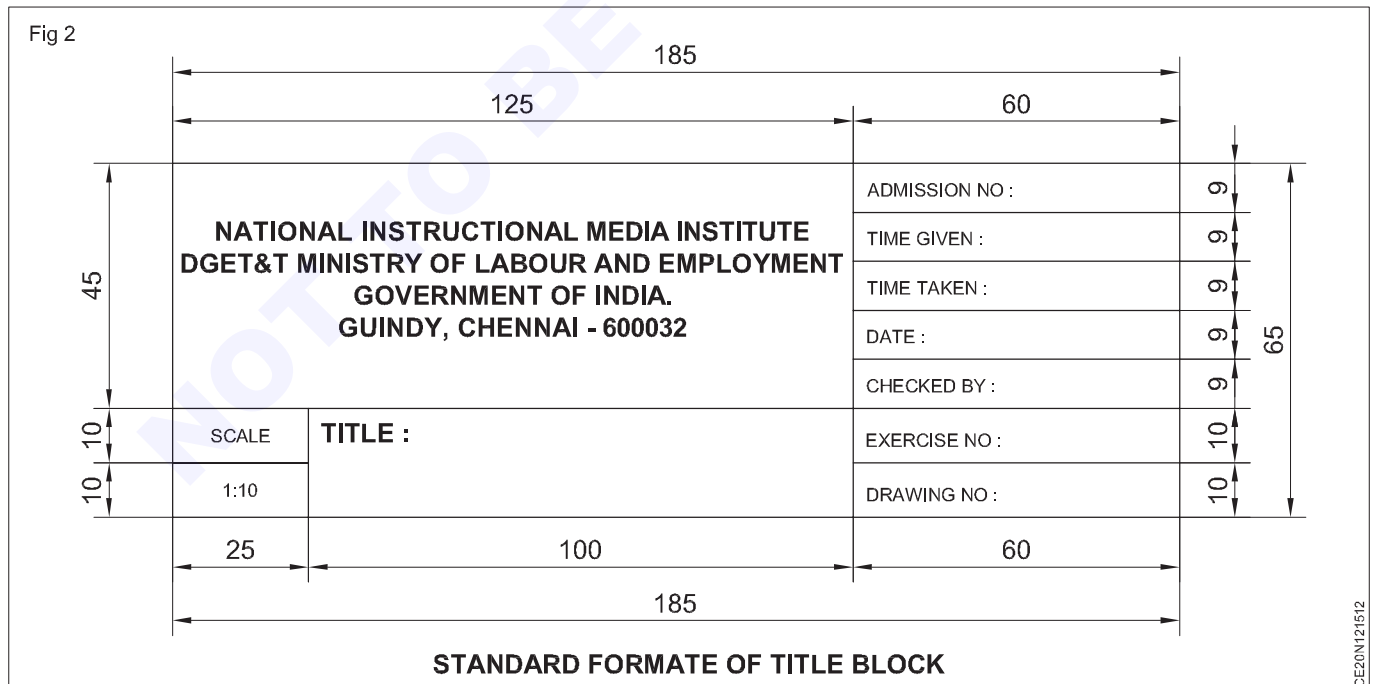
Right margin : 10 mm

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.

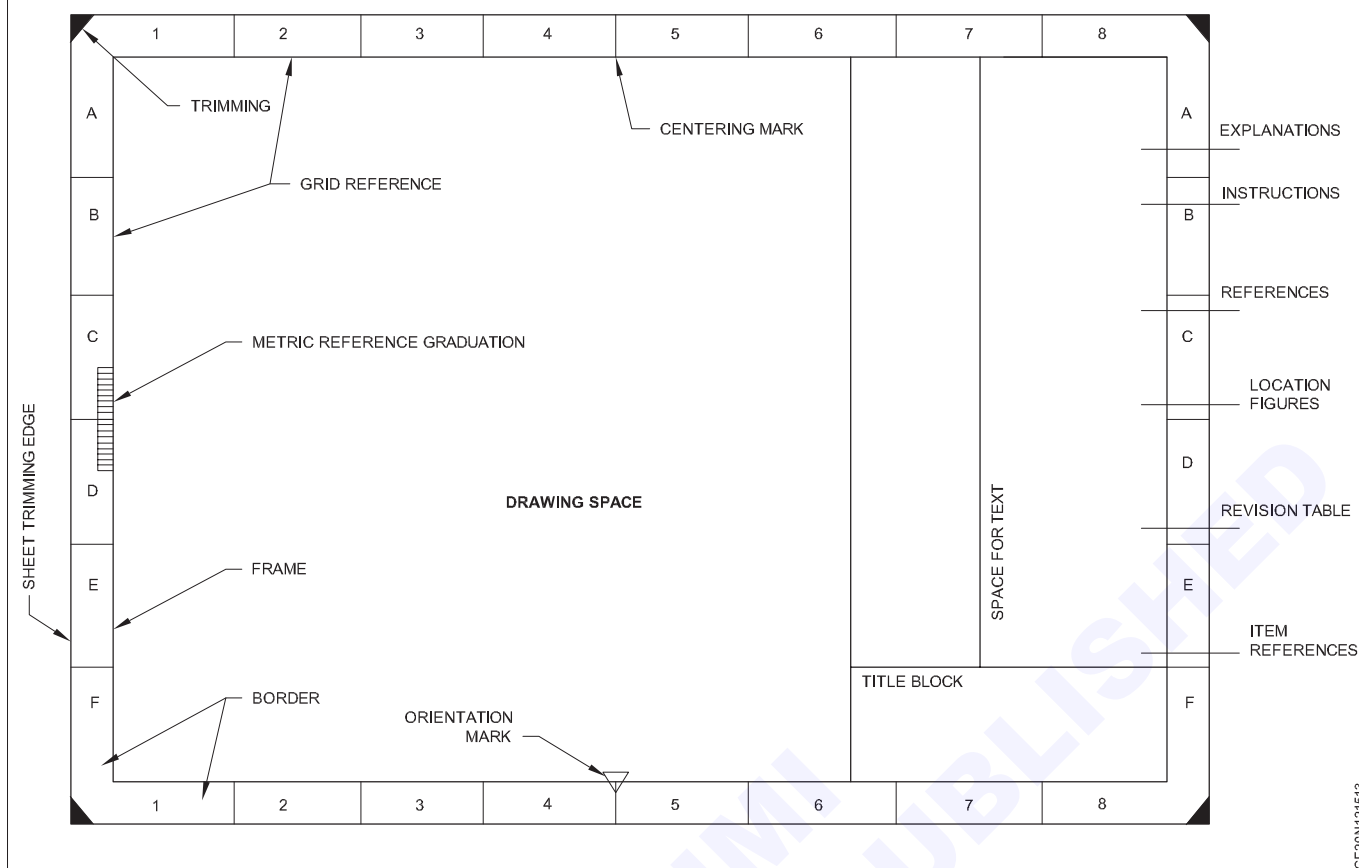


Spacing Drawing (Fig 3)

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 blocks.

Fig 3



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 inter section 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
D	Continuous (Straight) with zig-zags thin	D1 Line (see figure)
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 adjacent 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.

CE20N121521

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 - 1)

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 (Fig 1)

- 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.

Fig 1



CE20N121531

Dimensioning

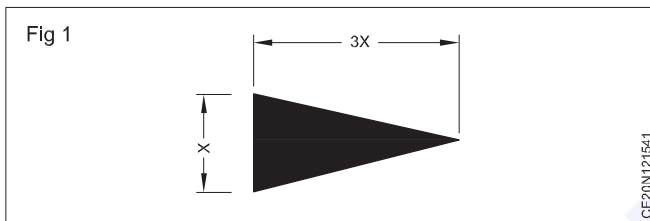
Objectives: At the end of this lesson you shall be able to

- 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)



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

Oblique strike and origin indication

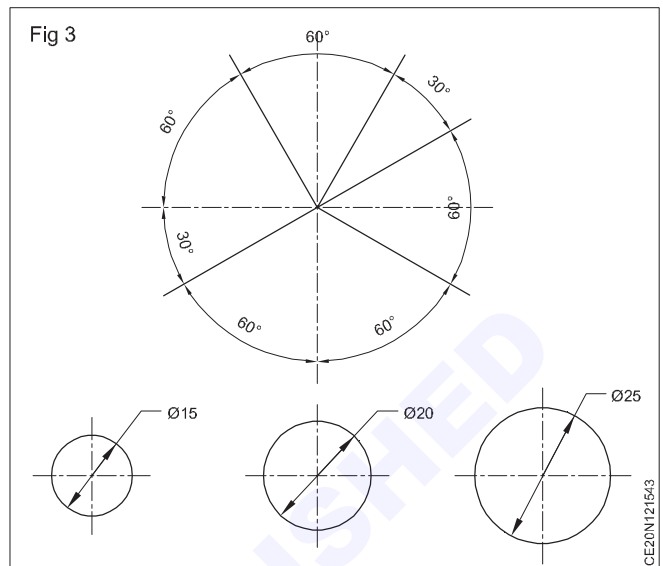
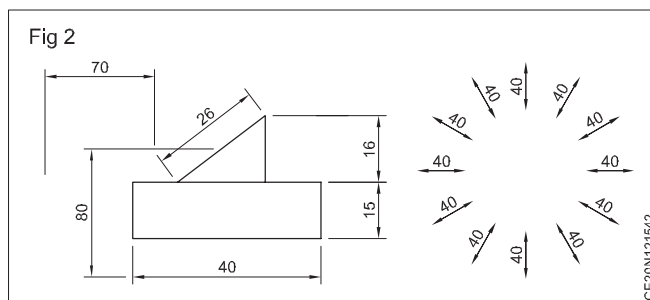
- 1 Where space is insufficient for arrowheads, oblique's stroke or dot may be used.
- 2 Oblique stroke is drawn as a short line inclined at 45 Degree. The origin indication is drawn as a small open circle of about 3mm Diameter.

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.
- 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.

Fig 4

The figure consists of two parts. The top part is a circular diagram with a circle divided into 12 sectors by 6 radial lines. The sectors are labeled with angles: 30°, 60°, 30°, 60°, 30°, and 60° in a clockwise direction starting from the top. The bottom part is a mechanical assembly diagram showing a rectangular base with a width of 45 and a height of 15. A vertical plate of height 30 is attached to the right side of the base. A diagonal plate of length 40 is attached to the top of the base, extending upwards and to the right.

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.

- 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

Technical drawing illustrating dimension line standards. The drawing shows a horizontal dimension line with an arrowhead on the left. The dimension value is 'XX'. The dimension line is labeled 'DIMENSION LINE'. The extension line is labeled 'EXTENSION LINE'. The gap between the extension line and the dimension line is labeled '3 MM'. The gap between the dimension line and the object is labeled '1.5 MM GAP'. The gap between the extension line and the object is labeled '8 MM'. The gap between the dimension line and the object is labeled '12 MM'. The gap between the extension line and the object is labeled 'XX'.

[illegible]

Knowledge of different types of scales and principle of R.F

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.

Introduction: 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,

$R.F = \text{distance on drawing} / \text{Distance on object}$

Reducing scale

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

$R.F = \text{distance on drawing} / \text{Distance on object}$

$$= 25\text{mm}/5\text{m}$$

=

$$= 1/200$$

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,

$R.F. = \text{Distance on drawings} / \text{Distance on object}$

$$= 50\text{mm}/10\text{mm}$$

$$= 5/1$$

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,

$R.F. = \text{Distance on drawing} / \text{Distance on object}$

$$= 30\text{mm}/30\text{mm}$$

$$= 1/1$$

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 1:500000

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

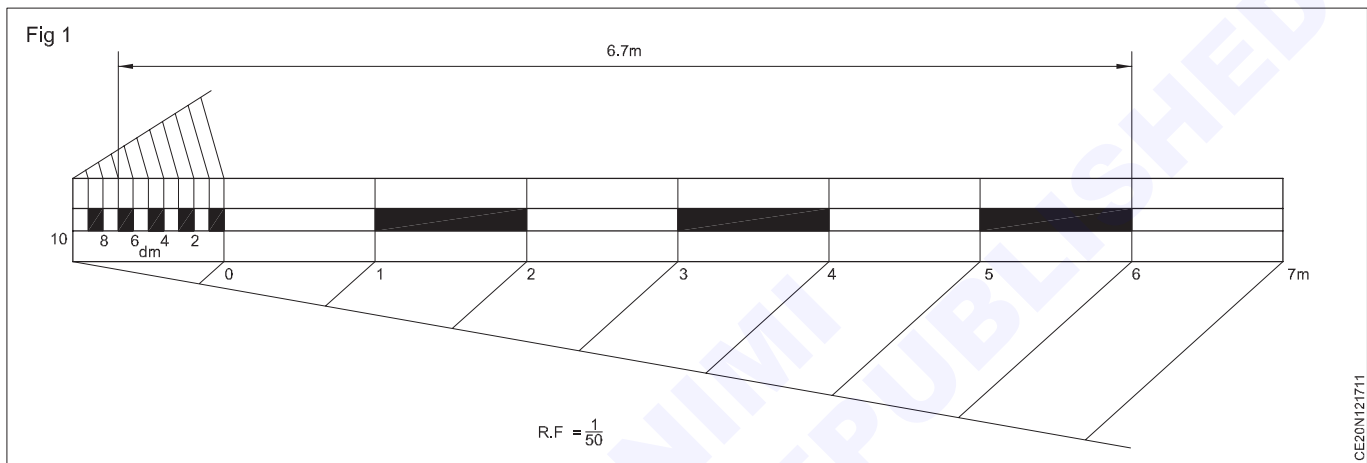
- Plain scale
- Diagonal scale
- Vernier scale
- Comparative scale
- Scale of chords (for angles)

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.



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.

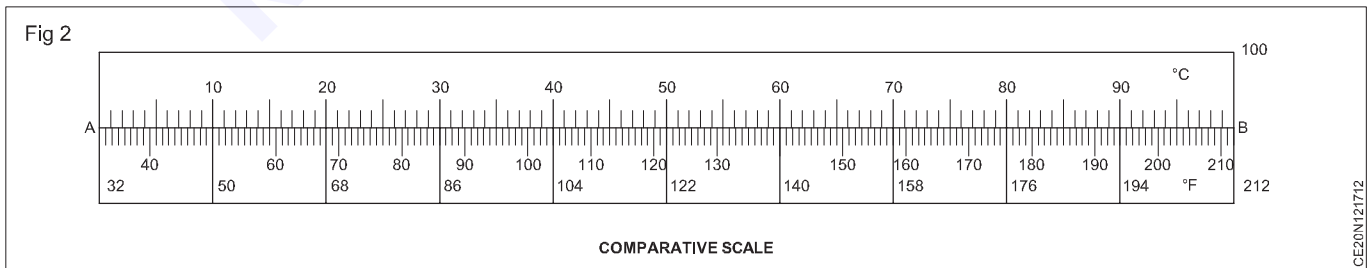
The length of the scale = RF x maximum length to be measured =

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, centigrade and Fahrenheit etc.

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



- 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

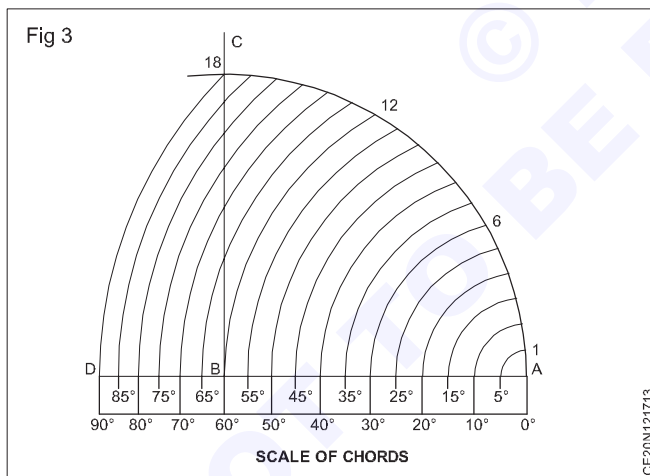
For the verification of the conversion using the scale use the following formulas.

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

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

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.



- 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

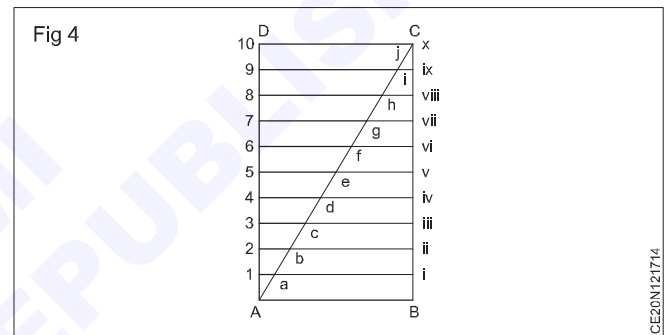
Principle of diagonal scale: Diagonal scale relies on a “diagonal” to divide a small distance into further equal parts.

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 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 of AB = 0.1 AB

Distance 2 - b is of AB = 0.2 AB

Distance a - i is of AB = 0.9 AB

Distance b - ii is of AB = 0.8 AB

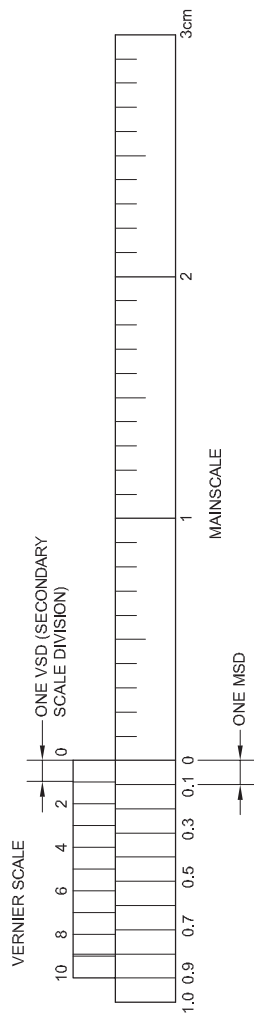
If AB is 1 mm then 1 - a will be 0.1 mm and 2 - b will be 0.2 mm.

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.

Fig 5



VERNIER SCALE LENGTH = 9 DIVISIONS OF MSD
LEAST COUNT = ONE MSD – ONE VSD

CE20N1217/15

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 depends 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.

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

Thereby one secondary scale (vernier) division is equal to

$$\frac{(n-1)\text{MSD}}{n} \text{ OR } \frac{(n+1)\text{MSD}}{n} \text{ as the case may be.}$$

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

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

According to Direct reading vernier

$$\begin{array}{lcl} 1 & \text{Main scale} & - 1 \text{ Secondary scale} \\ & \text{division} & \text{division (vernier)} = \frac{1}{n} \text{MSD} \\ 1 \text{ cm} & - & \frac{9}{10} = \frac{1}{10} \text{ CM} \end{array}$$

According to backward reading vernier

$$\begin{array}{lcl} 1 & \text{Secondary} & - 1 \text{ Main scale division} \\ & \text{division} & = \frac{1}{n} \text{MSD} \\ (\text{vernier}) & & \\ 1.1 \text{ cm} & - & 1.0 \text{ cm} = \frac{1}{10} \text{ CM} \end{array}$$

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.

Different types of projection views: orthographic, isometric, oblique and perspective

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

- define projection
- classify projections
- state the types of pictorial projection.

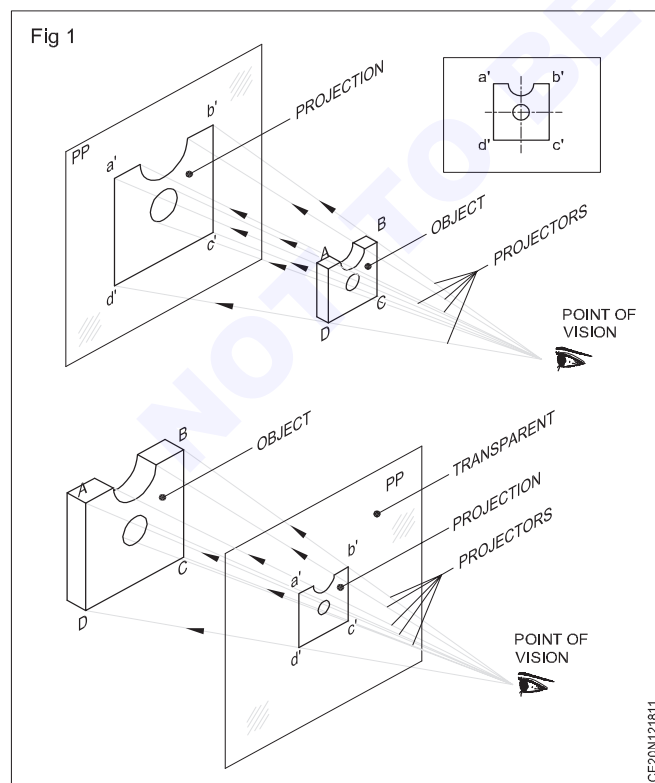
Introduction: As object, have three dimensions like length, width and height/ thickness. The shapes and sizes of three-dimensional objects have to be represented on a sheet of drawing paper, which has only two-dimensional planes.

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.

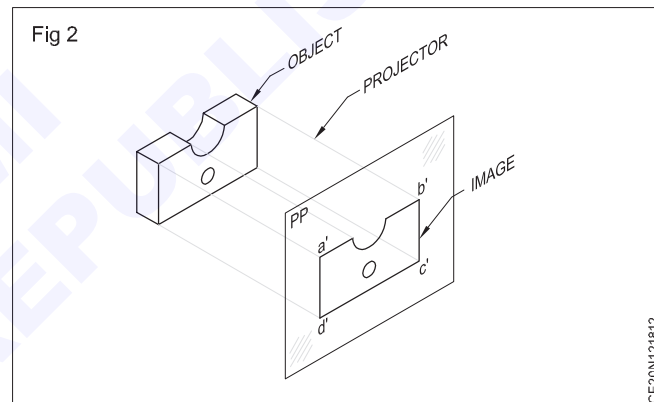
The figure formed by joining various points thus obtained on the plane, is the image of the object and is called Projection.

Projection: Projection is commonly used term in draughtsman's vocabulary. In the context of engineering drawing, projector 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 in between the eyes and the object by keeping a transparent plane. (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)



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

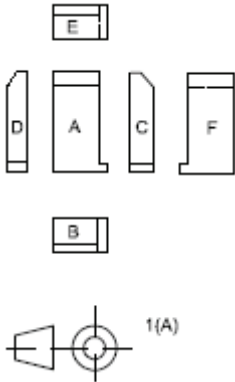
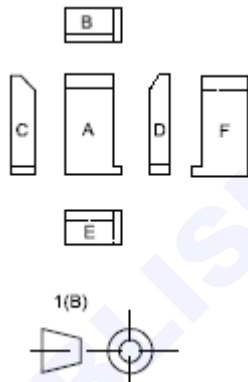
- Dimensions which are parallel to the direction of viewing will not be seen. Edges which are parallel to

- the direction of viewing is seen as points. Surfaces which are parallel to it are seen as lines.
- The visible edges and the intersection of the surfaces are shown by object lines. But the hidden edges are shown by dotted lines.

- The centre lines 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. With reference to the front view the other arranged as follows:  The view from above is placed underneath The view from below is placed above. The view from the left is placed on the right. The view from the right 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 distinctive symbol of this projection is Fig 1a	Arrangement of views in Third Angle Projection. With reference to the front view the other arranged as follows:  The view from above is placed above. The view from below is placed underneath The view from the right is placed on the right. 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 distinctive symbol of this projection is Fig 1b

- When a hole or a cylindrical part is 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 as an object line (visible outline)

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

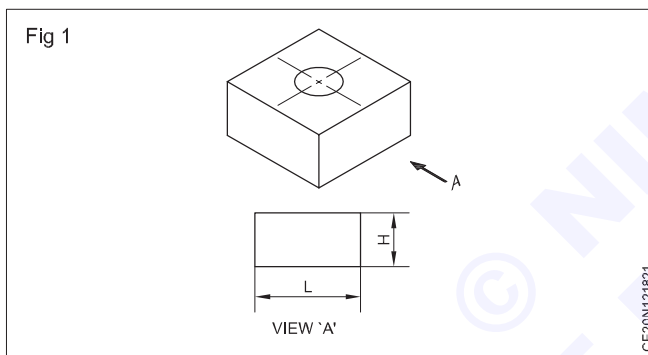
Objectives: At the end of this lesson you shall be able to

- 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 Fig 1 shows only the length and height of the object only.



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.

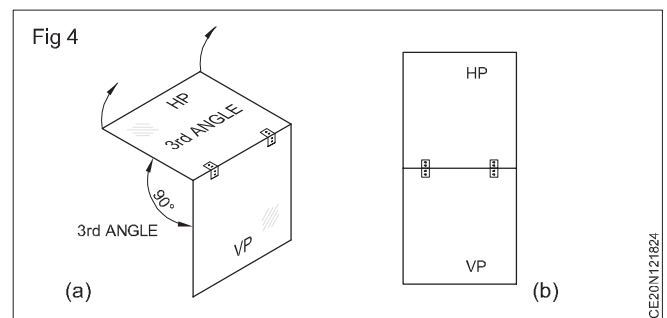
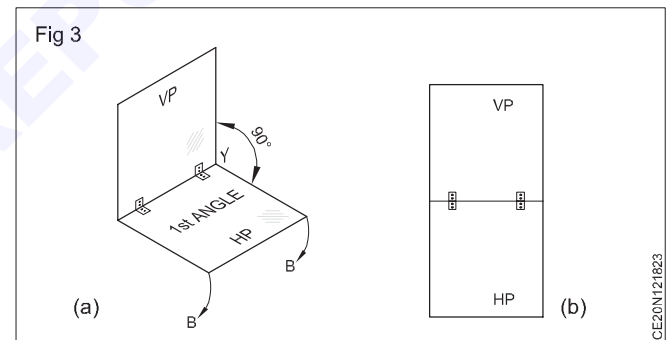
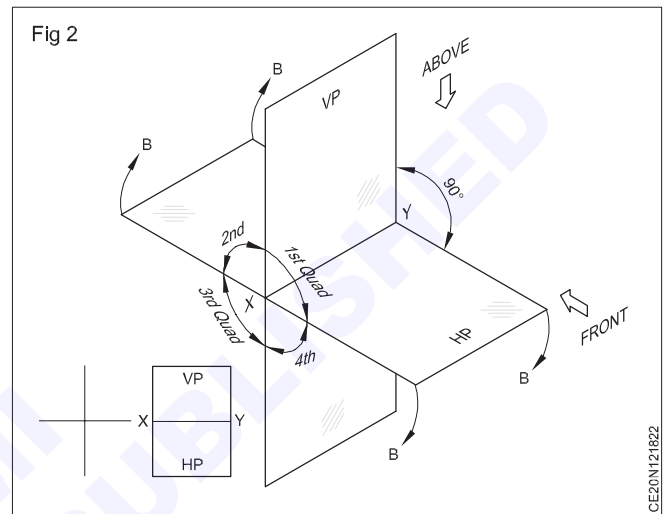
The two views thus required are to be obtained on two different planes which are mutually perpendicular (one HP and one VP) with the object remaining in the same position. The projection or the view obtained on the horizontal plane is called the top view or plan and the view obtained on the vertical 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 2)

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.

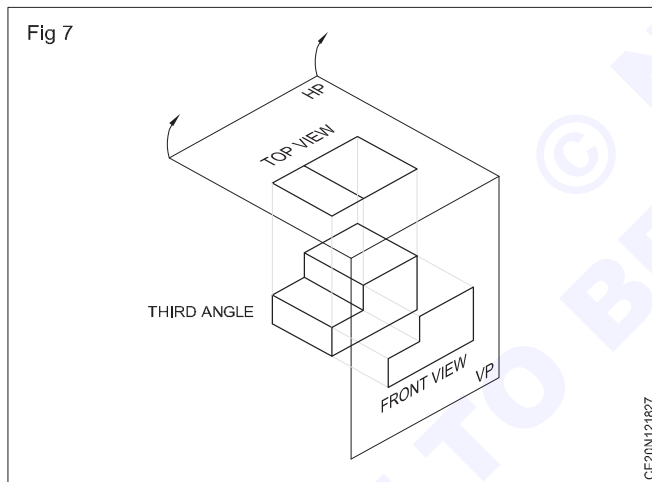
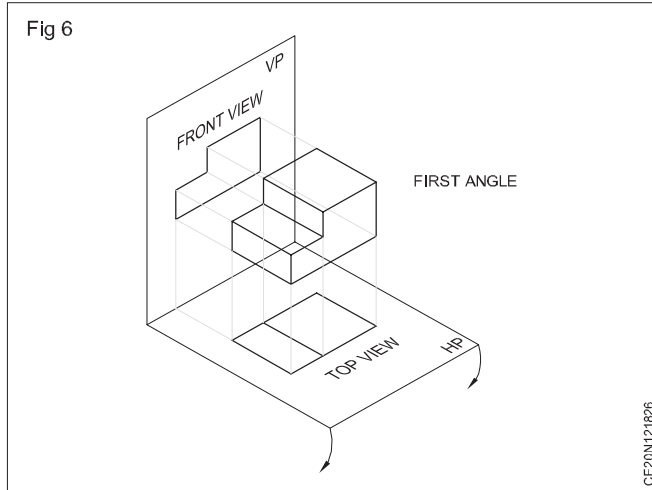
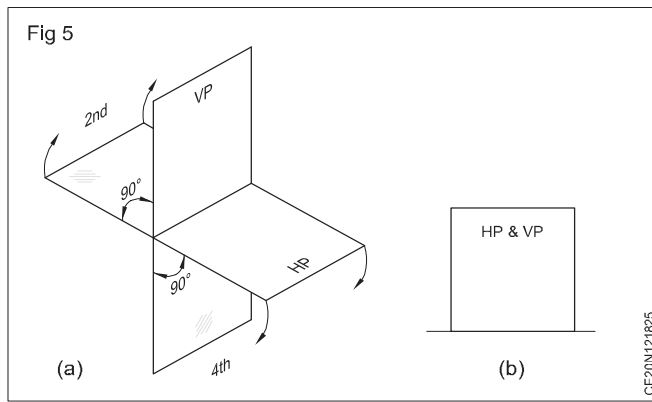
To draw two views of an object, we assume that the object is placed in any one of the quadrant/angles, 1st angle & 3rd angle Fig 3a, 4a and its plan and elevation projected to the respective planes. Now to

make 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.

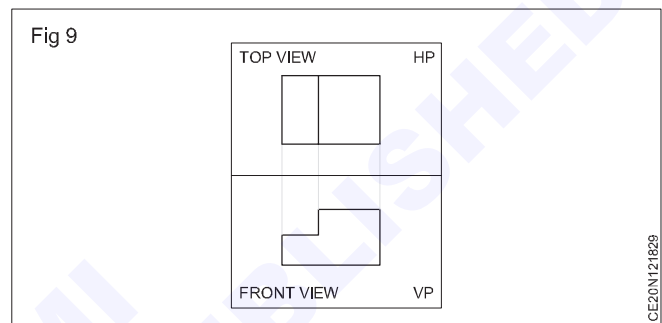
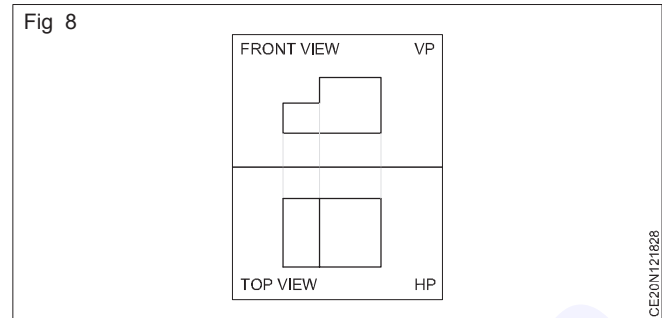


When the object is placed in the 2nd or fourth quadrant the plan and elevation will get super imposed (one up on the other)

Fig 5a & b. Due to this reason the 2nd and 4th angle is 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 6 & 7)



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 8 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 9)



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

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.

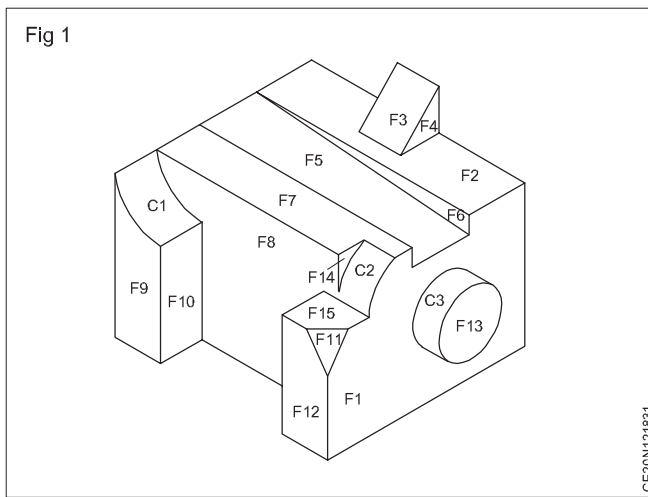
Types of surfaces (Fig 1): Surfaces may be flat or curved. Flat surfaces are also referred as planes. (Plain surfaces) Flat surfaces, depending on their orientation, may be vertical, horizontal or inclined. Fig 1 shows a solid and it has flat surfaces and curved surfaces. Flat surfaces are marked as F1, F2 etc.

Surfaces F1, F4, F6, F8, F9, F10, F12, F13 and F14 are vertical surfaces.

F2, F7 and F15 are the horizontal surfaces.

C1, C2 and C3 are the curved surfaces.

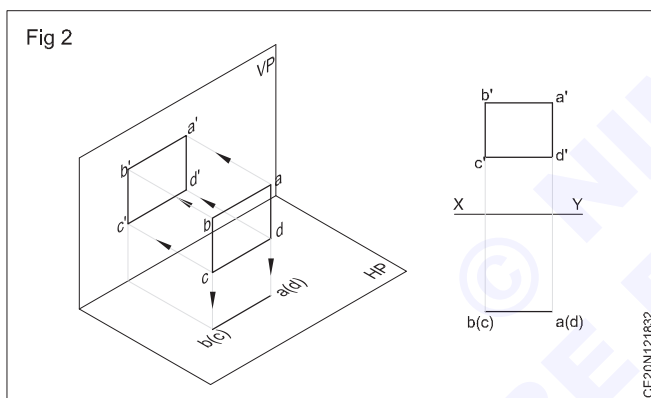
F3, F5 and F11 are inclined or oblique surfaces or their combination.



For example, in F3 is rectangular while F13 is circular. But surface F1 is a combination of several plane figure.

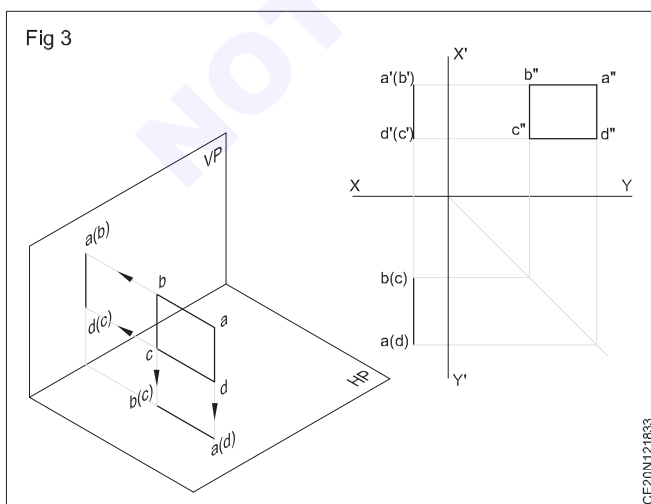
Projection of Flat surfaces: While drawing the projection of surfaces (plane figures) the following points should be noted.

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

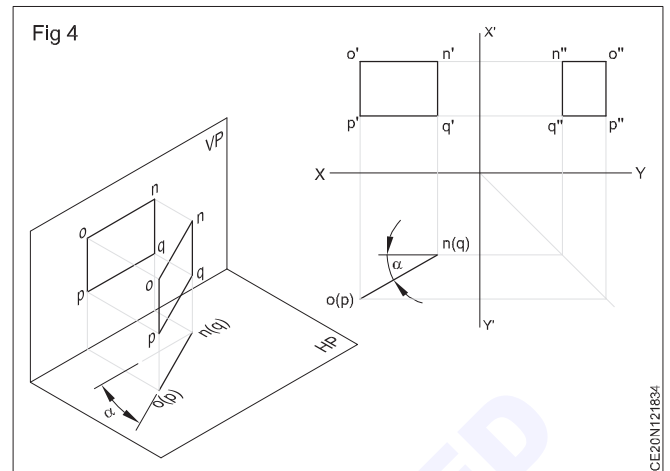


True shape: When the projection of a surface is identical to the surface projected, the projection is said to be of true shape.

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

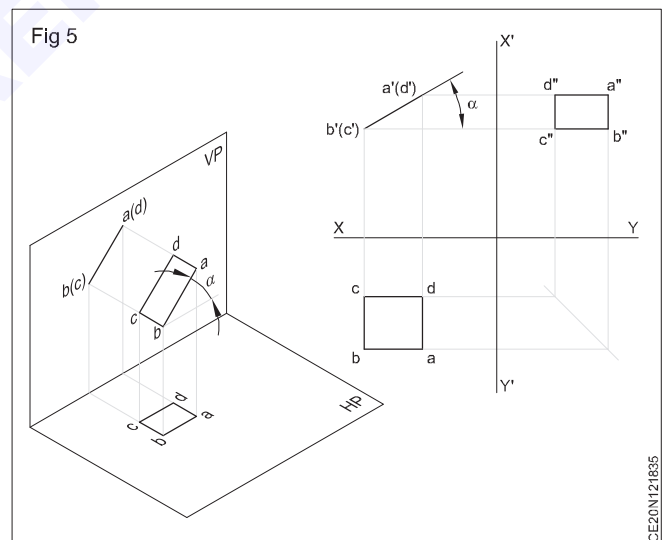


Foreshortened view: Where the projection of a surface is not identical to the surface projected, the projection is said to be foreshortened.

In figure 4, the length point or the length 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.

If a surface is inclined to horizontal plane the angle of inclination will be seen on VP and vice-versa. (Fig 5)

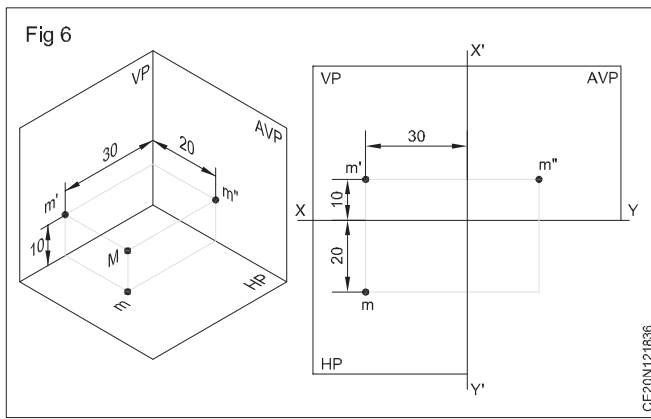


Guidelines to be followed: The intersection (folding lines) between HP and VP is marked as XY whereas the intersection between VP and AVP is marked as X'Y'.

In exercises/problems wherein the distances of the object (point, line, surface) from HP, VP and AVP are not given a convenient distance may be assumed and followed.

Terminology of views/projections (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 X'Y' 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 summarised 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'Y' 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.

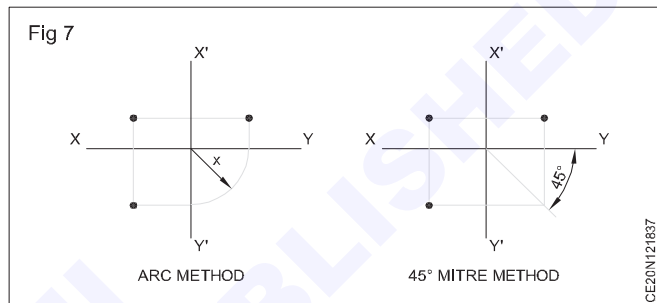
Distance 20 mm from VP is reflected in plan and side view.

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 transferring 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.

Following standard conventional markings are to be followed for points, lines and surfaces on plan, front view and side views.



	Final	just an alphabet	(a)
Plan	1st stage		(a1)
	2nd stage		(a2)
Elevation	Final	alphabet with	(a')
	1st stage	a dash	(a1')
Side elevation	2nd stage		(a2')
	Final	alphabet with	(a'')
	1st stage	two dash	(a1'')
	2nd stage		(a2'')

Isometric projection

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

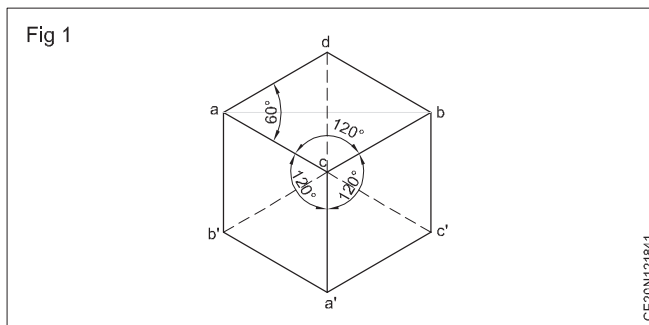
- state the method of isometric projection
- explain isometric scale
- explain box method of isometric view
- explain off set method of isometric view.

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:

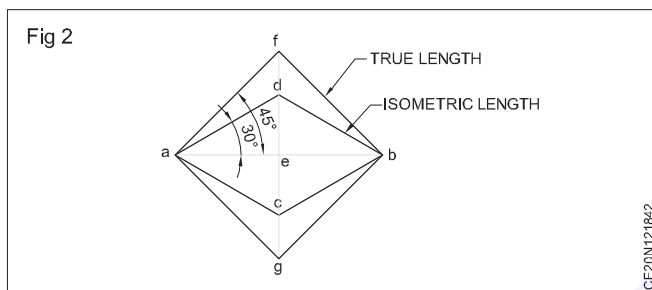
Consider the isometric projection of a cube. (Fig 1)



Separately draw the top face of the cube adbc and join the longer diagonal 'ab'. (Fig 2)

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 the cube as afbc.

Now superimpose the true top face afbg keeping the diagonal ab common. (Fig 2)



$$\angle FAE = 45^\circ \text{ and } \angle DAE = 30^\circ$$

$$\times AE = AF \times \cos 45^\circ \text{ and } AD = AE \div \cos 30^\circ = AF \times$$

$$\frac{\text{Isometric length}}{\text{True length}} = \frac{AD}{AF}$$

$$\frac{AD}{AF} = \frac{AF \times \cos 45^\circ}{AF \times \cos 30^\circ} = \frac{\cos 45^\circ}{\cos 30^\circ}$$

$$\frac{AD}{AF} = \frac{AF \times \cos 45^\circ}{AF \times \cos 30^\circ} = \frac{\cos 45^\circ}{\cos 30^\circ} = 0.8165$$

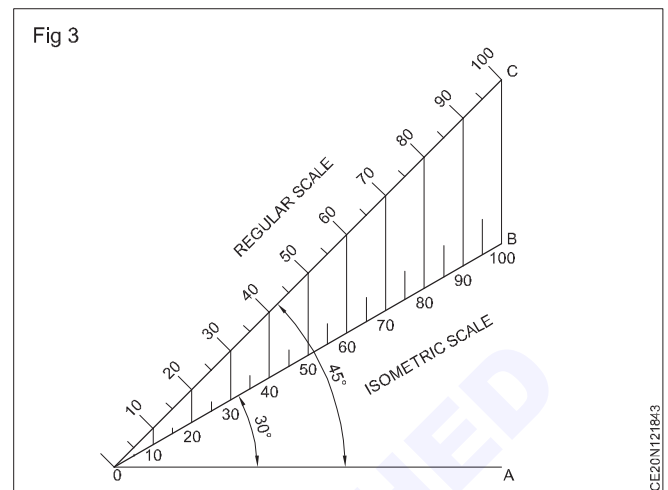
$AD = 0.82 AF$. This means that the length of a line in isometric projection is 0.82 times of its true length. While drawing an object in isometric projection, the dimensions on or parallel to isometric axes are reduced to this proportion. To make things easier we can construct a scale to the above ratio. Such a scale is called as isometric scale.

Procedure to construct

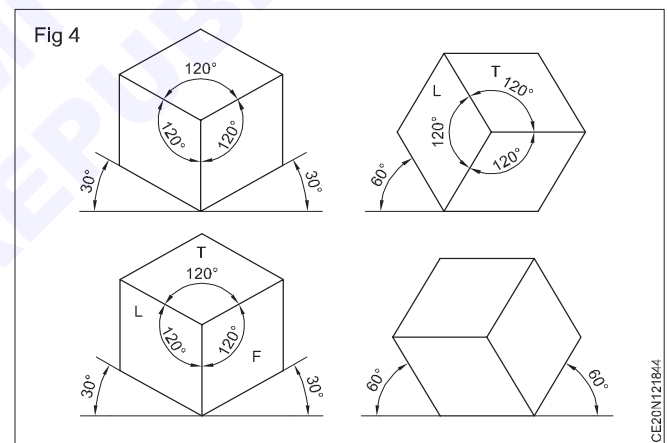
Isometric scale (Fig 3)

- Draw a horizontal line OA.
- Draw lines OB and OC making 30° and 45° with OA respectively.
- Mark 5 mm, 10 mm, 15 mm up to 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 shows 3 of the 6 faces (left, right, top, bottom, front and rear) are shown in different combinations.

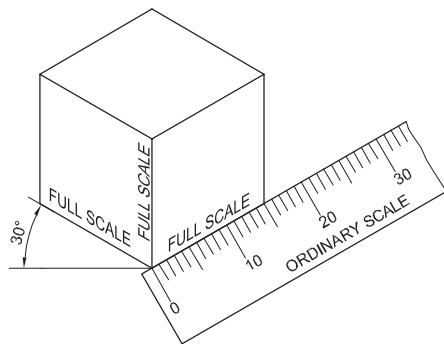


Isometric view and Isometric projection: A drawing is made with true lengths (dimensions) is called isometric view or isometric drawing. Whereas the same drawing made with isometric lengths is termed as isometric projection. (Fig 5)

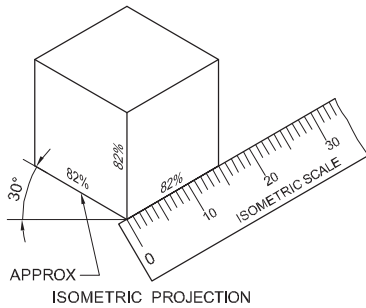
Isometric and non-isometric lines: Fig 6 shows the isometric view of a shaped block. Here all lines except AB, BC and DE are parallel to isometric axis. Lines such as those which are parallel to isometric axes are called isometric lines whereas such as lines AB, BC and DE which are not parallel to isometric axes are called non-isometric lines.

The length of non-isometric lines will not follow the scale used for isometric lines. To prove 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.

Fig 5



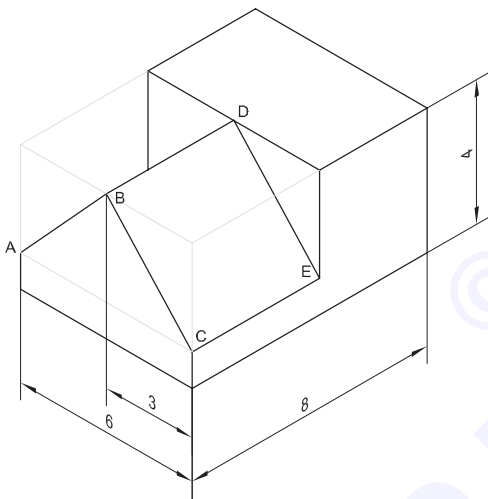
ISOMETRIC DRAWING



APPROX ISOMETRIC PROJECTION

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Fig 6



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To locate the end points and to draw the non-isometric lines two methods are employed. They are

- 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.

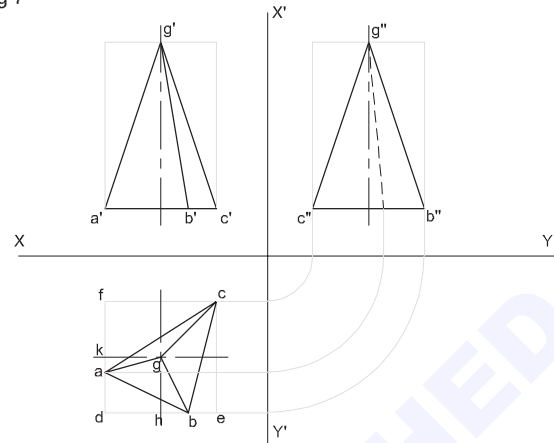
These methods are not only useful for isometric views involving non-isometric lines but also for the isometric views involving isometric lines.

Box method of drawing a pyramid

Example

Draw an isometric view for the triangular pyramid shown in Fig 7 using a box method.

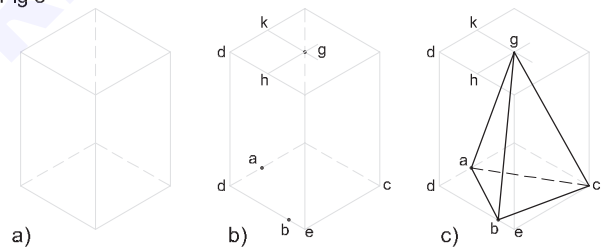
Fig 7



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- 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)
- Join the points AB, BC, CA, AG, BG and CG and complete the isometric view of the pyramid in box method. (Fig 8b)

Fig 8



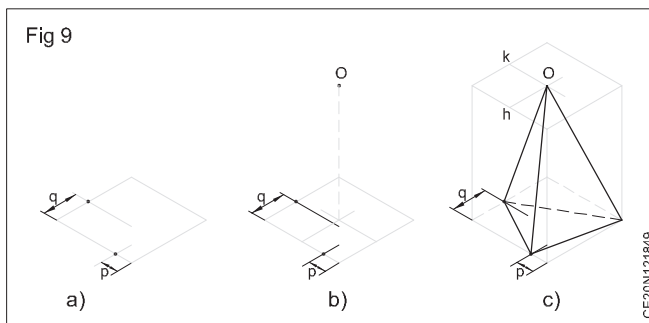
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Off-set method of drawing a pyramid

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 O1 on the base by offsets x and y and draw the vertical centre line O1O to the height of the pyramid. (Fig 9b)
- Join 1-2, 2-3, 1-3, O1-1, O1-2, O1-3 and complete the isometric view of the pyramid. (Fig 9c)

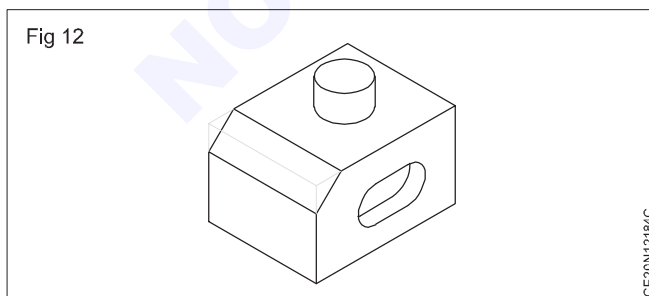
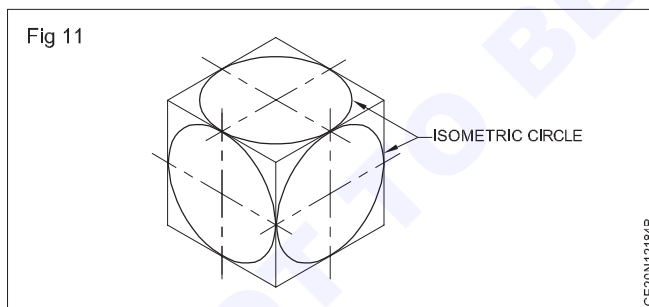
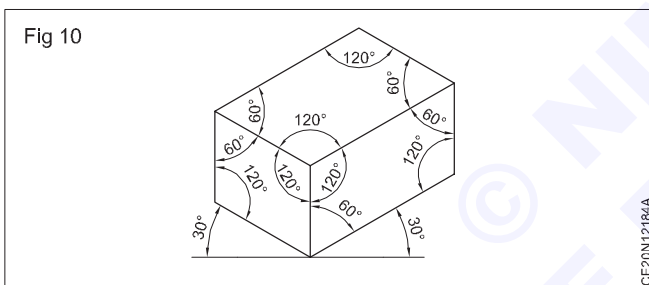


Angles in isometric projection: The angles of inclined surfaces will not have true value in the isometric projection, but will be more in some cases and less in other cases.

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.

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. (Fig 12)

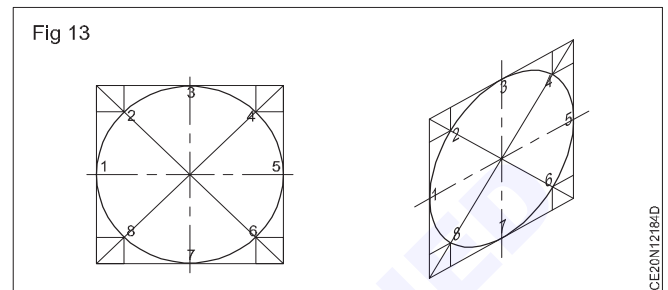
An isometric circle can be drawn either by plotting/offset method or by arc method.



Plotting method (Fig 13)

- 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 form an ellipse.

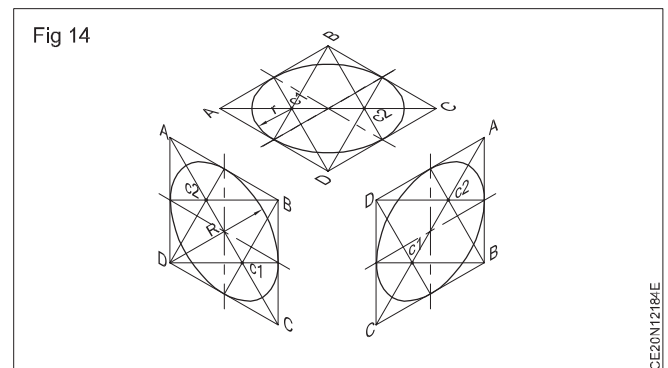


Note: The orientation of the isometric circle will depend upon the plane on which the circular feature exists.

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 are C1, C2, B & D. While centre B and D are the corner of the rhombus C1 and C2 are intersection points of the longer diagonal with lines from points B or D to the mid point of the side of the rhombus.

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.

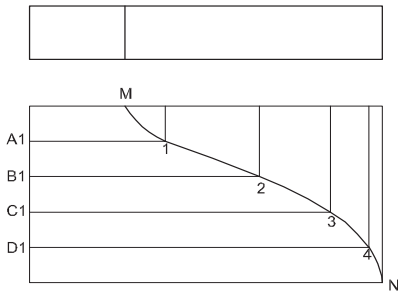


The isometric circles can also be drawn using templates which can be bought from stationary shops.

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.

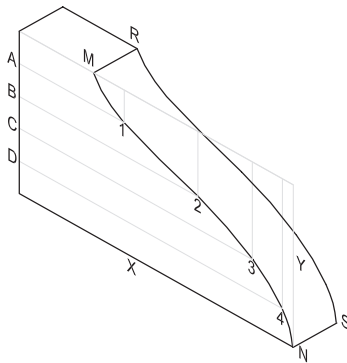
Note: In offset method more the number of points, better will be the accuracy of the curve.

Fig 15



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Fig 16

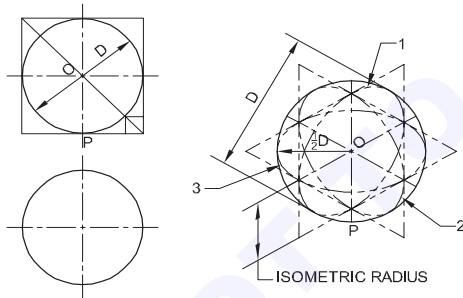


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Isometric projection of sphere: The Orthographic view of a sphere seen from any direction is a circle of diameter equal to the diameter of the sphere. Hence, the isometric projection of a sphere is also a circle of the same diameter.

The front view and the top view of a sphere resting on flat surface are shown in Fig 17a.

Fig 17



CE20N12184H

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.

Again, assume a horizontal section through the centre of the sphere.

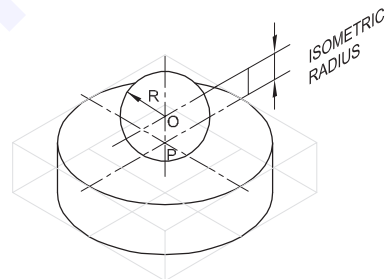
The isometric projection of this circle is shown by the ellipse 3, drawn in a horizontal position around the same centre O. In all the three cases 1, 2 & 3 the outermost points on the ellipse from the centre O is equal to $\frac{1}{2} D$.

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. (Fig 18)

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 18



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Oblique projection and perspective view

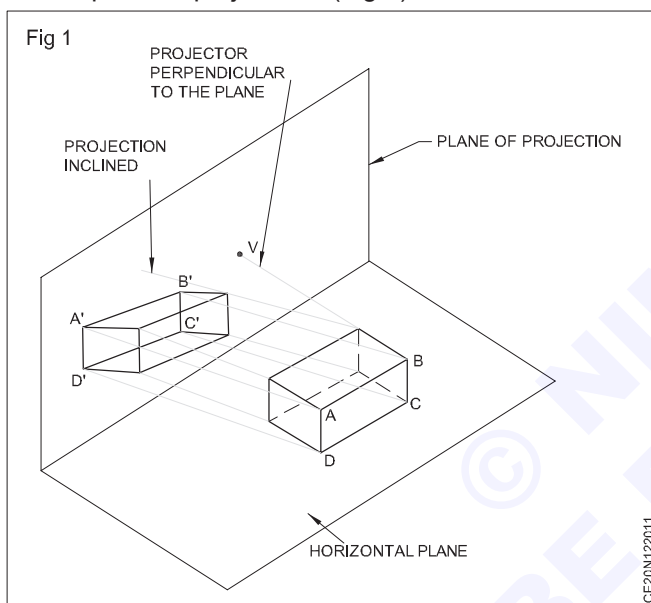
Objectives: At the end of this lesson you shall be able to

- state what is an oblique view, angle and uses
- list the hints on positioning and drawing oblique views.

Oblique projection

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)

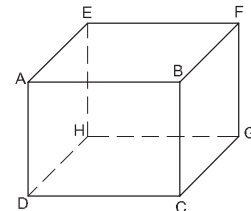


- In an oblique projection one of the principal faces of the object is kept parallel to the plane of projection, but in isometric, none of the faces of the object is parallel to the plane of projection.

Even though one of the faces of 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 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.

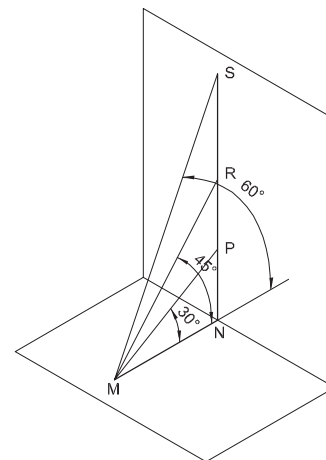
Fig 2



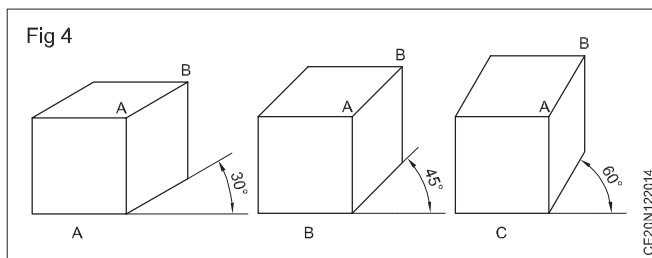
Projection of edges such as AE, DH, BF and CG which are perpendicular to the plane of projection will measure differently depending on the angle of inclination of the projectors. If the inclination of the projectors is 45° the projections of these edges measure to their true lengths. If the angle is 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.



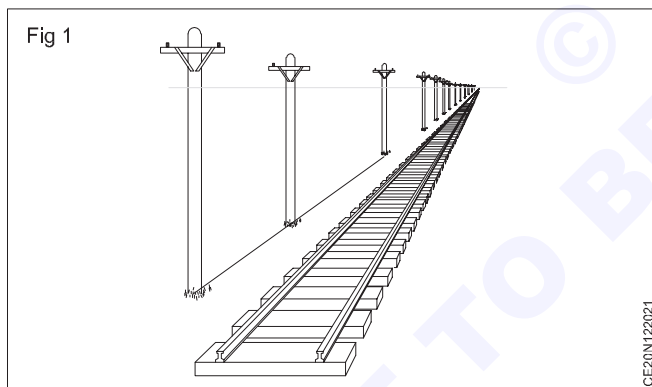
Oblique projections nevertheless have an unique advantage what we want to make pictorial drawings of object having curved features. For making isometric views of a curved feature we have first to draw their orthographic views in order to find out the offsets of points lying on the curve. But this difficult procedure is not necessary in the case of oblique views.

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)

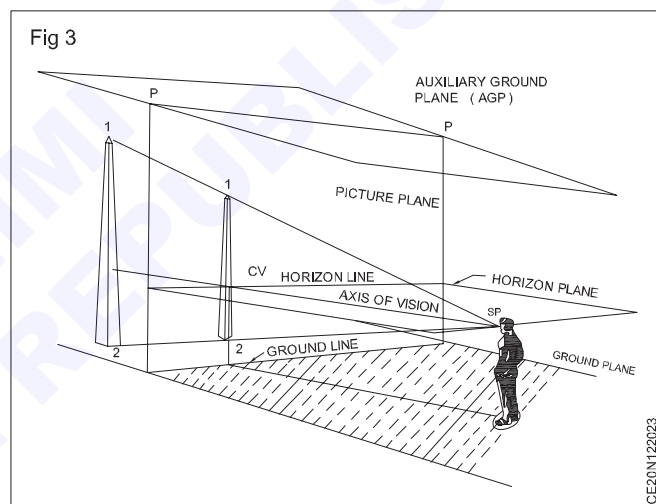
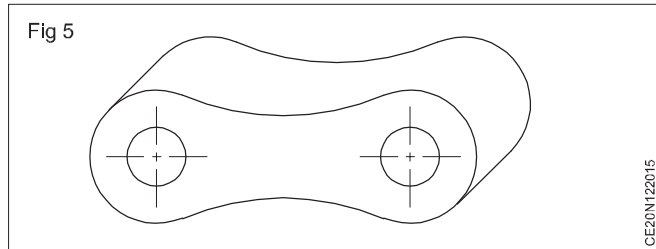
Ground plane (GP): It is the horizontal plane on which the object is assumed as resting on which the observer stands.

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.

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.



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.

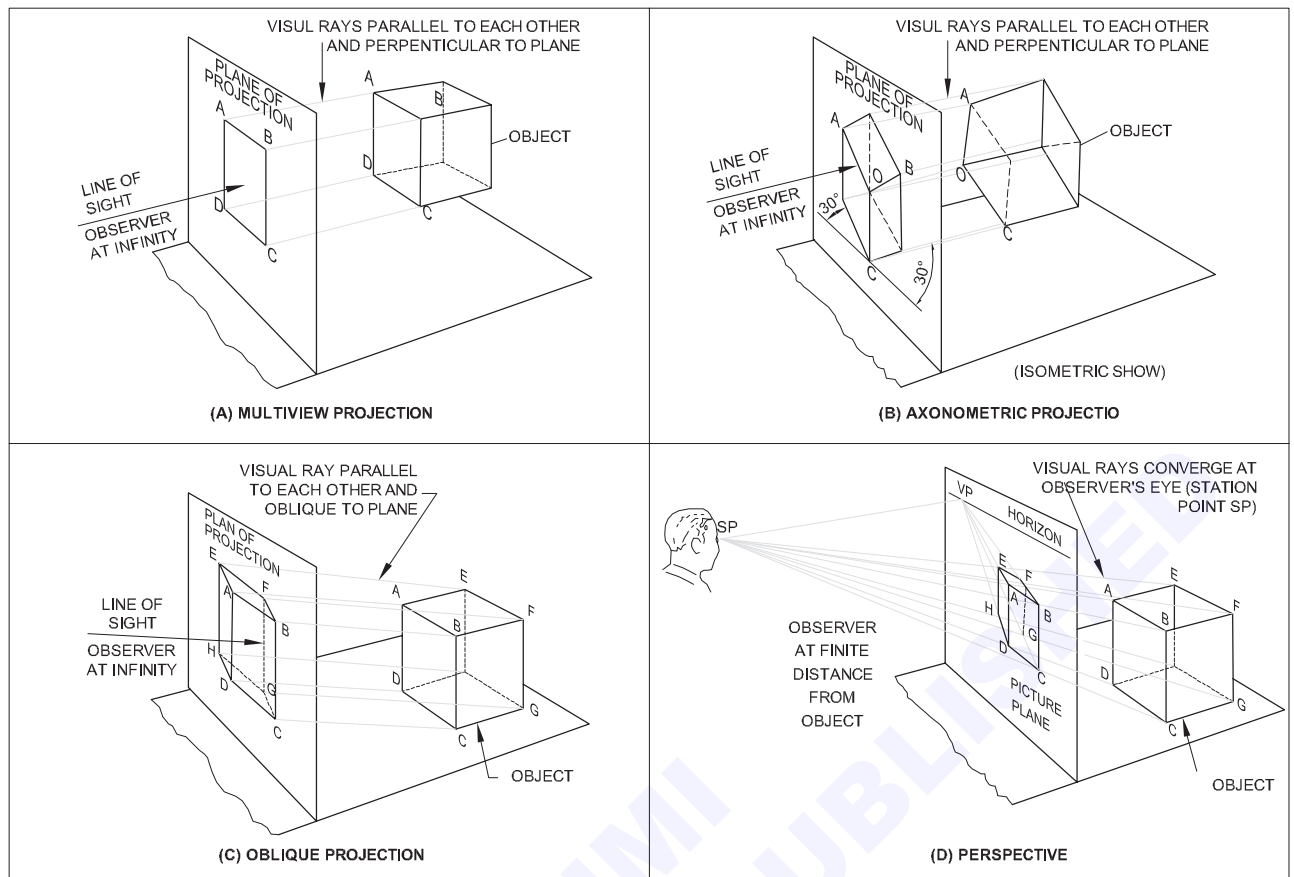
Horizontal line (HL): It is the line of intersection of horizontal plane and the picture plane.

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

Fig 2



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of vision. It is perpendicular to the picture plane as well ground plane.

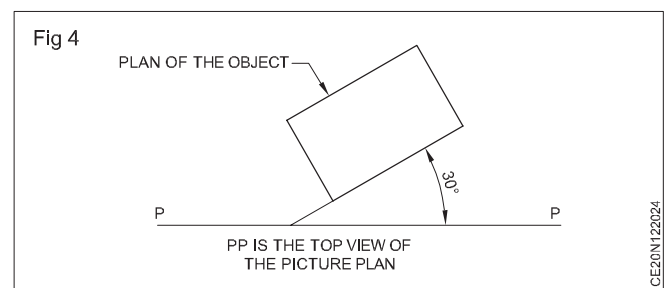
Position of station point: Station point is the viewing point and its location should be where the object can be viewed to the best advantage.

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° . If this angle is very wide, the picturisation may not be good.

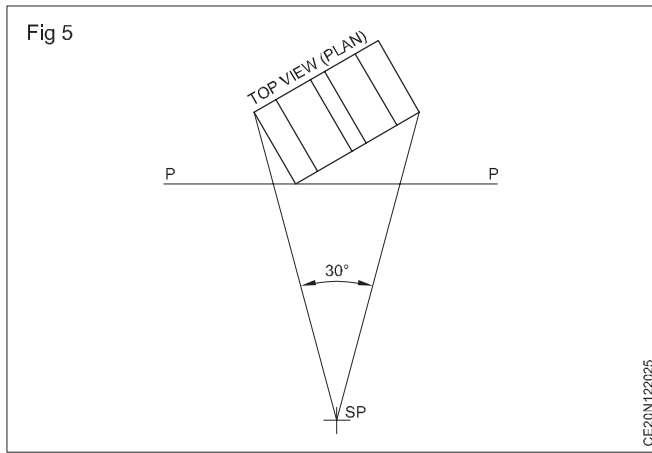
Position of object

- 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)



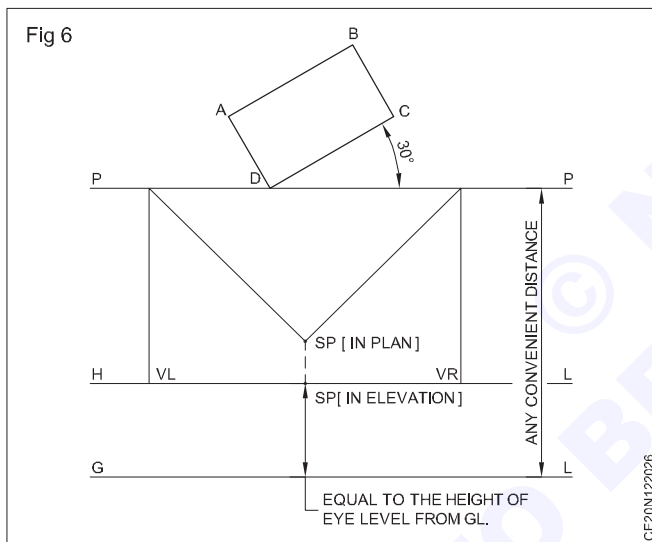
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The position of the picture plane with reference to the object determines the size of the perspective view. When the object is placed behind the picture plane, the view is reduced as it is moving towards the picture plane, the view increases. When 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. (Fig 5)



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).

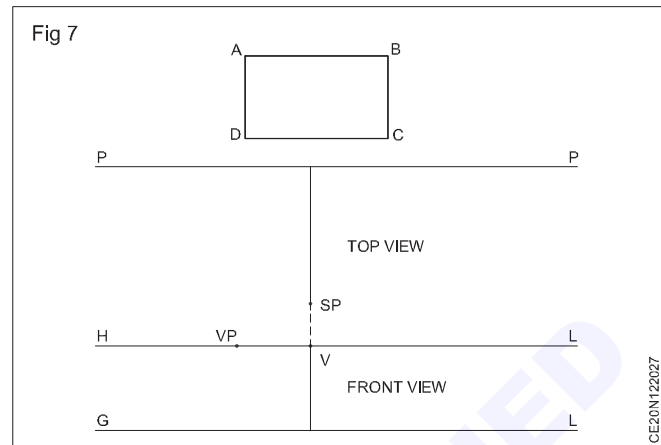
Procedure for determination of vanishing point

- 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)



- Mark the top view of the SP. This will be below the line PP. The picture plane is in between 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 are 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 faces 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 are 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

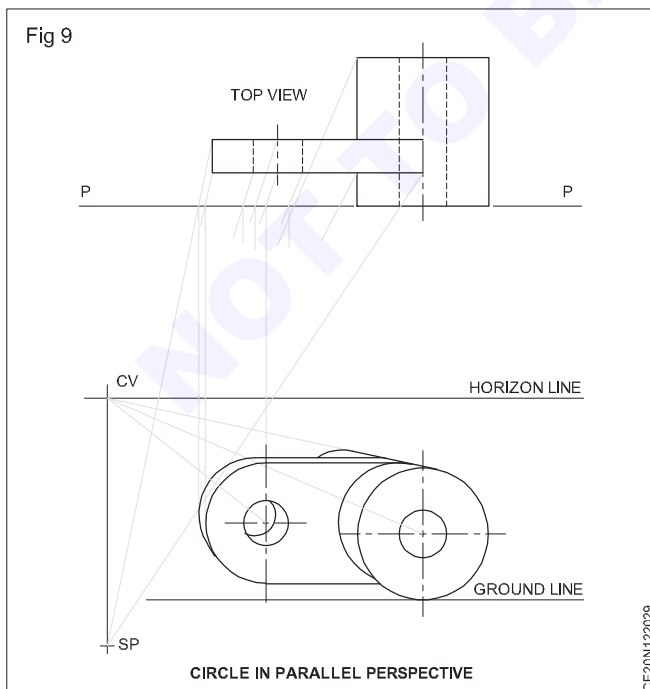
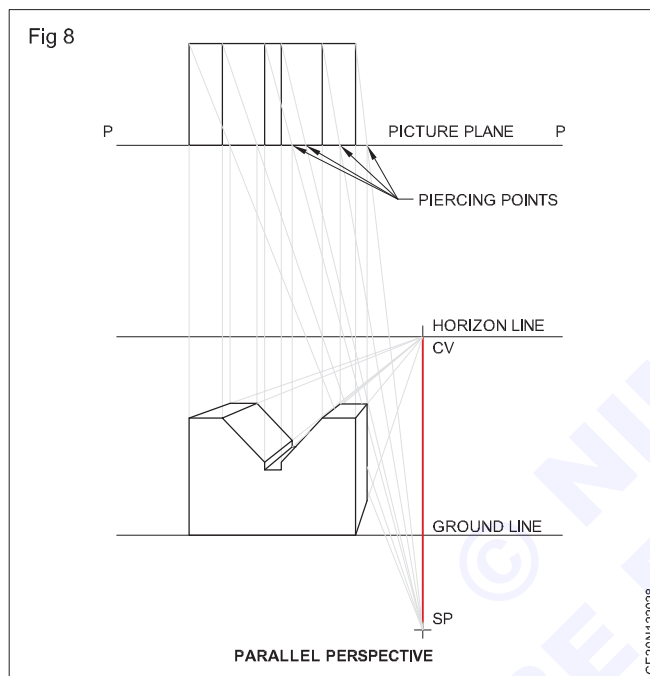
Depending on the position of the object relative to the picture plane vanishing point method is further classified as

- One point perspective

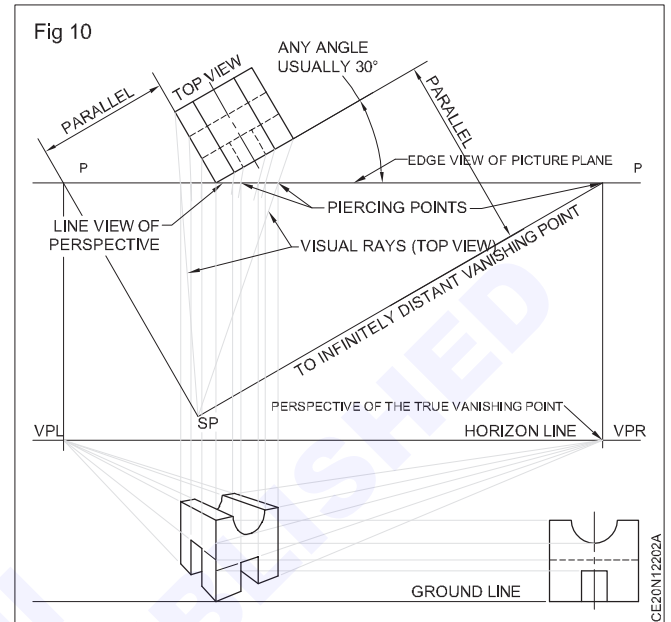
- Two point perspective
- Three point perspective

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).

One point perspective has the similar advantage as oblique drawings in the sense that we can draw curved features parallel to the picture plane and draw the circular features using compass.



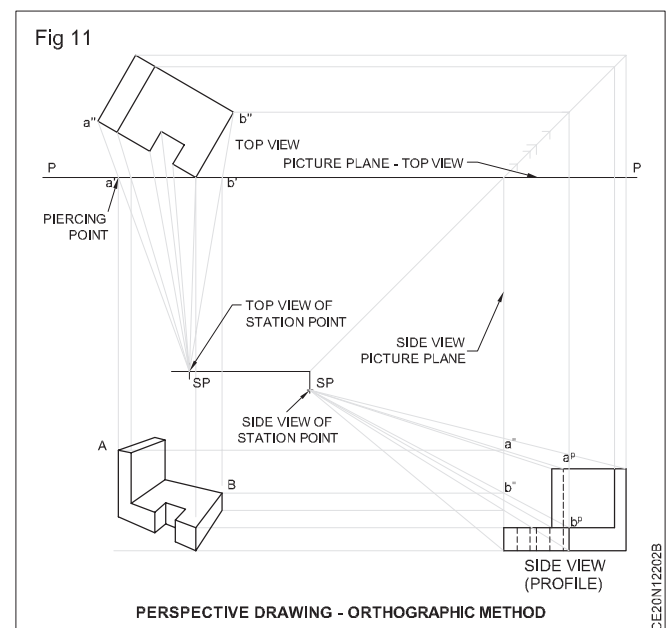
Two point perspective (Fig 10): Also called as angular perspective. In this method of construction, the vertical faces of the object are at an angle to the picture plane while the bottom face to parallel to the ground plane. As these are two sets of parallel edges, two vanishing points are required for this construction. Examples of two point/angular perspectives are shown in figures.



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)



Introduction of timber, defects, diseases of timber, seasoning, preservation, alternative material to timber, tar, bitumen and asphalt

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

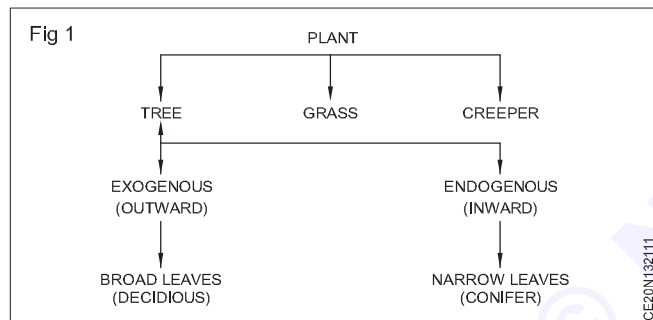
- state the introduction of timber
- explain the structure of timber trees, diseases and defects
- describe the process of seasoning and preservation
- explain wood based products for plywood, black board, particle board, MDF and FRP.

Introduction of timber

Timber is one of the important engineering materials. It finds its extensive use in building and other industries. The general study of timber will be helpful for better understanding of various processes a timber undergoes during its transformation into a product of actual use.

Types of trees

According to their mode of growth trees are divided into two categories (Fig 1)



Endogenous trees

Endogenous trees are those which grow inwards by depositing each tree layer internally.

Leaves of these trees needle shape.

The most common example of endogenous trees is bamboo, palm and coconut tree.

Exogenous trees

Those trees which grow (outward) by the addition of new layers of wood on the outside of the tree trunk and branches.

Leaves of these trees are broad shaped.

The most common example of exogenous trees is sal, teak and deodar.

Another important classification of timber is dicotyledons (hard woods) and conifers (soft woods).

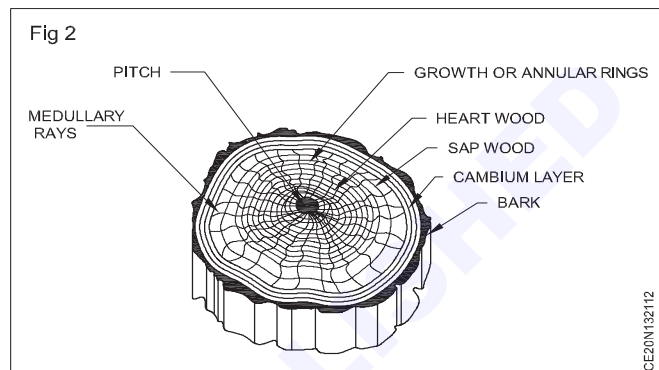
Cross-section of exogenous tree trunk and different parts of a tree (Fig 2)

Pith or medulla

Pith or medulla is the centre of or heart of the tree.

True wood or heart wood : It is the fully developed wood which surrounds the pith.

Heart wood thus increases in size as the tree ages.



Sap wood: This often surrounds the true wood (or) heart wood which is softer and lighter in colour.

Cambium layer

It is a layer of specialised cells immediately beneath the bark.

Bark

The outer most layer that can be distinguished is the bark. The main function of the bark is to give protection to soft tissues of wood.

Annular ring

Annular rings are layers of wood usually formed each year. The number of rings in a tree indicates the age of the trees.

Medullary rays

These are rows or build of cells running radially from the cambium layer to the pith or intermediate growth rings.

Defects in timber

Natural defects occur in all kind of timber depending upon the soil upon which they grow and climatic conditions to which they are subjected while growing.

A defect in any irregularities occurring in or on the timber

Defects reduce strength, durability or utility value of the timber.

Common defects

Case hardening

Is a condition of the outer layer of timber is abnormally hard?

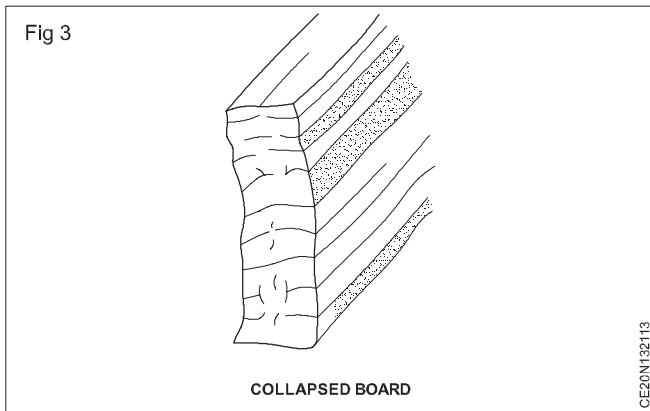
Caused by incomplete seasoning and this outer layer is dried too quickly.

Check

Check is the separation of the wood extending for a few (inches) centimeter along the grain and formed while drying.

Collapse

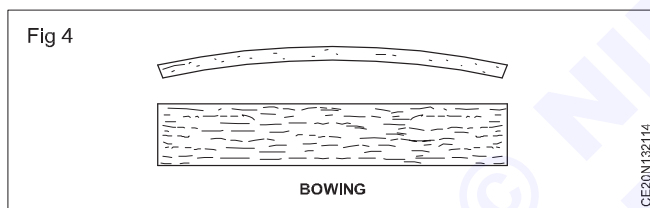
A flatter of the cells may be due to excessive or uneven drying. (Fig 3)



This may be prevented if drying in low temperature.

Bowing

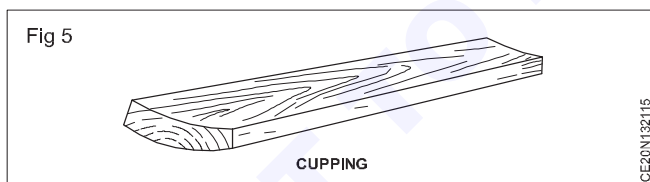
A curvature from plane along the wide surface of the board. Caused by uneven shrinkage and uneven drying during seasoning. (Fig 4)



Board not being out parallel to the growth rings.

Cupping

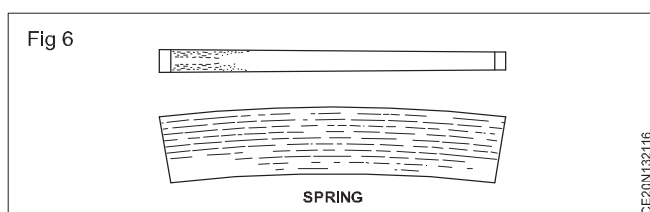
A simple curvature across the width of board due to greater shrinkage on the concave side. (Fig 5)



It is more pronounced in back sawn boards. The curvature is usually away from the heart

Spring

A curvature along the edge of the board. (Fig 6)
Not affecting the face, the face remaining flat caused by uneven shrinkage and poor drying of the timber.

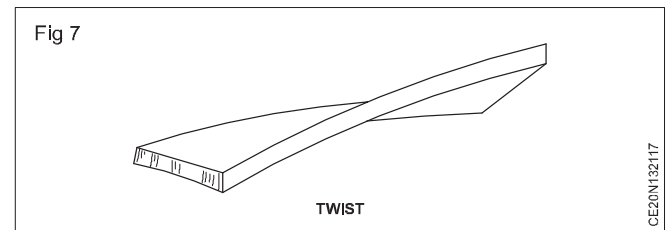


Twisted fibers

This defect is due to the tree being twisted constantly in one direction by the force of prevalent wind.

A spiral distortion along the length of the piece of timber.

This may cause by uneven shrinkage due to uneven drying. (Fig 7)



Warp

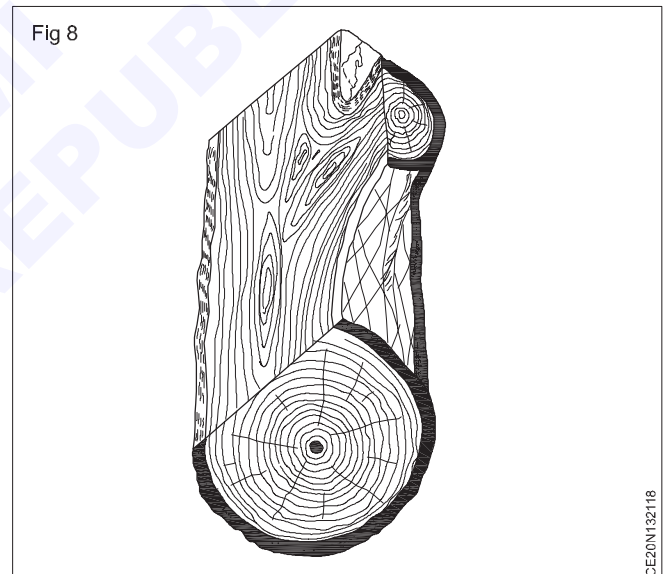
Any variation from a true flat surface (not perfectly flat).

Knots

Caused by a branch or limb being cut through during the process of sawing up the log.

They may live or dead but break the continuity of fibers.

Generally these are distinct defect either in appearance or weakening the wood. (Fig 8)

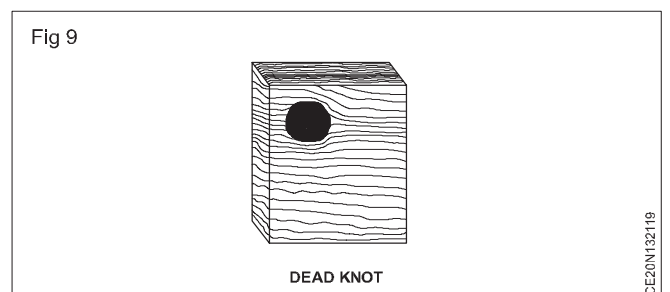


Loose or dead knot

Left by branches that have been cut off or broken before felling.

It is loose in position on the surface of the piece.

It cannot be relied on to remain in position in the piece. (Fig 9)



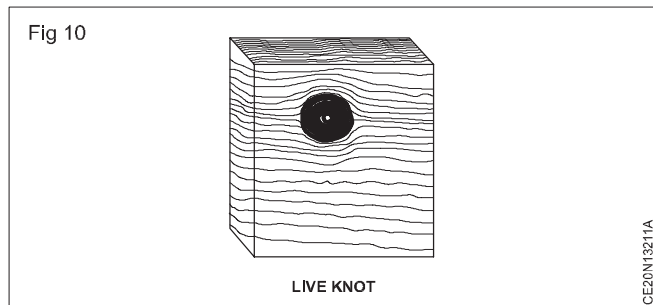
Live or sound knot

It is left by a branch when the tree is felled.

It is solid across its face and hard as the timber surrounding it.

It is free from decay

Knots are considered to add beauty and effect in the final appearance. (Fig 10)



Shakes

Is the partial or complete separation between adjoining layers of wood.

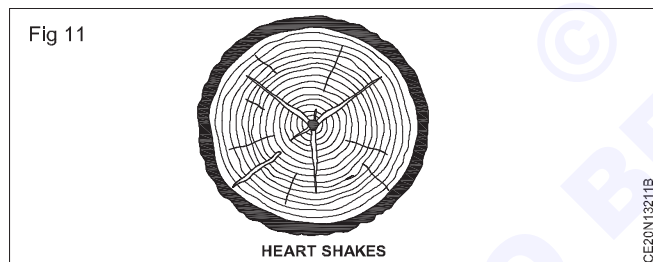
Due to the relief of growth stresses present in the stem at the time of felling.

To impact of the tree with the ground.

Heart shake

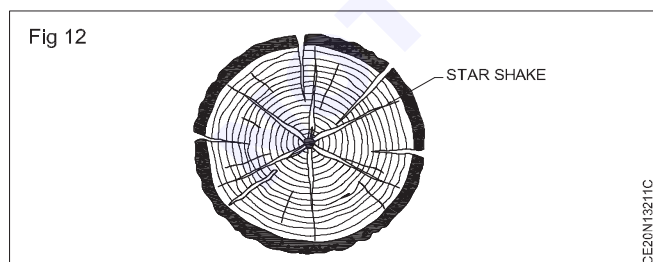
These are the cracks or splits in the center.

This defect is caused due to shrink of heart wood. (Fig 11)



Star shake (Fig 12)

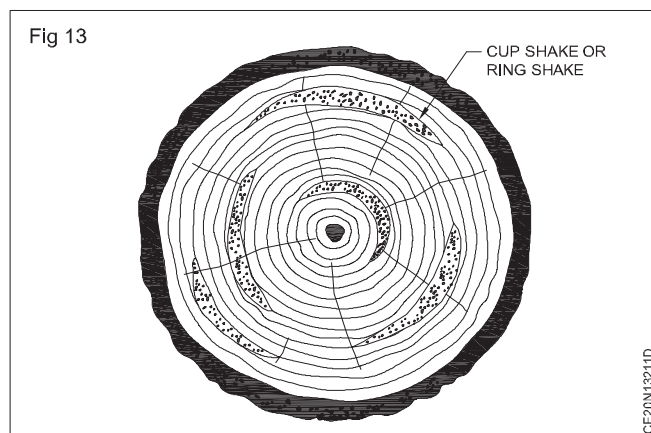
These are crack or split which extend from bark towards sap wood.



Cup shake or ring shake

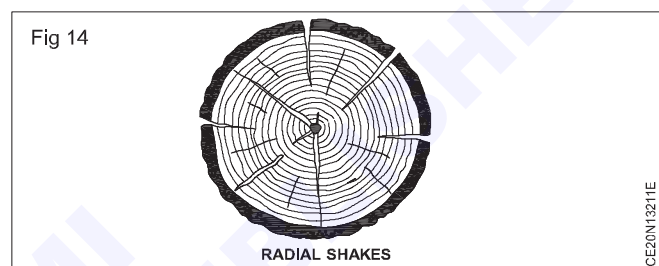
These are formed by the rapture of tissue in a circular direction across the cross section of a log.

It forms usually along the annual rings. (Fig 13)



Radial shake

Many cracks or split run for a short distance from bark towards center than follow the course of an annual ring and lastly go towards the centre radially. (Fig 14)



Diseases in timber and decay of timber

Diseases

When timber is confined to a place where it is liable to be subjected to alternate dry and wet conditions or when used in dark unventilated position it gives birth to two common diseases.

- 1 Dry rot
- 2 Wet rot

Dry rot

The disease in timber is caused due to lack of ventilation.

The following method can be adopted to prevent or eradicate this disease.

- 1 By allowing free circulation of free air.
- 2 Portion of wood attacked by dry rot should be cut off and the remaining portion painted with copper sulphate.
- 3 By exposing the infected portion to sunlight and sweeping of fungus.

Wet rot

This disease is the result of decomposition of timber caused by damp and moisture.

Decay

Timber is said to be decayed when it is deteriorated to the extent it loses its value as an engineering material. Timber deteriorates in strength when it is subjected to

excessive defects, diseases or attacked by insects. These insects damage the appearance and reduce their strength. Following insects generally attack the timber.

a Pinhole borers

They attack the standing tree or recently felled timber.

b Powder post beetles

They attack timber while it is stacked for seasoning sale or awaiting use for years.

c Termite or white ants

They attack timber used for structural purposes in buildings, bridges, poles, sleepers fence posts etc.

Characteristics of wood

The characteristics depend on the visibility and arrangements of the elements. Characteristic feature of each species of timber vary accordingly.

The arrangements and the types of cell together with the presence of varying quantities of chemical substances. such as starch, sugar, gum, resins, oils, colouring matter etc., give the different kinds of timber their special characteristics.

Seasoning of timber: Seasoning is the process of drying out the sap and moisture in the cell cavities and cell walls of the timber approximately, equal to the average humidity of situation where it is used.

Advantages of seasoning

- 1 To decrease the volume and weight of timber and thereby to lower the cost of transport and handling.
- 2 To improve strength, hardness and stiffness of timber
- 3 To improve the resisting power of timber so that it is less liable to attract by insects and fungus.
- 4 To improve the working qualities of timber so that it easily works under saw or plane during conversion.
- 5 To maintain the size and shape of the timber articles even after leaving the hands of carpenters and joiners.
- 6 To make timber fit for receiving treatment of paints preservatives varnishes, polish etc.
- 7 To reduce the tendency timber to crack warp bend or shrink.
- 8 To allow timber to burn readily.

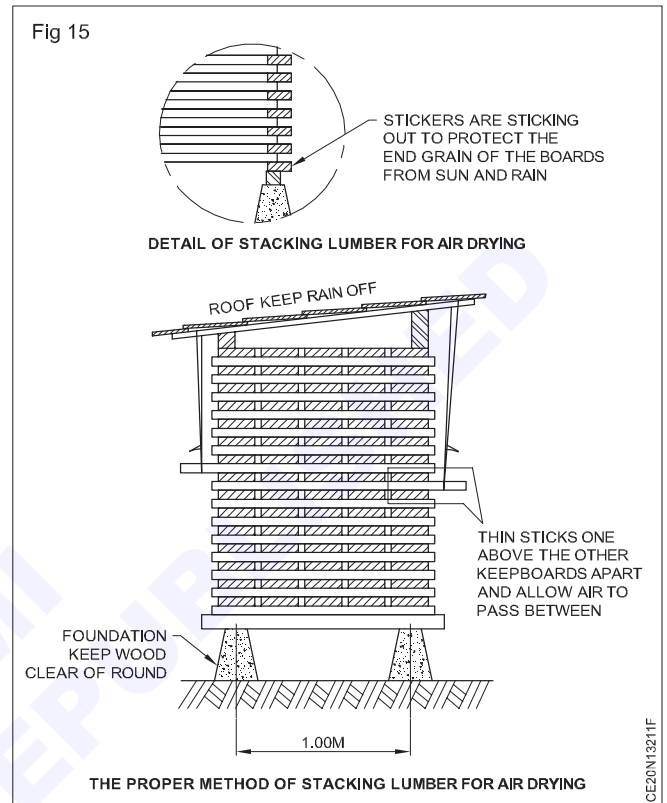
Types of seasoning: Seasoning is of two types

- 1 Natural seasoning
- 2 Artificial seasoning

Natural seasoning

Water seasoning: In this process the timber after felling in the form of logs of suitable sizes it totally immersed in a running stream of water for a period of 3 to 4 weeks.

Advantages: It is a quick method and renders timber less liable to warp and crack. It also removes organic materials contained in the sap of timber.



Air-drying or Air seasoning (Fig 15): Air-drying reduces the moisture content of lumber to a minimum of 15 percent. Wood is often stacked for air drying when it is to be used for exterior purposes.

Advantages: This method of seasoning is very simple cheap and requires no supervision.

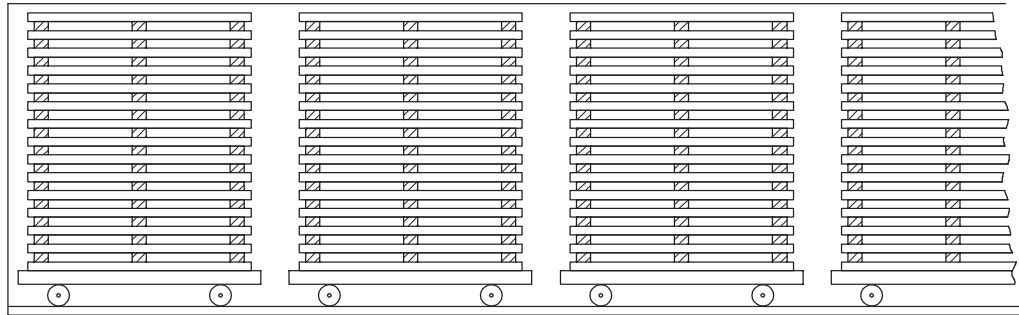
Kiln seasoning or kiln drying

Compartment kiln: Dry kilns are of two types, compartment and progressive kiln. After lumber is sawn, it is usually seasoned (dried) in kilns.

Advantages: Very quick method of seasoning and it reduces the shrinkage.

Progressive kiln (Fig 16) : Progressive kiln is similar to an assembly line. A car load of wood enters the kiln and goes through each of several drying compartments or stages of drying.

Fig 16

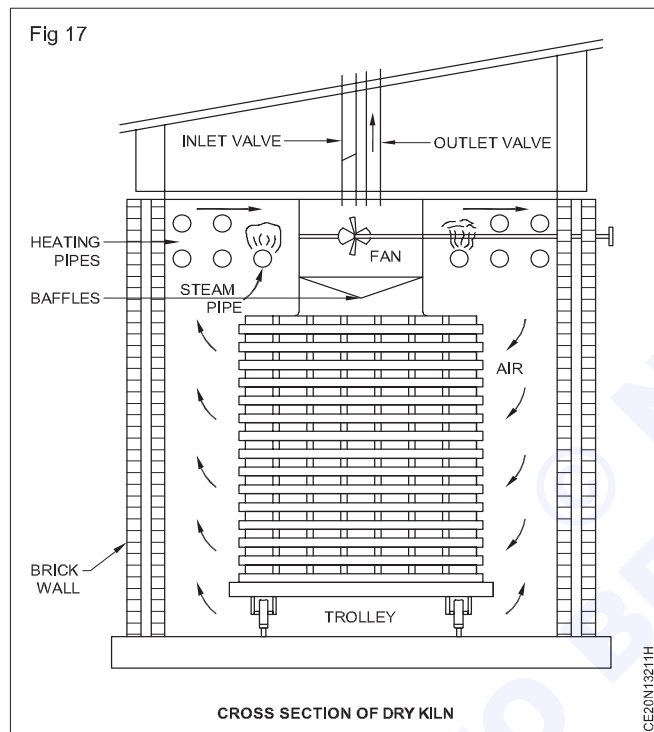


PROGRESSIVE KILN IS SIMILAR TO AN ASSEMBLY LINE. A CARLOAD OF LUMBE ENTERS THE KILN AND GOES THROUGH EACH OF SEVERAL DRYING COMPARTMENTS, STAGES OF DRYING

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Kiln seasoning (Fig 17): It is also called as hot air seasoning. The timber is stacked inside the chamber and the hot air is forced free.

Fig 17



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Boiling or steaming method of seasoning: In this method timber is immersed in water and the water is then boiled for three to four hours. In steam seasoning timber is exposed to the action steam spray. Thus the timber is dried out slowly and seasoned.

Preservation of timber

Necessity of preservation

In order to prolong the life of wood constructions it is necessary to apply some form of protection or preservative.

The timber may be coated with the preservative or it may be impregnated (i.e. saturated) with it.

As timber is mainly used for two classes of work. External and internal, the preservatives required may be divided into two groups.

- 1 Preservatives suitable for protecting wood used for posts, poles, railways sleepers, bridges

- 2 Preservatives required to protect the wood work of walls, ceilings furniture etc.

Preservatives for external wood work

To lengthen the life of timber used for external work it is necessary to coat or impregnate the wood with a solution which will reduce its liability to insect attack and decay (Fungus growths)

These preservatives are divided into

- a Oil preservatives
- b Water soluble preservatives
- c Mechanical preservatives

a Oil preservatives

Coal for creosote/creosote oil black or brownish oil produced by the distillation of coal tar.

Good protection from termites and decay provided the oil penetrates deeply and evenly into the wood in sufficient quantity

Easy to apply and does not evaporate quickly

b Water solution preservatives

These are chemicals which are soluble in water.

When applied to the wood assist in preventing decay and the action of insects. They will leach out when exposed to moisture

c Mechanical preservatives

This term applies to preservatives more or less coverings over the wood, such as:

Sheathing

Timbers that are continuously in contact with water, such as the bottom of boats, wharf piles and pontoons are some times protected from marine bores and pests by covering the wood with sheets of copper or muntz metal.

Charring

This method consists of charring the outside of the post or pole by means of an oil blow torch or oxy - acetylene torch.

The latter type of torch is to be preferred, as it produces a fine textured and harder char.

The coating of charcoal will not support fungi growth and therefore protects the wood beneath.

Alternative materials to timber

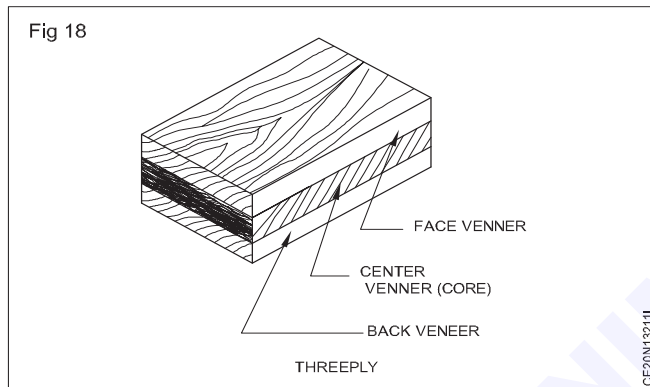
Plywood

Plywood is an assembled product, when three or more layer of veneers glued together. Central layer is called "CORE" it is usually thicker and inferior wood than the face veneers. The number of ply in plywood is usually odd varying from 3 to 13. The direction of the grain in each layer is at right angles. These layer gives greater strength and stiffness in all directions on plywood. It prevents the plywood from warping and shrinkage.

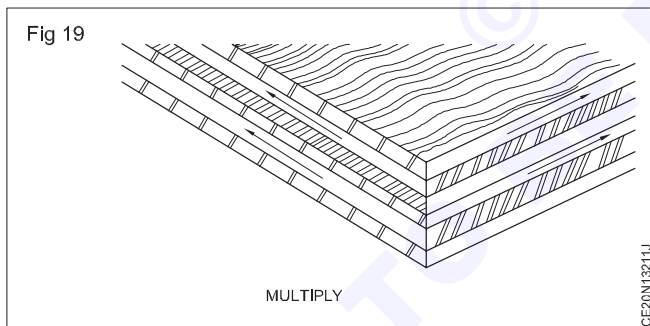
Types of plywood

Plywood is the name given to an assembly of individual layers of veneers.

- Three ply consist a face, bottom and a core or inner play. (Fig 18)



- Multiply has a face, bottom with core of three or more ply. (Fig 19)

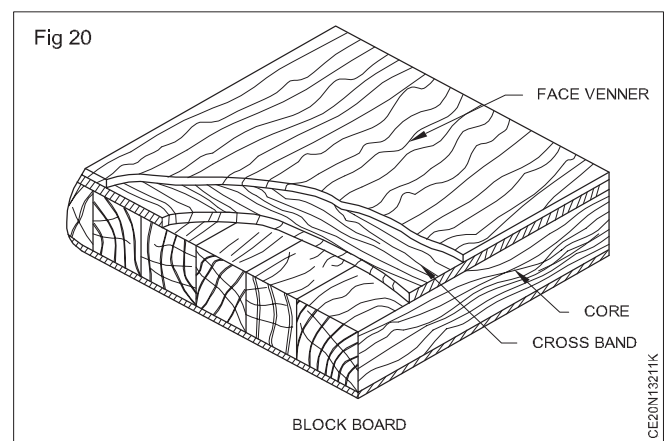


Advantages

- Manufactured in very large sizes.
- It is lighter in weight, possess high uniform strength than solid wood.
- It is free from shrink, warp and warping.
- It can be easily worked and bent into shapes and designs.
- Plywood can be satisfactorily nailed or screwed near the edge without damage.

Block board (Fig 20)

Block board are made up of country wood strips of various sizes ranging from 18mm to 38mm in thickness.



They are arranged and glued together to form a slab and pressed in between two outer veneers under heat to weld the fibres together.

And it is seasoned to a moisture content to 12% then cut to size commonly used in market size are 1220 - 2440mm.

Uses

Block boards are used extensively for both interior and exterior use.

Exterior may be for rails, buses, and lorry buildings and prefabricated houses.

Medium density fiber board (MDF) (Fig 21)



Properties : The term MDF has become a generic name for any dry process fiber board. MDF is typically made up of 82% wood fiber, 9% urea-formaldehyde resin glue, 8% water and 1% paraffin wax and the density is typically between 500 kg/m³ (31 lb/ft³) and 1,000 kg/m³ (62 lb/ft³).

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

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 fibers 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. Also 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.

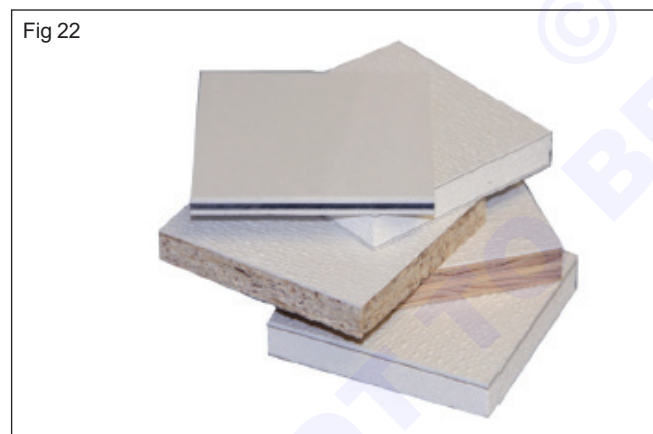
Advantages

- 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)

Applications: MDF is primarily used for internal use application 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.

Particle board or chip board (Fig 22)



Particle board production begins with planer shavings, wood chips and logs. Forming machines deposit the wood chips on belts forming then into mats.

Particle mats are cured with heat and pressure then trimmed and sanded to panel size which is commonly 1220mm x 2440 mm. Thickness range from 6mm to 25mm.

Uses

Particle board is extensively used a core stock for wood veneer and plastic laminates. It is also used as siding, floor under layment and for other construction and industrial purposes.

Fire proof reinforced plastic (FRP) (Fig 23)



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 some what 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.

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. FRP panels is commonly used in schools hospitals, recreational facilities and other industrial settings.

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 black 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 possess strong preservative property.

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 completely dissolves in carbon di sulphide.

- Bitumen is black or brown in colour.
- It is obtained in solid or semi-solid state.

Forms of bitumen

i Bitumen emulsion

It is a 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 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 contains 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 a good insulator of electricity and sound

Uses of asphalt

- 1 Asphalt is used as damp proof course
- 2 It is used in the basement of the building
- 3 It is used for preparing points
- 4 It is used as construction of road metal and pavement.

Introduction of AutoCAD and operating system, hardware & software

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

- **define the computer and CAD**
- **describe hardware & software.**

AutoCAD

AutoCAD is the leading computer-aided design and drafting (CAD) program in the world. Since its original introduction in November, 1982, AutoCAD has grown in sales and functionality to become the standard PC-based CAD program against which all other similar programs complete and against which they are judged. Over the years, AutoCAD has kept pace with developments in the computer industry. The program has grown from its original command line driven DOS-based roots to become a fully compatible windows application.

There are two main categories of computer software:

- System software
- Application program

The system software manages the internal operations of the computer. The application programs are tools that help you accomplish your work, such as CAD. (This topic is further described in CAD PRIMER)

CAD hardware

The following are the main hardware components of CAD

- System unit
 - Central processing unit.
 - Memory.
 - Hard disk, CD-ROM pen drive.
- External storage devices.
- Monitor.
- Printers and plotters.
- Keyboard.
- Digitizer, puck and mouse.

System unit

The system unit is the computer that is used for all data processing. The main components of the system units are the central processing unit (CPU) and memory. In mainframe and minicomputers CPU and memory are usually separate compartments that house thousands of devices. In today's PCs, however, they all fit in a small box commonly known as a desktop computer. Most desktop computers today come equipped with a hard disk, and CD-ROM. Let us have a look at the components of a system unit:

- Central processing unit.

- Memory.
- Hard disk, CD-ROM.

External storage devices

There are a number of external storage devices available such as magnetic tapes, zip drives and removable hard disks. They are commonly used to keep backup copies of electronic files for safekeeping.

Magnetic tapes are quite common for storing large volumes of data. A magnetic tape that looks like a small videocassette can store thousands of megabytes of data. However, they are quite slow and require a lot of time to store or retrieve data.

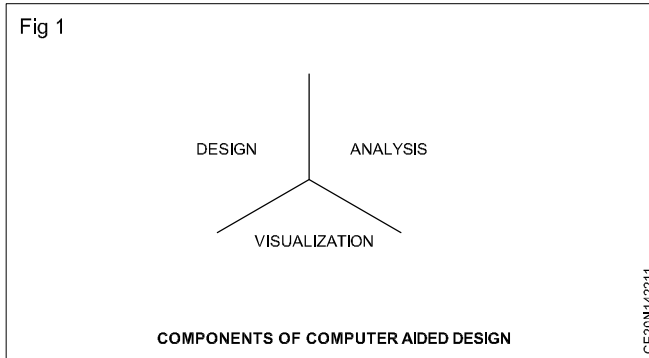
The new option for data storage is the removable hard disk. You can remove the entire hard disk from your computer and use it on another computer. This approach is commonly used when you need to work on different computers and you want the same information to be available instantly.

Computer Aided Design (CAD): Is simply, design and drafting with the aid of a computer. Design is creating a real product from an idea. Drafting is the production of the drawings that are used to document a design. CAD can be used to create 2D or 3D computer models. A CAD drawing is a file that consists of numeric data in binary form that will be saved onto a disk.

Learning to use a CAD system is similar to learning a new language. It is necessary to begin with the basic alphabet and learn how to use it correctly and effectively through practice. This will require learning some new concepts and skills as well as learning a different vocabulary. Today, the majority of the Mechanical CAD systems are capable of creating three-dimensional solid models. Nonetheless, all CAD systems create designs using basic geometric entities and many of the constructions used in technical designs are based upon two-dimensional planar geometry. The method and number of operations that are required to accomplish the basic planer constructions are different from one system to another.

In general, a Computer Aided Design (CAD) package has three components: a) Design, b) Analysis, and c) Visualization, as shown in the sketch. A brief description of these components are as follows in Fig 1.

Fig 1



Hardware and software overview

There are two parts of a computer system, hardware and software, and a CADD system in no exception. Computer hardware is the physical components of the computer such as system unit, monitor and plotter. Computer software is the program that determines the application of a system.

There are three main categories of computers with respect to hardware:

- Mainframe.
- Minicomputer.
- Microcomputers, for example personal computers (PCs).

The monitor (Fig 2)

Fig 2

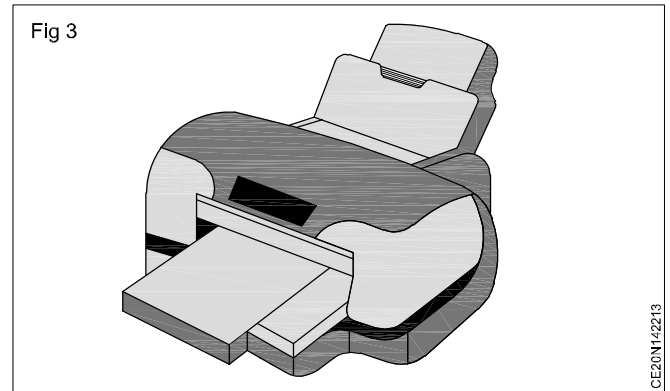


The monitor is the computer screen and is used to display information. A good monitor is very important for CAD in order to display fine graphics. A colour monitor is essential because many CAD drawing techniques are based on colours. Monitors are available in various sizes ranging from 13" to 30" or more. Today, average monitors have the ability to display millions of colours.

The main factor that determines the quality of a monitor is the resolution. The term resolution refers to sharpness of an image displayed on the screen. Resolution is measured by the number of picture elements (pixels) that a screen can display. The more pixels and the closer they are the sharper the image. The distance between pixels is called the "dot-pitch". The smaller the dot-pitch, the sharper the image. A 26 or smaller dot-pitch monitor is recommended for CAD applications.

Printers and plotters (Fig 3)

Fig 3

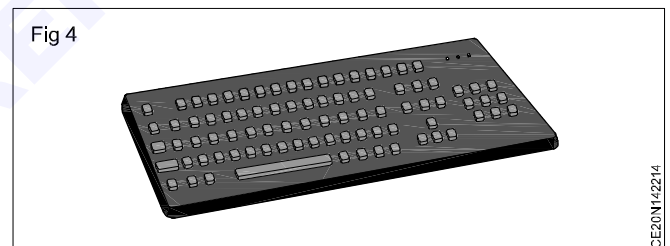


CAD drawings are printed using fine-quality printers and plotters. Drawings are neat and clean and as accurate as the naked eye can see. You can print drawings at as much as 1200-dpi (dots per inch) accuracy. This means 1200 dots are printed in a non-inch-long line! All the text dimensions and other graphics are printed highly accurate, neat and crisp. You can print drawings with a lot of variations; for example, drawings can be printed with different sizes, line types, text fonts and colours.

There are a variety of printers and plotters available in the computer industry. They work on different principles and their prices vary significantly. There are many types of pen plotters, ink-jet printers, laser printers and plotters, electrostatic printers, etc.

Key board (Fig 4)

Fig 4



Key board: This is an input device. which contains keys to feed information in to the computer.

Typewriter key: Used for letters, numbers and punctuation symbol.

Function Keys: F1 to F12 performs depend on the software use.

Cursor control keys: To move the cursor to the left, right, up, or down.

Page up and down key: To move the preceeding page and to move the text page.

Home key: To the top of the Document.

End key: To end of the Document.

Num lock key: Numeric 0-9, pressing any of them, a number gets displayed on the screen.

Caps lock key: By pressing, type letters will appear in the small or capital.

Shift key: To appear the upper symbol, if hold down this key.

Ctrl & Alt key: Often used in combination with other keys to carry out special actions. By pressing Ctrl, Alt & delete keys simultaneously, the machine automatically restart.

Enter key: It alert the PC that finish the given instruction to execute the Instructions.

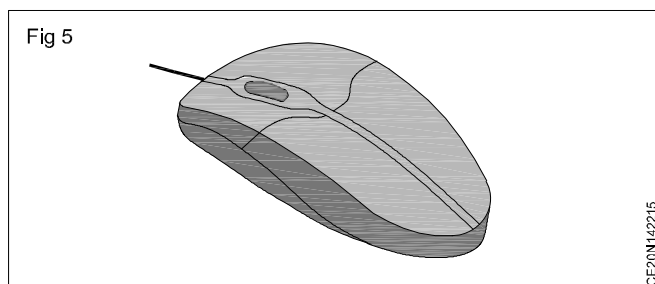
Tab key: Move the cursor along the line to a preset point and also to move from one option to another in a menu.

ESC key: To cancel or to ignore the entry or command that just Entered.

Delete key: Erase the character to the place to the right side of the Blinking cursor.

Back space key: Erase the character to the left side of the blinking cursor, also it moves the cursor back.

Digitizer, puck and mouse (Fig 5)



The digitizer (also known as a graphic tablet) and the puck are the data input devices most commonly used in CAD systems. These devices allow you to enter point locations on the screen and to make selections from the menus. As the puck is moved over the surface of the digitizer, it moves the indicator (cursor) on the screen relatively. To enter a point, you need to position the cursor at the appropriate position on the screen and then press the "Enter" button on the puck.

CAD software

A CAD program contains hundreds of functions that enable you to accomplish specific drawing tasks. A task may involve drawing an object, editing an existing drawing, displaying a view of the drawing, printing or saving it, or controlling any other operation of the computer. The functions contain a number of commands that enable you to specify exactly what you want to do and how you want to do it.

The functions are organized into modules that provide easy access to all the commands. The program is divided into modules such as draw, edit, data output, function control, data storage and management. A program may also have a number of specialized functions such as layers, database and 3D. Let's have a look at the CAD modules.

- Draw.
- Edit.
- Data output.
- System control.
- Data storage and management.
- Special features.

Draw

The draw module provides access to all the drawing functions of CAD. Whenever you need to draw something this group of functions is used. The draw module enables you to draw lines, arcs, circles, ellipses, text, dimensions, symbols, borders and many other drawing components.

Draw is CAD's most frequently used module because all drawing work is accomplished using it.

Edit

The edit module lets you change existing drawing elements and manipulate them in a number of ways. You can move, copy or erase drawing components. You can enlarge or reduce the sizes of diagrams or change the colour and line type of drawing components. You can also change the size and style of text and dimensions, as well as edit a dimension to show different units of measurement. A good CAD program is designed to change the appearance of all drawing elements created with CAD.

The edit functions also act as convenient drawing-aid tools. They enable you to join missing corners of lines, trim drawing components along a line, stretch them to fit a new shape, etc. The list of editing capabilities goes on and on. The edit functions make CAD a dynamic drawing tool.

Data output

The data output module enables you to display drawings on the screen and then print them on paper. There are two separate sets of functions that help accomplish this:

- View-display functions
- Print/plot functions

The view-display functions allow you to display different views of a drawing on the screen. These functions are used quite often, because every time you need to draw something or edit something, you need to focus on that portion of the drawing. With the help of view-display functions, you can zoom in on a specific portion of the drawing.

The print and plot functions allow you to print drawings using a printer or a plotter. You can control many aspects of printing and plotting. You can print the same drawing in different sizes by applying the appropriate scale factor. You can plot the drawings with specific colours, pen thickness, and line types.

Data storage and management

The data storage and management module allows you to store and manage drawing data. Through the use of the functions in this module, you can store drawings as files on the hard disk. You can manage the files in directories and sub-directories, and move, copy or delete them as needed.

CAD data management functions also let you translate drawings created by other CAD programs. These functions convert drawing data to a generic format that can be read by any CAD program. Data exchange format (DXF) is one of the common data translation formats used by CAD programs. There are a number of data exchange formats available.

System control

The system control module (also known as system defaults) allows you to control how CAD works. CAD programs are designed for a broad range of professionals, including architects, designers, engineers and surveyors. With the help of system control functions, you can set the working environment of CAD to suit your needs.

Example: You can set the type of units that you will be using, the accuracy of the units, a style for dimensions and text, colours, layers, line type in a drawing, etc. Additionally, you can customize screen menus, the display of colours on the screen, resolution of the screen, size, the speed of the cursor, etc.

You can also specify whether the selected defaults should apply to a single drawing, to a specific project, or to all the projects in a specific category. The defaults can be set on a temporary or permanent basis.

Special features

CAD programs usually offer a number of special features that make working with CAD easier and allow you to automate many drawing tasks. For example, you can create layers in a drawing that allow you to segregate drawing components. You can develop spreadsheets and databases that can be used to create many types of

project reports. You can create three-dimensional (3D) drawings, such as isometrics and perspectives, with the help of 3D functions. You can also accomplish many other automated tasks with the help of macros.

The number of special features a CAD program has or how elaborate they are varies from one program to another. Some vendors sell specialized features as separate packages, while others include them in a single package. It all depends how a program is written, how big or small it is, and how it is sold.

CADD user interface

CAD user interface provides the environment and the tools that allow you and the computer to communicate. Each CAD program establishes an environment that best suits its purpose. The goal is to make working with CAD efficient. Most programs use a Graphic User Interface (GUI) to communicate with the user. The GUI provides visual aids for quick data entry. You are given tools to select functions, enter textual or mathematical data, locate points in the drawing window, select objects in the drawing window, etc.

Graphical user interface (GUI) and method of installation

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

- describe graphical interface of Auto cad
- explain key board function keys.

Introduction

Note that AutoCAD automatically assigns generic name, Drawing X, as new drawings are created. In our example, AutoCAD opened the graphics window using the default system units and assigned the drawing name Drawing1.

Graphical user interface (GUI) OF Auto CAD (Figs 1 to 3)

Fig 1

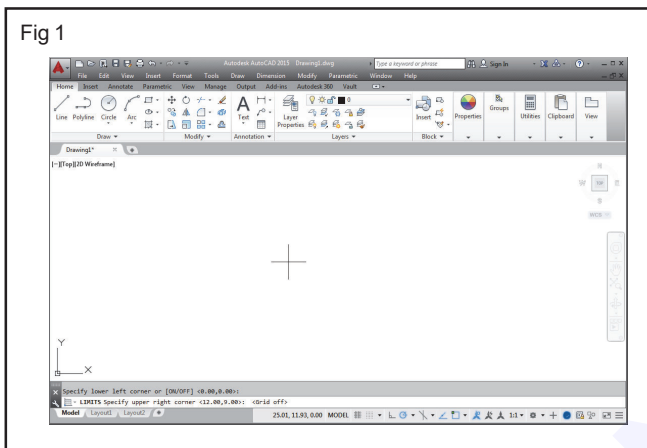


Fig 2

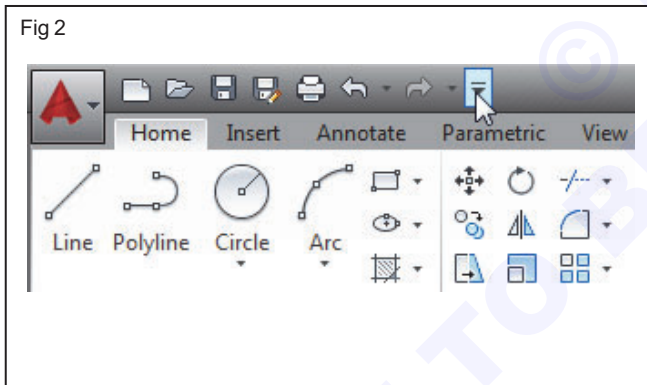


Fig 3



Quick access toolbar

- 1 Click on one of the following icons for quick access to commands QNEW, OPEN, SAVE, PLOT, and UNDO/ REDO. (Fig 4)

Fig 4



Right-click the quick toolbar and click customize quick access toolbar. The customize user interface dialog opens and displays the list of commands available.

Drag commands you want to add from the command list panel in the customize user interface dialog box to the quick access toolbar.

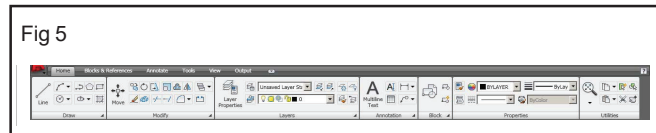
Info center

Quickly search for a variety of information sources, access product updates and announcements, and save topics with info center.

Ribbon

The ribbon provides a single, compact placement for operations that are relevant to the current workspace. It eliminates the need to display multiple toolbars, reducing clutter in the application window. The ribbon maximizes the area available for work using a single compact interface. (Fig 5)

Fig 5



The ribbon can be displayed horizontally, vertically, or as a floating palette. The horizontal ribbon is displayed at the top of the drawing window by default when you create or open a drawing.

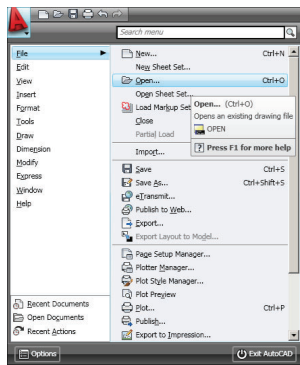
You can create your own panels to display on the ribbon; you can also modify the commands and controls on existing ribbon panels.

Menus and colours

Menu browser (Fig 6)

- 1 Click on a icon in the upper left corner of the drawing area.
- 2 Click the desired pull down menu.
- 3 Click on the command to be executed from the pulldown.

Fig 6



Workspaces (Fig 7)

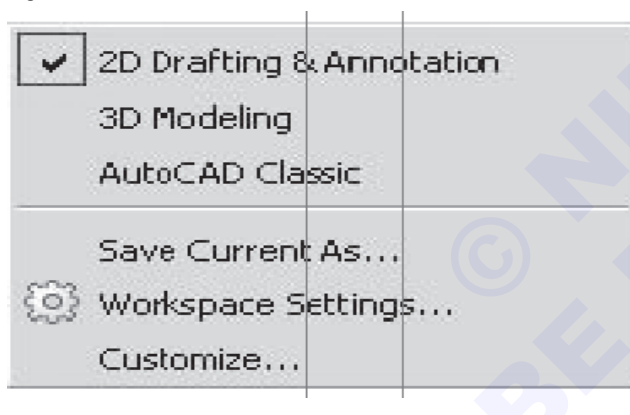
You can switch between the workspaces from the menu browser.

- 1 Click the workspace switching icon in the lower left corner of the screen.
- 2 Click on one of the following workspace options. (Fig 8)

Fig 7



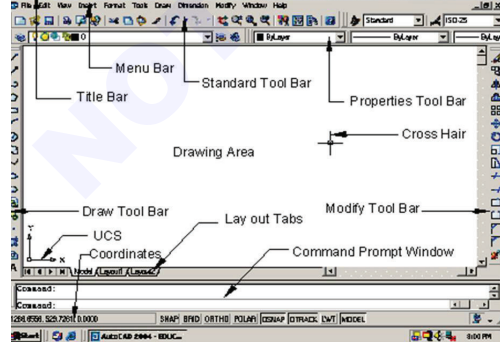
Fig 8



Auto CAD classic workspace (Fig 9)

Title bar: This shows the name of drawing which is currently used.

Fig 9



Menu bar: This menu bar help us quicker way to access the general controls and setting for AutoCAD. The main commands and functions are available in this menu bar it has the following facilities.

- 1 It gives a command that requires key board or drawing input.
- 2 It displays additional menus choice with > symbol, in this menu called cascading menus.
- 3 It displays a dialogue box that contains settings which have changing options.

Standard tool bar: This tool bar contains the standard functions of commands which is used for getting information's and modifications.

Properties tool bar: This tool bar has the properties of the entity such as thickness of line, colour, layer type of line etc. We can change the properties of the entity by using this tool bar.

Draw tool bar: This tool bar contains the group of drawing commands such as line, arc, circle etc.

Modify tool bar: This tool bars are used to do the modifications in the entities such as erase, trim etc.

Draw area: This is a blank space to draw the drawings. This area has formed as grids; we can increase or decrease the area by using boundary limit command.

UCS: UCS (user coordinate system) is an indication to the use for which plane the drawing is drawn. We can change any plane according to our wish to draw the drawing in views.

Command prompt window: This window is used to give commands by typing in key board.

Cross hair: This is the pointer used to draw, select and to locate.

Layout tabs: These tabs are used to select the particular lay out of the drawing.

Function tabs: Below the command prompt window drawing function tabs are available. These tabs show us the position of grid, other, o snap etc. The functional keys are used for effective function of the drawing.

Key board function keys

There are some function keys in the keyboard for quick access to certain commands.

You can disable the group selection quickly by pressing FUNCTION KEYS (Ctrl + Key) combination to quickly toggle some of the modes and invoke some of the commands.

Function keys	used in Auto CAD
Key strokes	Function defined
Ctrl+Z	Undo
Ctrl+C	Copy clip
Ctrl+E	Osoplane top/right /left

Ctrl+G	Grid on/off
Ctrl+L	Ortho on/off
Ctrl+O	OPEN command
Ctrl+S	QSAVE command
Ctrl+U	Polar tracking on/off
Ctrl+W	Object snap tracking on/off
Ctrl+Y	Redo
Ctrl+2	ADCENTER command
Ctrl+F6	Switch between open drawings
Ctrl+B	Snap on/off
Ctrl+D	Coordinate display on/off
Ctrl+F	Osnap setting dialog box
Ctrl+K	HYPERLINK command
Ctrl+N	NEW command

Ctrl+P	PRINT command
Ctrl+T	Tablet on/off
Ctrl+V	Paste
Ctrl+X	Delete
Ctrl+1	Object properties window on/off
Ctrl+6	DBCONNECT command
Ctrl + Tab	Switch between open Drawings.

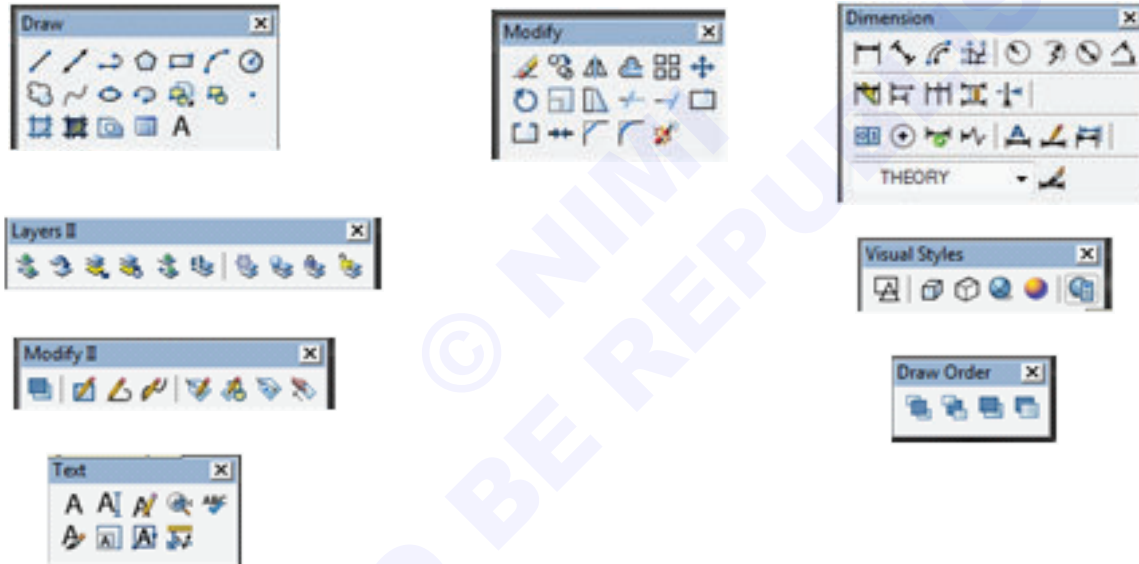
The functionality of these Ctrl + Key combination depends on the settings done on the User Preferences tab on the option dialog box. (Fig 10)

Example

That is to say Ctrl+ C works for COPYCLIP command, if the check box is cleared, Ctrl + C works for the CANCEL command.

Text edit keys : The following accelerator keys, which are effective within the Multilane Text Editor, dialog box.

Fig 10



Key strokes	Function defined
Ctrl+A	Select all text in the multiline texteditor.
Ctrl+B	Applies or removes bold format for selected text.
Ctrl+C	Copies selected text to the clip board.
Ctrl+I	Applies or removes italic format for selected text.
Ctrl+Shift+L	Converts selected text to lower case.
Ctrl+Shift+U	Converts selected text to upper case.
Ctrl+U	Applies or removes underline format for selected text

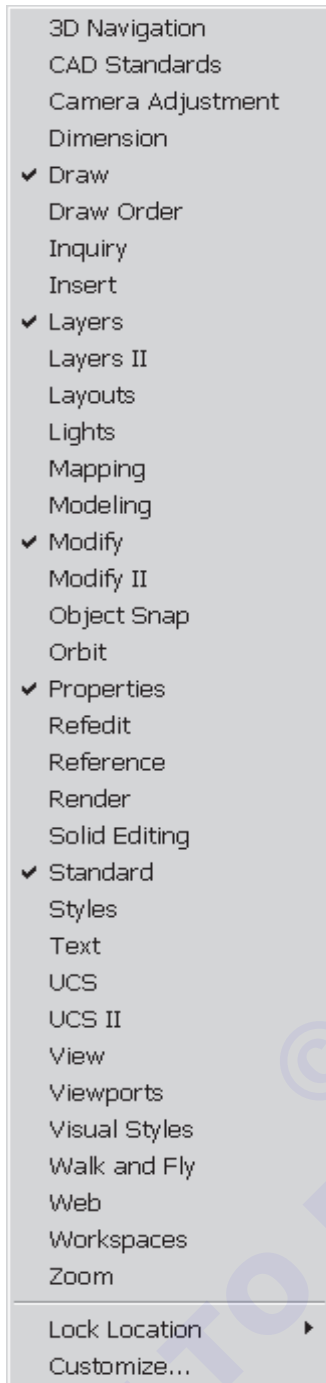
Ctrl+V	Pastes Clipboard contents to cursor location
Ctrl+X	Cuts selected text to the clipboard
Ctrl+SPACE	Removes character formatting in selected text.

Loading toolbars.

Right- clicking on an icon in any toolbar.

This will show a list of all available toolbars.

Fig 11



Method of installation

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

- introduction of cad installation
- system requirements serial number and production
- installing of CAD.

Introduction of CAD Installation

Auto CAD installation provides information on how to prepare and then how to install. If the product is never installed before, one should familiarize with the installation process. It should be done before installing and in the beginning. Before installing one should be aware of the minimum requirements to install and run the product.

System requirements

One should review about the system requirements administration permission locating serial number and product key closing all numbering applications completing the dead tasks and now it is ready for installing auto cad. Before installing auto cad make sure the minimum hardware and software needs for the computer serial number and product key.

Whatever auto cad you install, which prompt the person about the serial number and the product key of the product and the user information page. This can be done by installing the product in trial mode. The serial number and the product key are located on the outside of the product packing or in the auto desk. The serial consist of three digit pre fix followed by the product key consists of fine characters.

The information entered is permanently retained with the product. This information cannot changed later with out uninstalling. To review this product information later and the mars menu bar click auto cad about auto cad. In the about dialog box, click product, information.

The Auto CAD installation wizard contains all installation related material in one place from the installation wizard one can select installation register product and customize the install.

Installation AutoCAD

1 Switch on the computer and wait for few minutes to do the process of ROM. Now we see the monitor screen as shown in Fig. Insert the AutoCAD CD in to CD-ROM drives; double click on My Computer icon then a display as follows.

Open file explorer

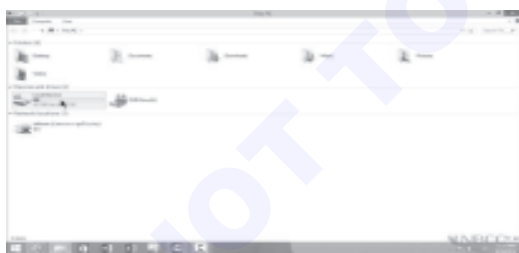
Open local disk(C) (Fig 1)

Fig 1



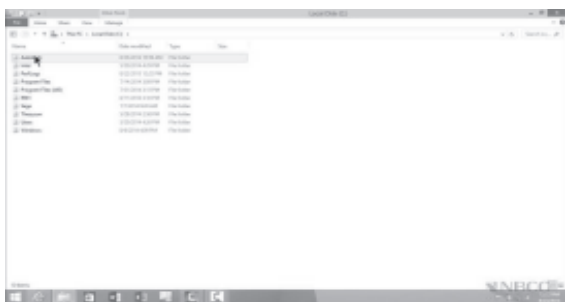
Open Autodesk (Fig 2)

Fig 2



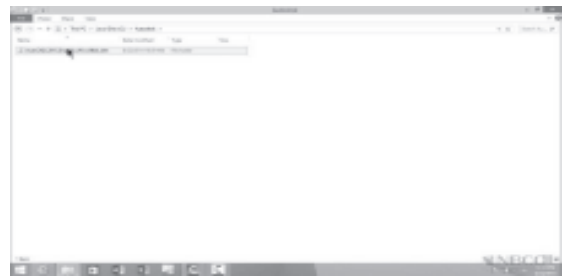
Open Autocad_2015 (Fig 3)

Fig 3



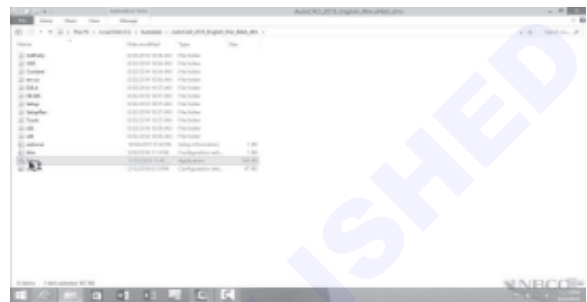
Run setup (Fig 4)

Fig 4



The installer will start once setup is clicked. Please click on install. (Fig 5)

Fig 5



Change country to India, and accept the license terms, now click next. (Fig 6)

Fig 6



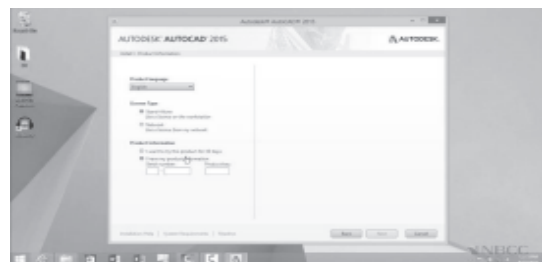
Select your language preference, stand alone license, and input and product key that you made note of while downloading the software. Now click next. (Fig 7)

Fig 7

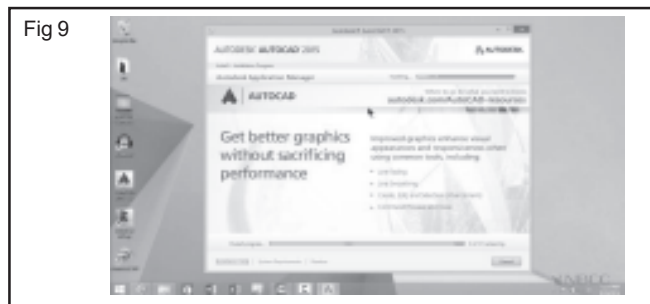


Click on Autodesk AutoCAD 2015 to open and configure the options. (Fig 8)

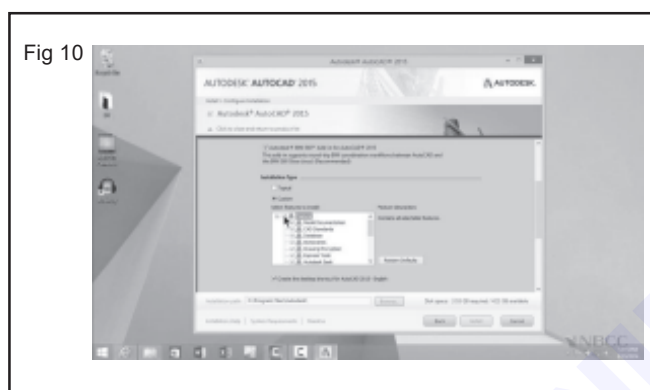
Fig 8



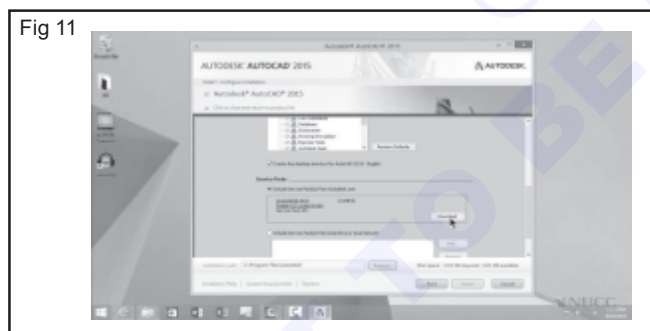
Under installation type select custom then make sure you place a green check mark next to feature. This will ensure all components get installed. (Fig 9)



Scroll down a bit further and you will see an option for including service packs. Click include service packs and then click the download button. Wait for the service pack to download. Note that this step requires an internet connection. (Fig 10)



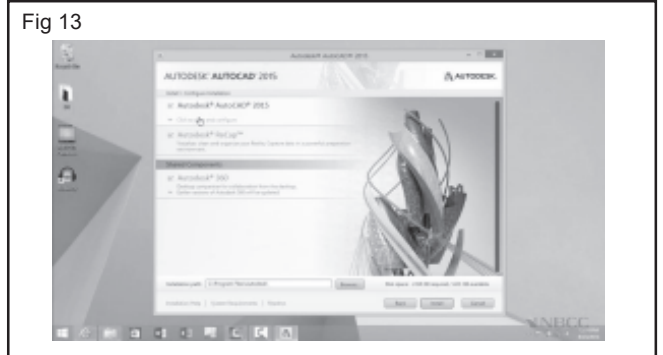
Go back to the top and click on the "Click to close and return to product list" banner. Now click install. The install will take some time. Please be patient. (Fig 11)



Once the install is completed you should see this message. (Fig 12)



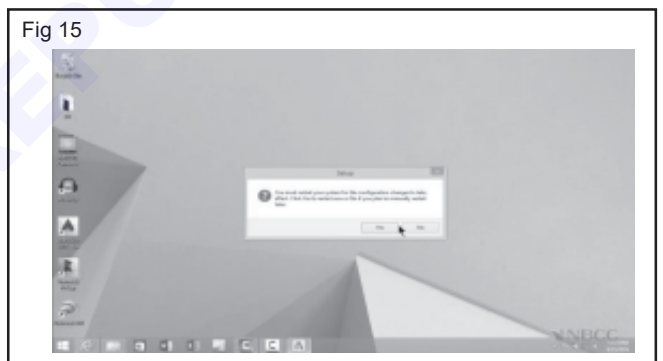
Press finish to complete the install. (Fig 13)



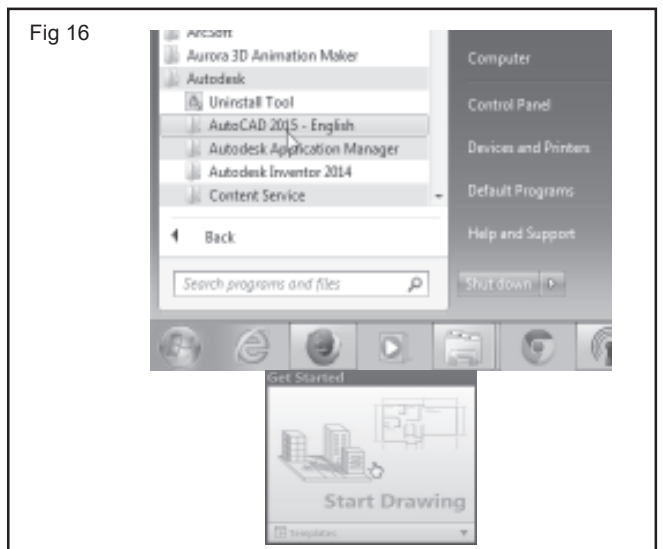
Your system may ask you to reboot once the install has finished. (Fig 14)



Click yes to reboot your system. You have now successfully installed AutoCAD 2015. Then finally restart the computer. (Fig 15)



Select the AutoCAD 2015 option on the program menu or select the AutoCAD 2015 icon on the Desktop. Click Start Drawing to start a new drawing. (Fig 16)



Basic commands of CAD

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

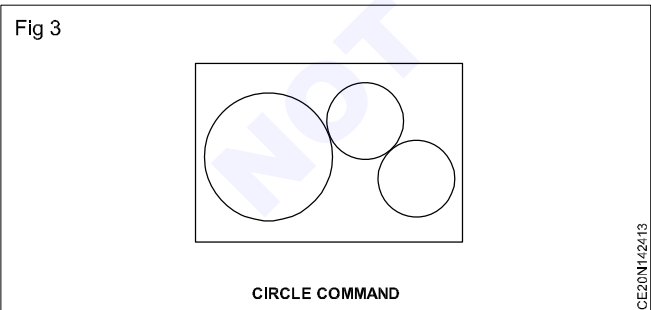
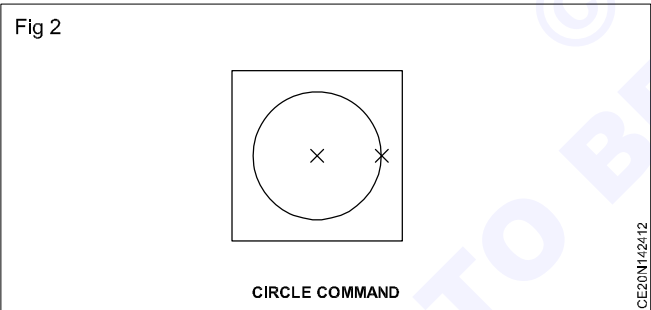
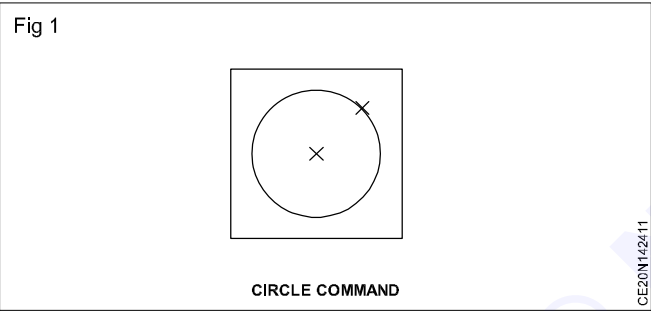
- state circle, arc
- state ellipse, polygon.

Introduction

The important thing to remember is that AutoCAD will expect you to give information in a very particular order. The most frustrating thing when you begin using this program is that you will try to do something, but auto cad will not work. In most cases, it means that you are trying to input information at the wrong time. This is why it is very important to be in the habit of looking at the command line.

Circles

Circle command (Figs 1, 2 & 3)



1	Choose	Draw, circle. (or)
2	Click	The Circle icon. (or)
3	Type	Circle at the command prompt.
4	Type	One of the following options: 3P/2P/TTR/ <<center point>>: (or)
5	Pick	A center point
6	Type	A radius or diameter. (or)
7	Pick	A radius or diameter Diameter/ <<radius>>:

TIPS

- To create circles that are the same size, press ENTER when asked for the circle radius.
- When selecting a circle with a pick box, be sure to select the circumference of the circle.

The command line tells you what information AutoCAD requires to continue.

Your first drawing alignment will be to use the drawing commands in conjunction with the co-ordinate system. It is very important to understand on how to give the program the accurate information. You will use the following commands.

Drawing arcs and circles

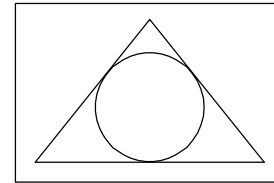
CADD provides many ways to draw arcs and circles. There are a number of advanced techniques available for drawing arcs and circles, which can simplify many geometrical drawing problems. You can draw an arc by specifying circumference and radius, radius and rotation angle, chord length and radius, etc.

Arc command (Fig 4)

- 1 Choose Draw, arc.
(or)
- 2 Click The Arc icon.
(or)
- 3 Type Arc at the command prompt
command: ARC
- 4 Draw One of the arcs.



Fig 4

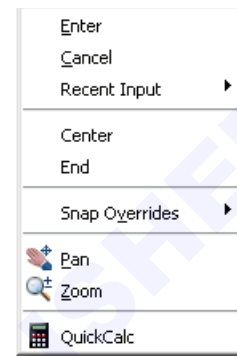


CIRCLE COMMAND

CE20N142414

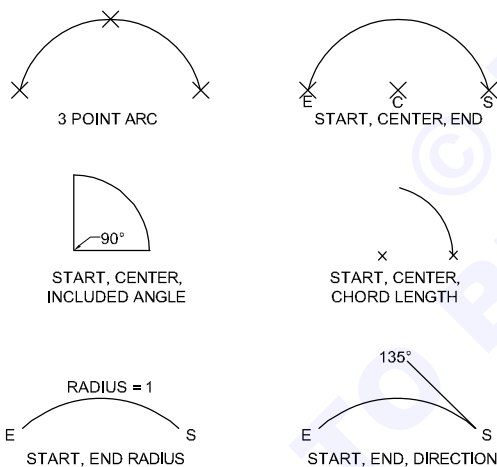
TIPS

- Except for 3 point arcs, arcs are drawn in a counter clock wise direction.
- While in the arc command, press the right mouse button to select the following options for arcs:



Arc examples (Fig 5)

Fig 5



ARC COMMAND

CE20N142415

3 point arc

Start, centre, chord length

Start, centre, end

Start, end, radius

Start, centre, included angle

Start, end direction

Drawing ellipses and elliptical arcs

Ellipses are much easier to draw with CADD than on a drawing board. On a drawing board, you need to find the right size template or draw a series of arcs individually to draw an ellipse. With CADD, all you need to do is to specify the size of the ellipse.

The following are two basic methods for drawing ellipses:

- Length and width.
- Axis and rotation angle.

Ellipse.

Creates an ellipse or an elliptical arc:

- 1 Choose Draw, Ellipse.
(or)
- 2 Choose The ellipse or partial ellipse icon
(or) 
- 3 Type Ellipse at the command prompt
Command: ellipse
- 4 Type One of the following options:

Arc/Center/Isocircle/<Axis endpoint1>:

Ellipse options

Axis endpoint 1: Defines the first axis by two specified endpoints. The angle of the first axis determines the angle of the ellipse. The first axis can define either the major or the minor axis of the ellipse.

Ellipses options

Axis end point 2: <Other axis distance>/Rotation: Specify a point or enter a distance

Arc: Creates an elliptical arc. The angle of the first axis determines the angle of the elliptical arc. The first axis can define either the major or the minor axis of the elliptical arc.

Center : Creates the ellipse by a specified center point.

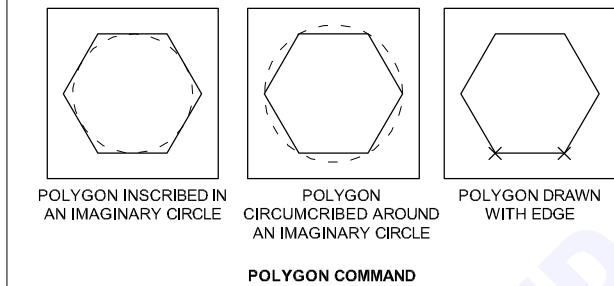
Isocircle: Creates an isometric circle in the current isometric drawing plane.

Rotation : The major axis is now treated as the diameter of a circle that will be rotated to a specified amount around the axis. You enter an angle between 0 and 89.4 degrees.

Polygon (Fig 6)

- 1 Choose Draw, polygon.
(or)
- 2 Click The polygon icon.
(or)
- 3 Type Polygon at the command prompt.
- 4 Type The number of sides for the polygon (3-1024).
- 5 Pick The center of the polygon. Edge/
<Center of polygon>: pick.
(or)
- 6 Type E to define the polygon by two edges.
(or)
- 7 Type I or C to place the polygon inside or outside of an imaginary circle. Inscribed in circle/ circumscribed about circle (I/C)

Fig 6



CE20N12416

Basic commands - II

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

- **express move, copy, offset, rotate, trim, on, fillet, array, straighten, lengthen.**

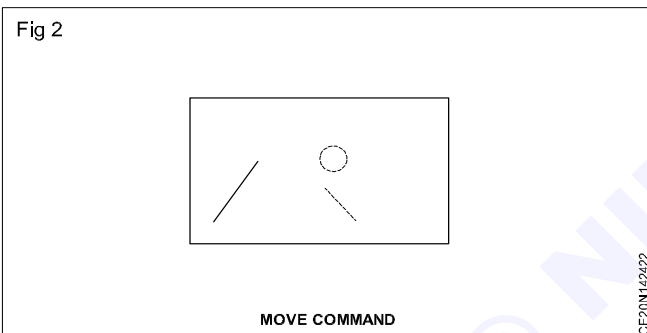
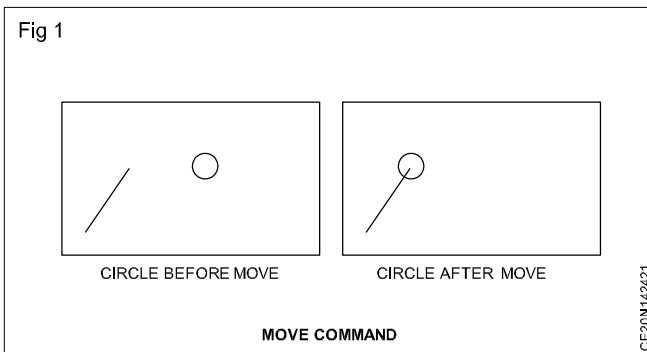
The previous lesson dealt with drawing commands. This lesson will introduce some common modifying commands. In AutoCAD, you may actually use modifying commands more often than drawing commands. Now that you know

the basics, here's some more commands to add to your collection. Three commands, Trim, Extend and Offset are used often in 2D AutoCAD work.

Command	Keystroke	Location	Result
Rectangle	RECTANGLE/REC	Home>Draw>Rectangle	Draws a rectangle after you enter one corner and then the second.
Trim	TRIM/TR	Home>Modify>Trim	Trims objects to a selected cutting edge.
Extend	EXTEND/EX	Home>Modify>Extend	Extends objects to a selected boundary edge.
Offset	OFFSET/O	Home>Modify>Offset	Offsets an object (parallel) by a set distance.
Object snaps	OSNAP/OS/F3	Tools>Object Snap Settings	Brings up the OSNAP dialog box.
Move	Move/M	Home>Modify>Move	Moves an object or objects.
Copy	Copy/CP	Home>Modify>Copy	Copies object(s) once or multiple times.
Stretch	Stretch/S	Home>Modify>Stretch	Stretches an object after you have selected a portion of it.
Mirror	Mirror/MI	Home>Modify>Mirror	Creates a mirror image of an object or selection set.

Command	Keystroke	Location	Result
Rotate	Rotate/RO	Home>Modify>Rotate	Rotates objects to a certain angle.
Fillet	Fillet/F	Home>Modify>Fillet	Creates a round corner between two lines.
Chamfer	Chamfer/CHA	Home>Modify>Chamfer	Creates an angled corner between two lines.
Array	Array/AR	Home>Modify>Array	Creates a repeating pattern of the selected objects.

Move command (Fig 1 & 2)



- 1 Choose Modify, Move. Or
- 2 Click The Move icon or 
- 3 Type Move at the command prompt command: MOVE or M
- 4 Pick Objects to move select objects (select)
- 5 Pick A point to move from base point of displacement: (Pick point)
- 6 Pick A point to move to second point of displacement: (pick point)

TIP

To move an object a specified distance, type a distance at the second point of displacement prompt: @1<0

Moving drawing objects

CADD allows you to move drawing objects within a drawing in a convenient manner. Unlike on a drawing board, you don't need to first erase and then redraw in a new place. You can simply rearrange the existing drawing objects, as you like. This is a very useful tool for analyzing design alternatives and making quick adjustments to drawings.

Previous selection

Places selected objects in the previous selection set

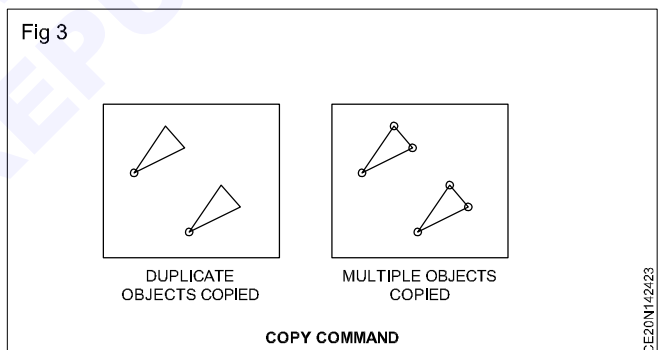
- 1 Choose Modify, move.
(or)
- 2 Click The move icon.
(or)
- 3 Type Move at the command prompt.
Command: Move or M
- 4 Pick Objects to move.
Select objects : (P)

Previous selection set highlighted

TIP

AutoCAD requires that objects be selected in order to be processed. The Select Objects prompt occurs after many commands, including the SELECT command itself.

Copying drawing objects (Fig 3)



CADD allows you to make quick and easy copies of existing drawing objects. You can copy individual drawing objects or the entire drawing all at once. You can even make multiple copies of drawing objects within seconds.

Using the copy function is quite similar to the way the move function is used. First, you need to select objects using any of the methods described earlier. Then you need to indicate a base point and a relocation (or destination) point. The copied objects are placed according to the relocation point.

Making multiple copies in a rectangular fashion

There are separate functions available in CADD that allow you to make multiple copies in a linear or rectangular fashion (commonly known as a rectangular array). You can make hundreds of copies within seconds. You don't need to enter a base point and a destination point. You just need to select the objects, specify how many rows and columns you need and the distance between them.

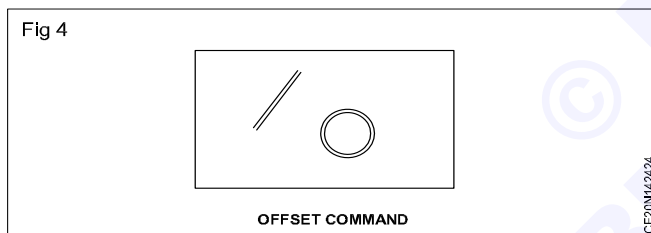
Copy command

- 1 Choose Modify, copy.
(or) 
- 2 Click The copy icon
(or)
- 3 Type Copy at the command prompt.
- 4 Pick Objects to copy.
Select objects: (select)
- 5 Pick A point to move from.
Base point or displacement /multiple: (pick point).
- 6 Pick A point to copy to.
Second point of displacement: (Pick point)
(or)
- 7 Type A point to copy to.
Second point of displacement: @1<0

TIP

To copy many objects in the same copy command, type M for Multiple at the "Base point or displacement / Multiple" option.

Offset command (Fig 4)



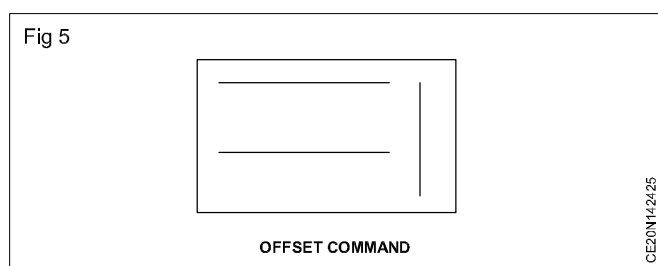
Offset distance

To offset a specified distance:

- 1 Choose Modify, Offset.
(or) 
- 2 Choose The offset icon.
(or)
- 3 Type OFFSET at the command prompt.
Command: OFFSET or O
- 4 Type The distance to offset. Offset distance or <Through point>: (number)
- 5 Pick The object to offset. Select object to offset: (select object)
- 6 Pick A side to offset object to. Side to offset: (pick side)
- 7 Pick Another object to offset
Select object to offset: (Pick side)
(or)
- 8 Press Enter to end the command.

Offsetting objects by specifying a distance

Offset through point (Fig 5)

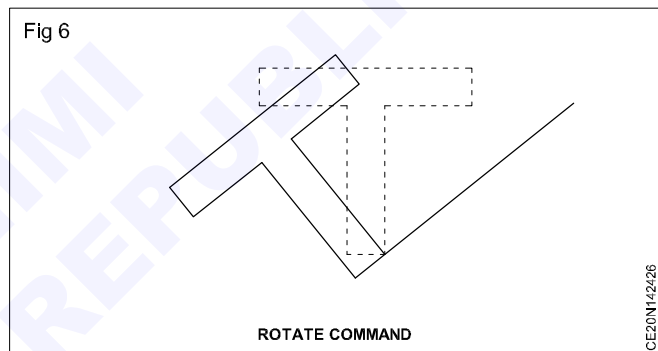


To offset through point

- 1 Type Offset at the command prompt
Command: Offset
- 2 Type T to specify a through point
Offset distance or <Through point>: (T)
- 3 Pick A point to offset through (HINT: use object snaps) Select object to offset: (pick) through point: (select object)

Offset through a point

Rotate (Fig 6)



- 1 Choose Modify, rotate
(or) 
- 2 Click The modify icon.
(or)
- 3 Type Rotate at the command prompt
Command: Rotate
- 4 Pick Objects to rotate:
Select objects: (select)
- 5 Pick A pivot point to rotate around
Base point: (point)
- 6 Type A rotation angle<Rotation angle>/Reference: (number)
(or)
- 7 Pick A rotation angle<Rotation angle>/Reference: (point)

Rotating the drawings

CADD drawing allows you to rotate selected drawing objects to a specified angle. To rotate, you need to select the drawing objects, enter a reference point (or base point)

and the rotation angle. The base point acts as a pivot point around which the objects are rotated. The rotation angle determines by how much the objects will be rotated and in which direction.

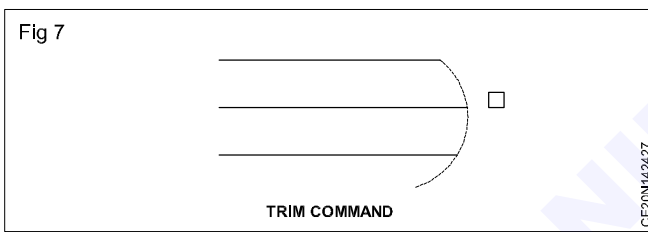
Reference angle rotation

A positive angle causes counterclockwise rotation, and a negative angle produces clockwise rotation. If you respond to the last prompt with r, you can specify the current rotation and the new rotation you want. AutoCAD prompts

- 1 Type R for a rotation angle<Rotation angle>/Reference: (R)
- 2 Choose An existing rotation angle Rotation angle: (number or points)
- 3 Choose A new rotation angle New angle: (number or points)

TIP (Fig 7)

You can show AutoCAD the reference angle (by pointing to the two endpoints of a line to be rotated), and then specify the new angle. You can specify the new angle by pointing or by dragging the object.



Trim

The trim command allows you to trim objects in a drawing so they end precisely at a cutting edge defined by one or more other objects in the drawing.

- 1 Choose Modify, trim (or) 
- 2 Click The trim icon. (or)
- 3 Type Trim at the command prompt
Command: trim
Select cutting edge(s)
- 4 Pick The cutting edge to extend to
Select objects: (select)
- 5 Press Enter to accept the cutting edge
Select objects: (press enter)
- 6 Pick Objects to trim
<Select object to trim>/Project/Edge/
Undo:

Select an object, enter an option, press enter

- 7 Press ENTER when you are done choosing objects

Select object to trim/Undo: (press enter)

TIP: Hold the SHIFT key to interactively extend instead of trim.

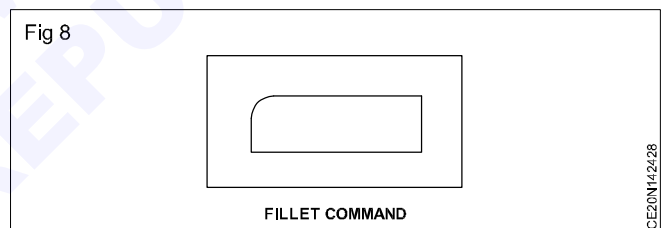
Cutting drawing objects along an edge

CAD allows you to erase drawing objects along a selected edge (this technique is often called trimming). When you use this function, you are prompted to select the drawing object that is to be used as the cutting edge and then select the objects that are to be erased along that edge.

Making sharp and rounded corners

CAD allows you to make fine corners of any two lines or arcs. This technique, often called filleting, is the quickest way to join the missing corners of lines and arcs. With this function active, to make a corner all you need to do is select the lines or arcs that have missing corners. CAD automatically extends or shortens the selected objects to form a corner. You can also specify whether you want a sharp corner or a rounded corner.

Fillet (Fig 8)



- 1 Choose Modify, fillet. (or) 
- 2 Click The fillet icon. (or)
- 3 Type FILLET at the command prompt. Command: FILLET
- 4 Pick First object to fillet. Polyline/radius/trim<Select two objects>: Select first object.
- 5 Pick Second object to fillet.
Select second object: select second object. (or)
- 6 Type One of the following options:
P Fillets an entire Polyline
R Sets the fillet radius.
T Sets the trim mode (trim cuts the fillet corner and no trim keeps the fillet corner).

TIP

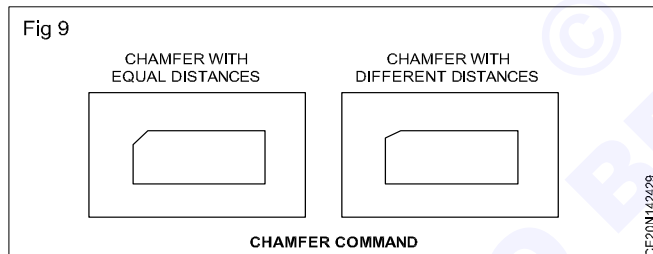
You can also fillet PARALLEL lines as well as PLINES with LINES

Type a radius of Zero (0) to create a clean 90 degree corner.

Chamfer

- 1 Choose Modify, chamfer.
(or)
- 2 Click The chamfer icon. 
- 3 Type CHAMFER at the command prompt.
Command: Chamfer
- 4 Pick First object to chamfer. Polyline/
distance/angle/trim/method<Select first
line>: select first object.
- 5 Pick Second object to chamfer.
Select second object: select second
object.
(or)
- 6 Type One of the following options:
P Chamfers entire Polyline.
D Sets chamfer distances.
A Uses a distance and angle method
instead of two distances.
T Sets the trim mode
M Sets the method to distance or angle.

Chamfer with equal distances (Fig 9)



Chamfer with different distances

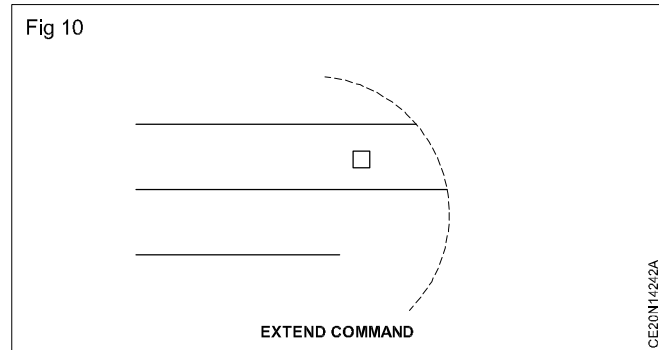
Making chamfered corners

CAD allows you to make a chamfered corner between two lines. It works quite like the fillet command. When you enter the chamfer command, you are prompted to select the lines that are to be chamfered and enter a chamfer distance. The chamfer distance determines the size of the chamfer.

EXTEND (Fig 10)

- 1 Choose Modify, extend, 
(or)
- 2 Click The extend icon.
(or)
- 3 Type EXTEND at the command prompt
command: EXTEND
Select boundary edge (s)....

Fig 10



- 4 Pick The BOUNDARY edge to extend to
select objects: (select)
- 5 Press ENTR to accept the boundary edge
select objects: (press enter)
- 6 Pick The object to extend
<Select object to extend> / Project/
edge/ undo: Select an object, enter
an option, or press enter: (select)
- 7 Press ENTER when you are done choosing
objects.

Lines extended to an arc (Arc is boundary edge)

TIP

Use the object selection option FENCE to choose multiple objects.

Extending drawing objects to an edge

CAD allows you to extend lines to a selected drawing object. Often you need to extend lines to construct a drawing and to fix any graphical errors. To extend lines, you need to select an edge to which the lines should extend and then select the lines to be extended.

Dividing an object into equal parts

CAD allows you place dividing marks on a drawing object such as a line, arc, ellipse or spline. To use this command, you need to select an object and specify how many divisions are required. This function places markers at equal distances on the drawing object.

Break (Fig 11 & 12)

Fig 11

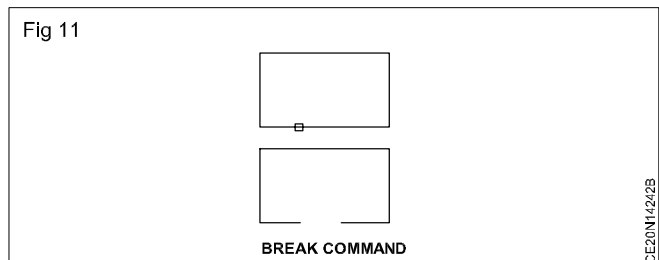
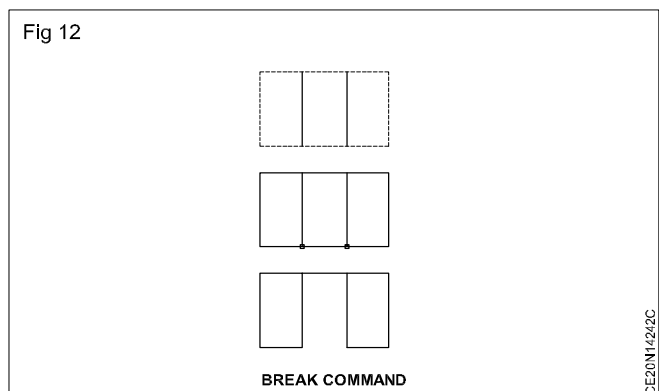


Fig 12



- 1 Choose Modify, break.
(or) 
- 2 Click The break icon.
(or)
- 3 Type BREAK at the command prompt.
Command: BREAK
- 4 Pick Object to break.
Select object: (select one object)
- 5 Pick A second break point. Enter second point: (point)
- 6 Type F to choose a different break point
Enter second point (or F for first point): (F)
- 7 Pick The first break point on the object
Enter first point: (point)
- 8 Pick A second break point

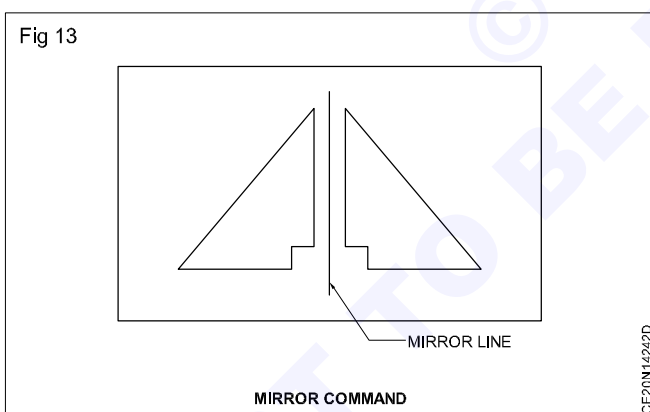
TIP

You can also type coordinates instead of picking a break point. Enter second point (or F for first point): @3'<0

If you break a circle, it changes to an arc by deleting the portion from the first point to the second, going counterclockwise.

Breaking a polyline with nonzero width will cause the ends to be cut square.

Mirror command (Fig 13)



- 1 Choose Modify, mirror.
(or) 
- 2 Click The mirror icon
(or)
- 3 Type MIRROR at the command prompt.
Command: MIRROR
- 4 Pick Objects to mirror. Select objects:
(Select)
- 5 Pick First point of mirror line: (point)
- 6 Pick Second point: (Point)

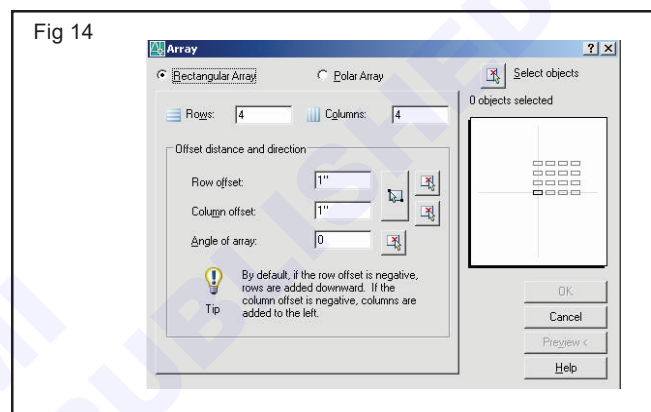
- 7 Type Yes to delete the original objects and
No to keep them.
Delete old objects? Y or N

Mirroring drawings

CAD allows you to create mirror images of drawings. This capability is very useful when you want to draw something that is symmetrical on both sides. You need to draw only one half of the drawing; the rest of the drawing can be completed using the mirror function. To make a mirror image, you need to select the objects to be mirrored and indicate a mirror axis. The mirror axis is an imaginary line along which the diagram is mirrored.

Array Commands

Rectangular array (Fig 14)



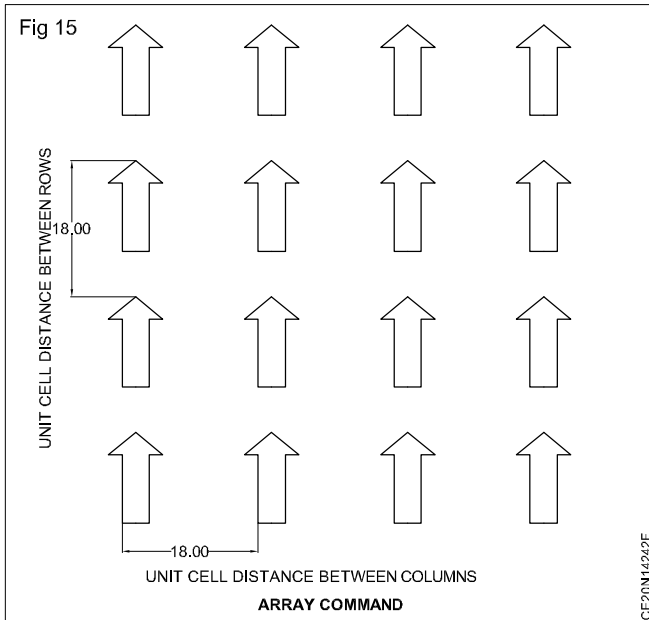
To draw rectangular array

- 1 Choose Modify, array.
(or) 
- 2 Click The array icon.
Or
- 3 Type ARRAY at the command prompt.
Command: ARRAY objects to array.
Select
- 4 Pick Objects to array. Select Objects:
(select)
- 5 Type The number of rows top to bottom.
Number of rows (----) <1>: (number)
- 6 Type The number of columns left to right.
Number of columns (III) <1>:
(number)
- 7 Type The unit cell distance between items
in each row. Distance between rows:
(+number=up, number = down)
- 8 Type The unit cell distance between items
in each column.
Distance between columns:
(+ number = right, - number = left)

Creating an array of objects (Fig 15)

The array command in AutoCAD is used to make multiple copies of objects. Although you can use the copy

Fig 15

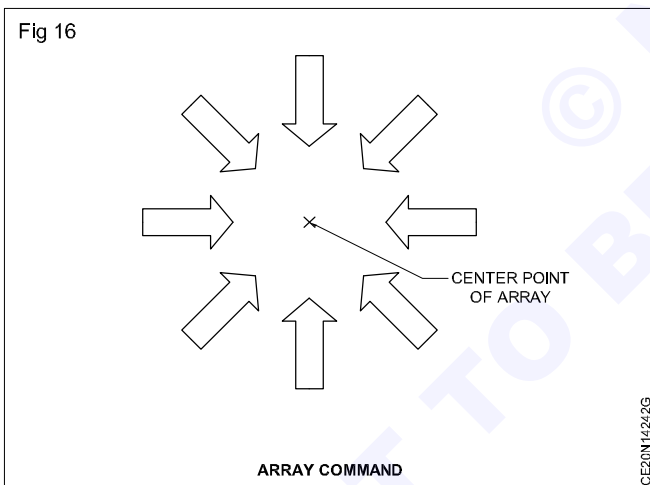


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command to duplicate objects, the array command is more flexible and precise. One advantage of using the array command is that it allows you to copy objects in a defined angle and exact number of copies. Therefore, you can create array in various pattern. For example, you can show multiple objects in a row, column, or irregular pattern such as a spiral. Let's look at a few examples below:

Polar array (Fig 16)

Fig 16



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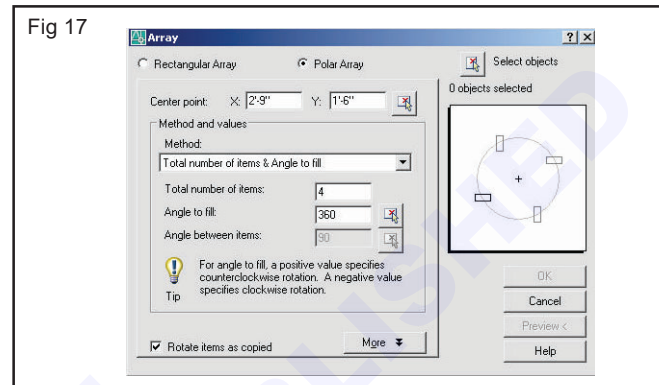
To draw a polar array:

- 1 Choose Modify, array.
(or)
- 2 Click The array icon.
(or)
- 3 Type Array at the command prompt.
Command: Array
- 4 Pick Objects to array. Select
Objects: (select)
- 5 Type P to draw a polar array. Rectangular or Polar array (R/P):P

- 6 Pick A center point for the array. Center point of array. Pick point
- 7 Type The total number of items in the array.
Number of items: number
- 8 Type The number of degrees to rotate the objects. Degrees to fill (+CCW, -CW) <360>:
Number
- 9 Type Yes No to rotate objects. Rotate objects as they are copied? <y> Y or N

Stretch (Fig 17)

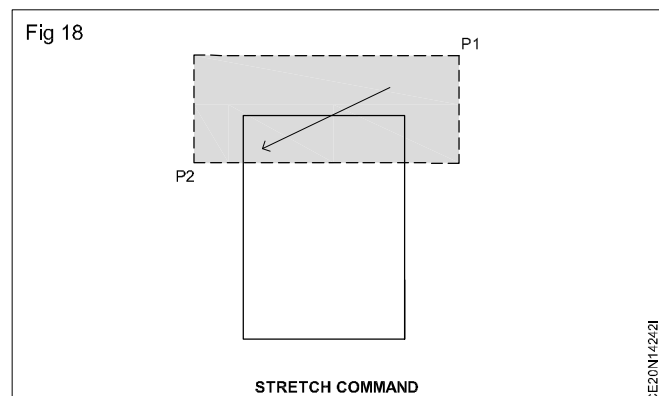
Fig 17



- 1 Choose Modify, stretch
(or)
- 2 Click The stretch icon.
- 3 Type STRETCH at the command prompt.
Command: STRETCH select objects to stretch by window.
- 4 Type C to choose CROSSING window Select objects: C
- 5 Pick A first corner to stretch. First corner: (point)
- 6 Pick The opposite corner to window the objects to stretch.
Other corner: (point)
- 7 Press ENTER to accept objects to stretch
- 8 Pick A base point to stretch from Base point: (point)

Stretching diagrams (Fig 18)

Fig 18



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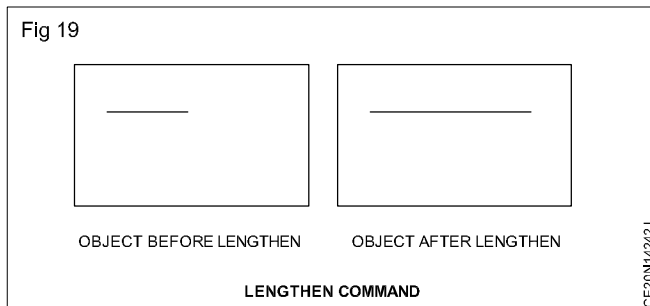
CADD allows you to quickly change the size of diagrams by stretching lines, arcs, splines, etc. This function is very helpful to make quick alterations to drawings. To use the stretch function, you need to select the drawing objects to be stretched and specify the distance and direction of stretching.

- 9 Pick A point to stretch to New point: (point)
- 10 Type A distance to stretch. New point: @ 1<0

TIP

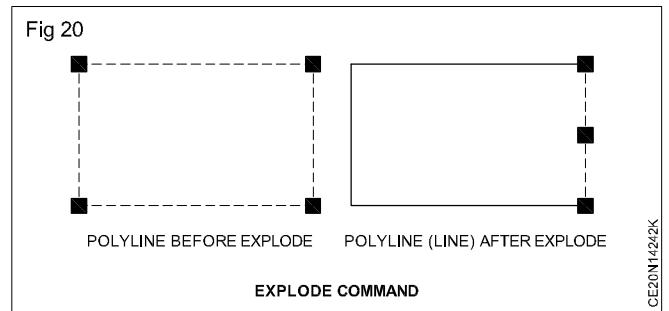
The Stretch command must use a CROSSING window or a CROSSING POLYGON window.

Lengthen (Fig 19)



- 1 Choose Modify, lengthen.
(or)
- 2 Type Lengthen at the command prompt.
Command: _lengthen (Fig 17)
Select an object or [Delta/Percent/Total/
Enter delta length or [Angle]<0.0000>:2
Select an object to change or [Undo]: pick
object
Object before lengthen
Object after lengthen

Explode command (Fig 20)



- 1 Choose Modify, explode.
(or)
- 2 Pick The explode icon.
- 3 Type EXPLODE at the command prompt.
Command: EXPLODE (Fig 18)
(or)
- 4 Pick The object to explode. Select objects:
(pick)

OOPS commands

Reinserts the last erased set of objects or block even if it was not the last command issued. Otherwise oops acts like UNDO.

- 1 Type OOPS at the command prompt to
reinsert erased objects
Command: OOPS

Knowledge of tool icons and set of tool bars

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

- state points, rectangle, polyline, spline, multilines, construction line
- state adding patterns to drawings.

Introduction

Drawing multiple parallel lines

CADD allows you draw parallel lines simultaneously just by indicating a starting point and an end point. These lines can be used to draw something with heavy lines or double lines. For example, they can be used to draw the walls of a building plan, roads of a site map, or for any other presentation that requires parallel lines.

Drawing flexible curves

CADD allows you to draw flexible curves (often called splines) that can be used to draw almost any shape. They can be used to create the smooth curves of a sculpture, contours of a landscape plan or roads and boundaries of a map.

To draw a flexible curve, you need to indicate the points through which the curve will pass. A uniform curve is drawn passing through the indicated points. The sharpness of the curves, the roughness of the lines and the thickness can be controlled through the use of related commands.

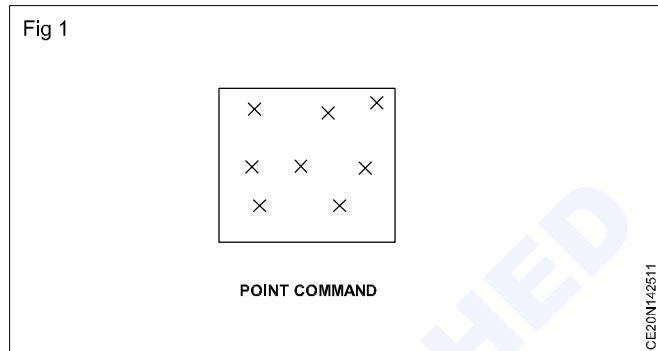
Adding hatch patterns to drawings

The look of CAD drawings can be enhanced with the hatch patterns available in CAD. The patterns can be used to emphasize portions of the drawing and to represent various materials, finishes, and spaces. Several ready-made patterns are available in CAD that can be instantly added to drawings.

Hatch patterns are quite easy to draw. You don't need to draw each element of a pattern one by one. You just need to specify an area where the pattern is to be drawn by selecting all the drawing objects that surround the area. The selected objects must enclose the area completely, like a closed polygon. When the area is enclosed, a list of available patterns is displayed. Select a pattern, and the specified area is filled.

Point command (Fig 1)

- 1 Choose Draw, point, single or multiple point
(or)
- 2 Click The point icon
(or)
- 3 Type Point at the command prompt
Command: Point
- 4 Pick A point on the drawing

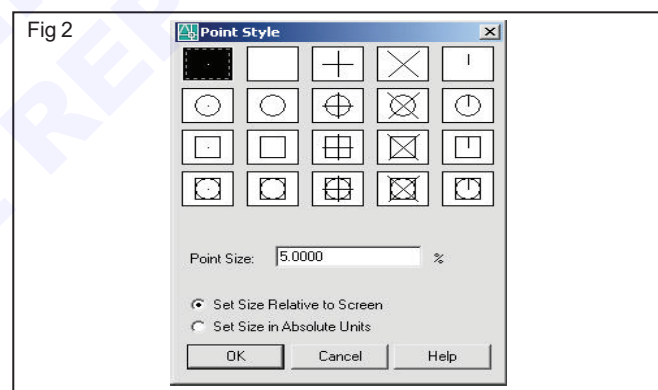


Point (point)

Point styles (Fig 1 & 2)

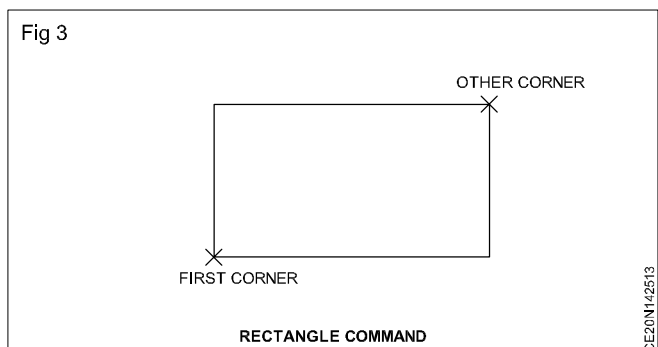
Changes the appearance of points and point sizes.

- 1 Choose Format, Point Style...
(or)
- 2 Type DDP TYPE at the command prompt.
Command: DDP TYPE (Fig 2)



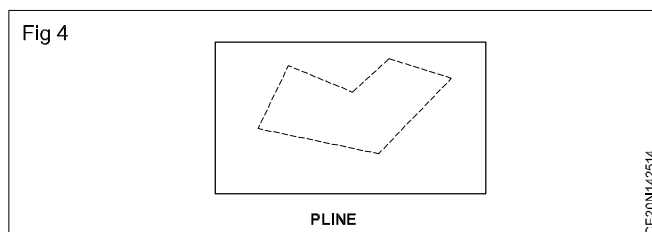
Rectangle (Fig 3)

- 1 Choose Draw, rectangle (or)
- 2 Click The rectangle icon (or)
- 3 Type Rectangle at the command prompt
Command: RECTANG chamfer/Elevation/
Fillet/Thickness/Width/<First corner>



- 4 Pick first corner
- 5 Pick other corner or type coordinates (i.e. @ 4,2)

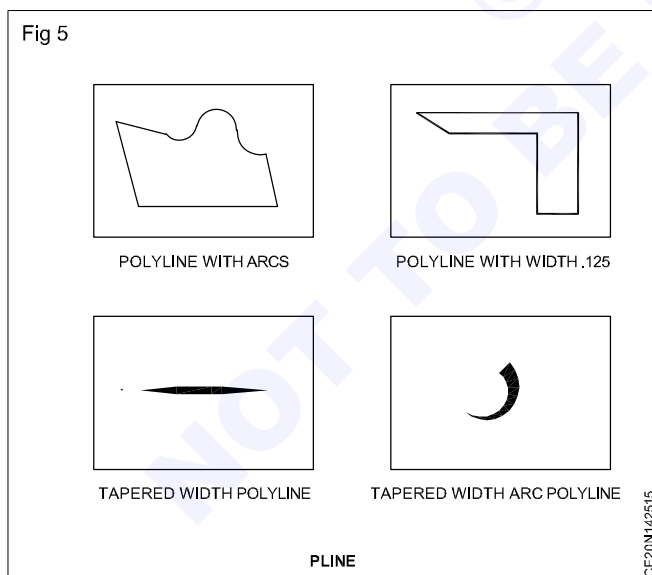
Pline command (Fig 4)



A polyline is a connected sequence of line segments created as a single object. You can create straight line segments, arc segments, or a combination of the two.

- 1 Choose Draw, polyline.
(or)
- 2 Pick The pline icon.
- 3 Type PLINE at the command prompt
Command: PLINE or PL
- 4 Pick A point on the drawing to start the polyline
Form point: (select)
- 5 Type One of the following options Arc/Close/
Halfwidth/Length/Undo/Width/<endpoint
of line>:
(or)
- 6 Pick A point to continue drawing Arc/Close/
Halfwidth/Length/Undo/Width/<endpoint
of line>: (pick point)

PLINE options (Fig 5)



Arc : Toggles to arc mode and you receive the following: Angle/Center/CLose/Direction/Halfwidth/Line/Radius/Second Pt/Undo/Width/<enter of arc>:

Close : Closes a polyline as it does in the line command.

Halfwidth : Specifies the halfwidth of the next polyline segments. Can be tapered.

Length : Specifies the length to be added to the polyline in the current direction.

Undo : Undoes the previous pline segment as with the line command.

Width : Specifies the width of the next polyline segments. Can be tapered.

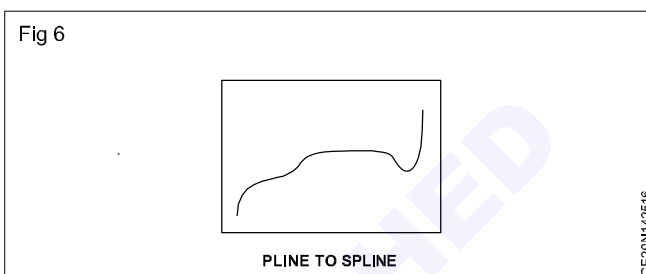
Polyline with arcs

Polyline with width 125

Tapered width polyline

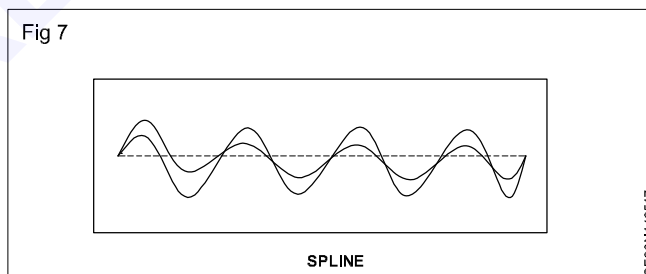
Tapered width arc polyline

Convert pline to spline (Fig 6)



- 1 Draw A Pline
- 2 Type PEDIT to edit the polyline as a spline.
- 3 Choose Draw, Spline
- 4 Type Object at the command prompt.
- 5 Click Once on the polyline to turn it into a spline.

Spline (Fig 7)

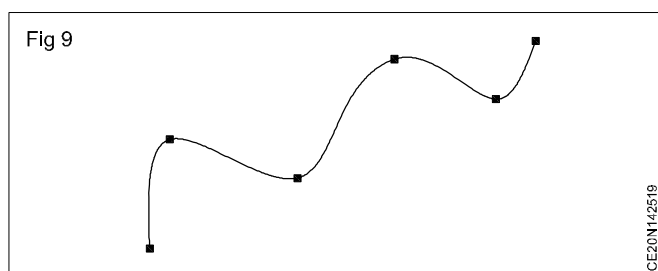
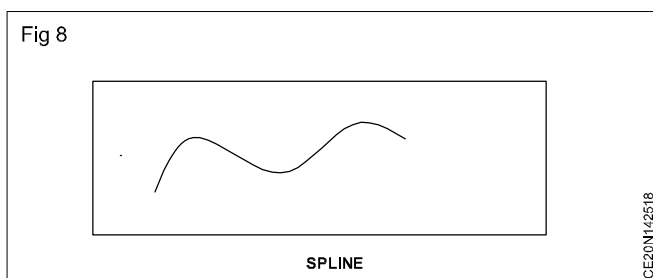


The spline command creates a particular type of spline known as a non uniform rational B-spline (NURBS) curve. A NURBS curve produces a smooth curve between control points.

- 1 Choose Draws, spline.
(or)
- 2 Click The spline icon
(or)
- 3 Type Spline at the command prompt
Command: Spline
- 4 Pick A start point for the spline Object /
<Enter first point> (pick point)
- 5 Pick Points until you are done drawing splines
Enter point: (pick points)
- 6 Press Enter or close to complete the spline

- 7 Pick Starting tangent point for the spline
Enter start tangent (pick point)
- 8 Pick Ending tangent point for the spline
Enter end tangent (pick point)

Spline options (Fig 8&9)



Object: Converts 2D or 3D spline-fit polylines to equivalent splines

Points: Points that defines the spline

Close: Closes a spline

Fit Tolerance: Allows you to set a tolerance value that creates a smooth spline.

TIP: Refer to AutoCAD online help topic for more information on spline options.

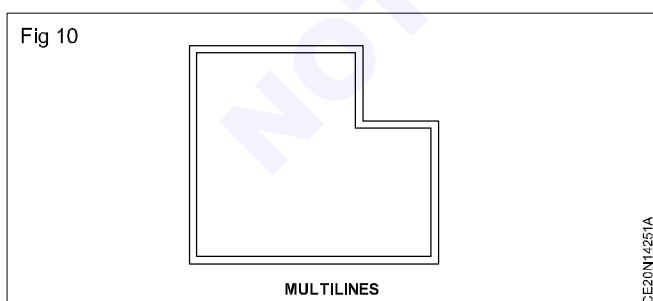
Editing splines

- 1 Choose Modify, Object, Spline.

TIP

Drawings containing splines use less memory and disk space than those containing spline-fit polylines of similar shape.

Multiline (Fig 10)

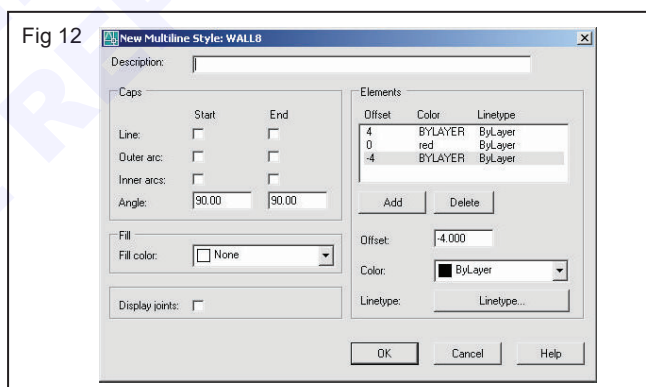
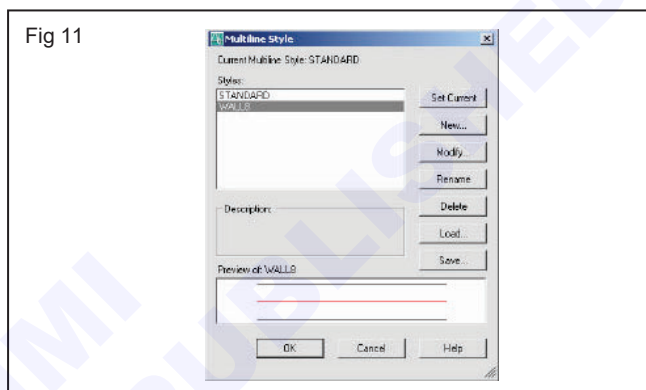


MLINE Command

- 1 Choose Draw, multiline.
(or)
- 2 Type MLINE at the command prompt
Command: MLINE

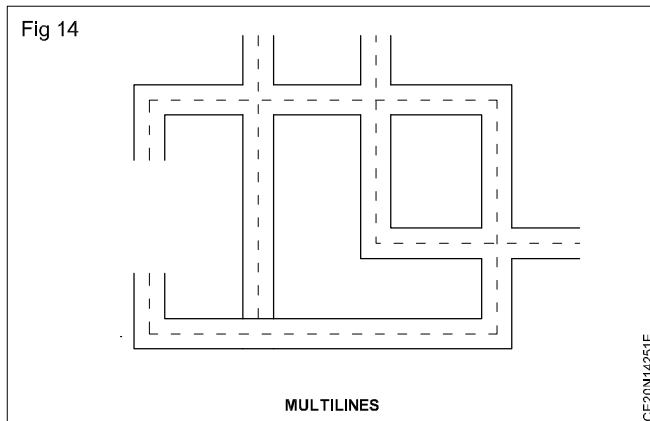
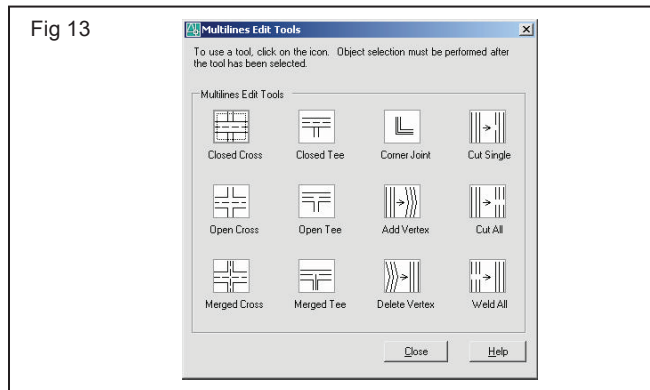
- 3 Pick A point to start the multiline.
Justification/Scale/Style/<From point>:
pick point
- 4 Pick A second point to continue the multiline.
<To point>: Pick point
- 5 Pick The next point to continue drawing
Multiline. Undo/<To point>: pick point
- 6 Press ENTER to end the multiline
Close/Undo/<To point>: press enter
(or)
- 7 Type C to close the multiline back to the first point. Close/Undo/<To point>:C

Multiline styles (Figs 11 & 12)



- 1 Choose Format, multiline style.
- 2 Type Mlstyle at the command prompt.
Command: Mlstyle
- 3 Rename The existing style called STANDARD to your new style.
- 4 Choose Element properties to change the appearance of the Multiline.
- 5 Choose ADD to create the new multiline.

Editing multiline (Fig 13 & 14)



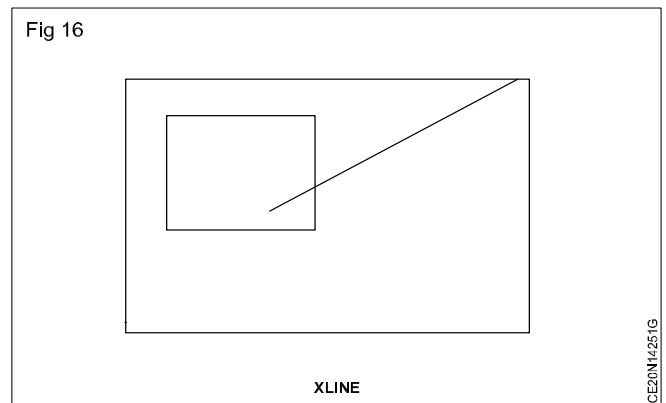
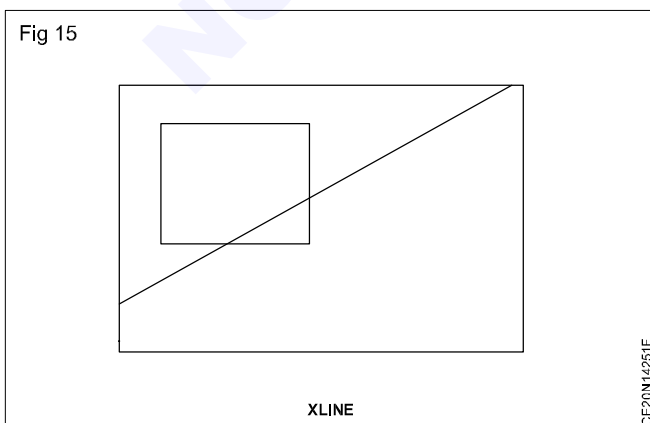
- 1 Choose Modify, Multiline (or)
- 2 Type MLEDIT at the command prompt
Command: MLEDIT
- 3 Choose from one of the ml edit options

Construction line

Creates an infinite line.

- 1 Choose Draw, Construction Line (or)
- 2 Choose the XLINE icon. (or)
- 3 Type XLINE at the command prompt.
Command: XLINE
Specify a point or [Hor/Ver/Ang/Bisect/Offset]

XLINE options (Fig 15 & 16)



- HOR:** Creates a horizontal x line passing through a specified point
- VER:** Creates a vertical x line passing through a specified point
- ANG:** Creates an x line at a specified angle.
- BISECT:** Creates an x line that passes through the selected angle vertex and bisects the angle between the first and second line
- OFFSET:** Creates an x line parallel to another object.

Ray command

Creates an infinite line in one direction

- 1 Choose Draw, ray (or)
- 2 Type Ray at the command prompt. Command: Ray specify a point: (pick through point)



HATCH command

- 1 Choose Draw, hatch... (or)
- 2 Click The hatch icon. (or)
- 3 Type BHATCH at the command prompt
Command: BHATCH

HATCH options (Fig 17 & 18)

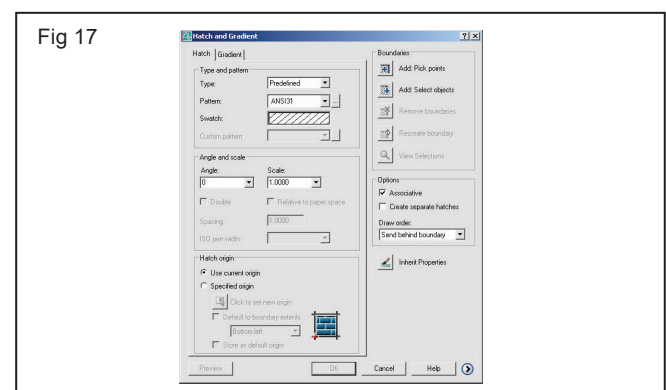


Fig 18

Pattern properties: Sets the current pattern, scale, angle, and spacing, Controls if hatch is double spaced or exploded.

Select objects: Selects specific objects for hatching. The boundary hatch dialog box disappears and AutoCAD prompts for object selection.

Inherit properties: Applies the properties of an existing associative hatch to the current pattern type and pattern properties options.

Preview hatch: Displays the hatching before applying it. AutoCAD removes the dialog box and hatches the selected areas.

CAD basics

- explain user co-ordinate system
- enumerate Auto CAD commands
- express line & erase commands.

Fig 1

USER COORDINATE SYSTEM

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Designs and drawings created in a CAD system are usually defined and stored using sets of points in what is called world space. In most CAD systems, the world space is defined using a three-dimensional Cartesian coordinate system. Three mutually perpendicular axes, usually referred to as the X-, Y-, and Z-axes, define this system. The intersection of the three coordinate axes

Apply: Crates the crosshatching in the boundary.

Annotative hatch (Fig 19)

Fig 19

Windows Explorer window showing the 'ANSI' folder contents. The folder list on the left includes 'cham.dwg', 'direct.dwg', 'overhead.dwg', 'm_dwg.dwg', 'B1.spd.dwg', 'Template', 'Features', 'UseDataCache', 'Data Links', 'Plot Styles', 'Patterns', 'Support', 'AutoCAD', 'Help', 'Profiles', 'ToolPalette', 'acad.pwt', 'acadiso.pwt', and 'Template'. The main pane displays a grid of files with patterned thumbnails and names: ANSI, ANSI01, ANSI02, ANSI03, ANSI04, ANSI05, ANSI06, ANSI07, ANSI08, AR-B1B1S, AR-B1B1C, AR-B1B, AR-B1E1M, AR-B1S1D, AR-C1C1C, AR-H1E1E, AR-P1A1Q1, AR-P1B1F, AR-P1S1H1E, AR-S1A1D, and B1K.

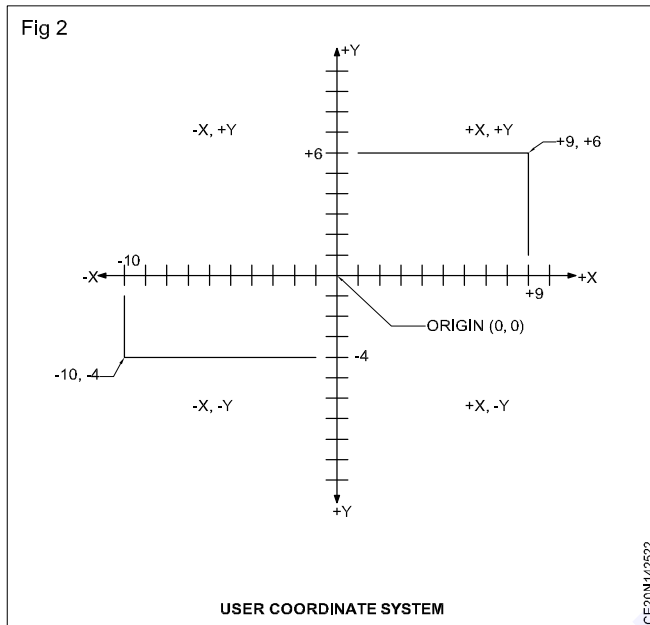
Hatching from the design center

- 1 **Choose:** A cross hatch pattern from the following AutoCAD directly\AutoCADxxxx\Support\acad.pat or \AutoCADxxxx\Backup
- 2 **Drag:** and drop a pattern into a drawing.

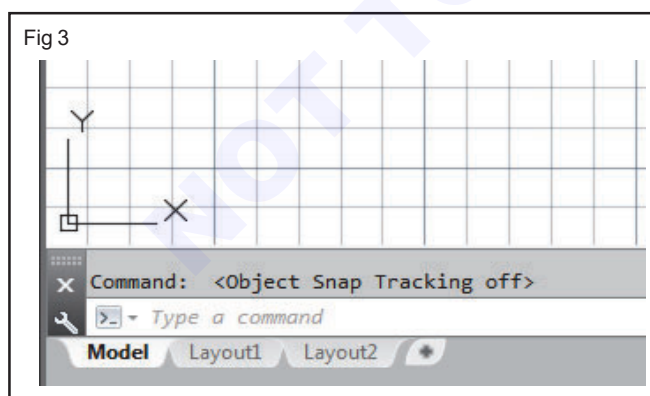
TIP

Be sure the HPSCALE is set before dropping a hatch pattern into a drawing.

is a coordinate system used by AutoCAD as the basis for defining all objects and other coordinate systems defined by the users. We can think of the origin of the world coordinate system as a fixed point being used as a reference for all measurements. The default orientation of the Z-axis can be considered as positive values in front of the monitor and negative values inside the monitor. (Fig 2)



AutoCAD uses points to determine where an object is located. There is an origin where it begins counting from. This point is (0,0). Every object is located in relation to the origin. If you were to draw a line straight out to the right from the origin, this would be considered the positive X-axis. If you were to draw a line straight up, this would be the positive Y-axis. The picture above shows a point located at (9,6). This means that the point is 9 units over in the X-axis and 6 units up in the Y-axis. When you are working with points, X always comes first. The other point shown is (-10,-4). This means that the point is 10 units in the negative X-axis (left) and 4 units in the negative Y axis (down) (Fig 3)



A line has two points, a start point and an end point. AutoCAD works with the points to display the line on the screen. Move your cursor over the picture above and you will see line drawn from the absolute points of (-10,-4) to (9,6).

Most of the time you will not have an indication of where the origin is. You may need to draw a line from the endpoint of an existing line. To do this you use relative points. These work the same way, but you have to add the @ symbol (shift+2) to tell AutoCAD that this next point is relative from the last point entered.

To review

Absolute points are exact points on the drawing space. Relative points are relative to an object on the drawing space.

Its a simple system, but mastering it is the key to working with AutoCAD and is explained in more detail further below. In order to work effectively with AutoCAD, you have to work with this system. Until you are comfortable and familiar with it, learning AutoCAD will be more of a chore. My experience in teaching is that the better a student is with coordinates, the faster they will learn.

Entering points in AutoCAD

You can enter points directly on the command line using three different systems. The one you use will depend on which is more applicable for the situation. The first assignment will get you used to this. The three systems are as follows.

Absolute co-ordinates: Using this method, you enter the points as they relate to the origin of the WCS. To enter a point just enter in the exact point as X,Y.

Relative co-ordinates: This allows you to enter points in relation to the first point you have entered. After you've entered one point, the next would be entered as @ X,Y. This means that AutoCAD will draw a line from the first point to another point X units over and Y units up relative to the previous point.

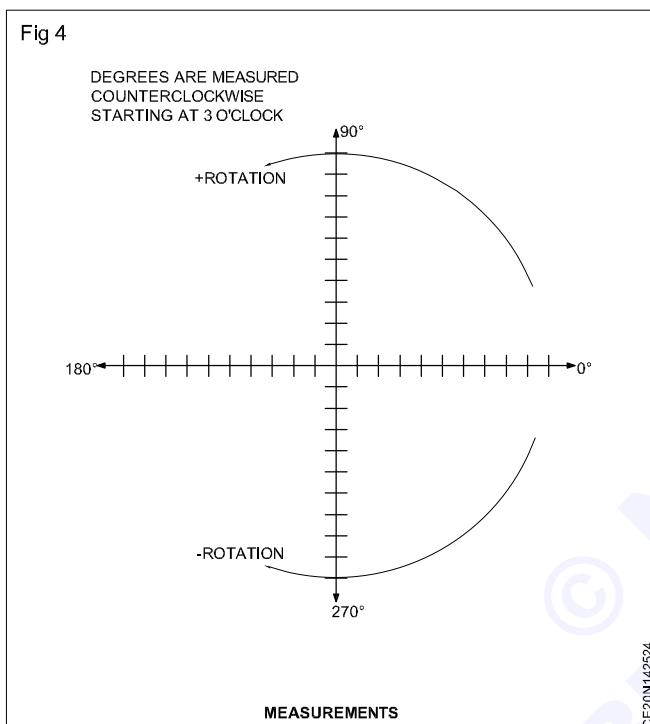
Polar co-ordinates: You would use this system if you know that you want to draw a line a certain distance at a particular angle. You would enter this as @ D<A. In this case, D is the distance and A is the angle. Example: @10<90 will draw a line 10 units straight up from the first point.

The three ways of entering coordinates shown above are the only way AutoCAD accepts keyboard input. First decide which style you need to use, and then enter as shown. Remember that X is always before Y (alphabetical). Don't forget the '@' symbol when you are entering relative points. Any typing error or omission will give you results you don't want. If you make a mistake and need to see what you typed, Press F2 to bring up the text screen and check your typing. (press F2 to get back to your drawing).

Key terms	
Term	Description
Absolute coordinates	Distance measured from a fixed reference point.

Aperture	Effective diameter of the cursor on the screen.
Cartesian coordinates	A rectangular system of measurement to locate points in the drawing area.
Object snaps	A method for indicating point locations using existing drawing objects as a reference.
Origin point	The 0,0 location of the coordinate system.
Polar coordinates	A system to locate of the coordinate system.
Prototype drawing	A template drawing that has a last location of the cursor.
Relative coordinates	Distance measured from the last location of the cursor
User-defined co-ordinates System	A mode of measurement that allows the user to set up a customized coordinate system.

Angular measurement (Fig 4)



AutoCAD measures angles in a particular way also. Look at the diagram below and then place your mouse on it to see how this is

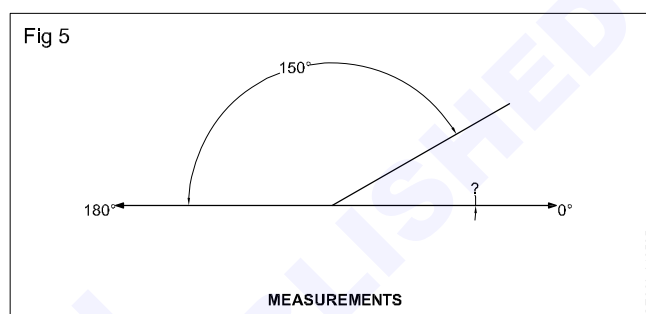
Degrees are measured counterclockwise starting at 3 O'CLOCK

When drawing lines at an angle, you have to begin measuring the angle from 0 degrees, which is at the 3 O'clock position. If you drew a line at 90 degrees, it would go straight up. The example above (When you move your mouse over it) shows a line drawn at +300 degrees (270+30), or -60 degrees.

You might not always have an obvious reference point for 0 degrees. Look at the example below and place your mouse on the image to find out the angle in question.

In this example, you are given information about the lines, but not the angle AutoCAD needs to draw the line from the start point. What you are given though, is (a) the knowledge that 0° is at the 3 o'clock position (b) the knowledge that 180° is at the 9 o'clock position and (c) the angle between 180° and the line you want to draw is 150°. With this information, you can figure out what angle

you need. Here is a fool-proof way of getting the angle you need (Fig 5)



- 1 Start at the 0° position and measure counter-clockwise (+) to 180°
- 2 From 180°, measure clockwise 150° (-)
- 3 Consider that you just went +180-150 and use that as an equation: +180-150=30
- 4 Now you can draw your line using polar coordinates (discussed below)

There are many ways to do things in most windows programs. AutoCAD is no exception. Everyone will develop a way that works best for him or her. In this course, we will primarily be working with the keystroke commands. The reason for this is because they will work in most AutoCAD versions (including DOS versions), and in some other CAD programs. The icons work well, but as you will see, icons can be placed anywhere on the screen and can be difficult to find quickly. You may be working on another employee's computer that is set up differently than what you're used to. The pulldown menus will access almost all commands, but are a slower way of doing things. Icons in AutoCAD 2010 are found on the ribbon, divided into panels-just click on the appropriate tab to open the panel you need.

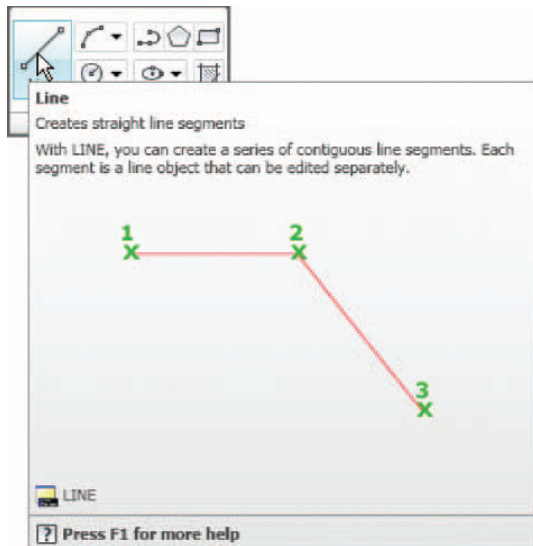
Example: If you want to draw a line, you can do it a few ways: (Fig 6)

At the command line type: LINE (or) L and press the ENTER key.

Select the line icon from the DRAW Panel.

Another way is to Right-Click on the drawing space and choose "Recent Input" from the menu. This will give a list of the most recent command that you have used. (Fig 7)

Fig 6



All three approaches will do the same thing: prepare AutoCAD to draw a line where you tell it.

AutoCAD is a popular program because it can be customized to suit an individual's needs. The toolbars are a good example of this. You can have the toolbars you use most often on the screen all the time. You can easily make them go away so that you have more drawing space. You can also customize them so you have the most common commands on one toolbar. For example, the dimensioning toolbar is one that you will not want taking up space on your screen while drawing, but is very handy when you're dimensioning your drawing. (Fig 8)

To remove the ribbon and have the most drawing space available, click on the "Clean Screen" icon in the bottom right corner of the screen (or press CTRL+O [letter O]). To go back to the standard display, click again on the same icon.

Fig 7

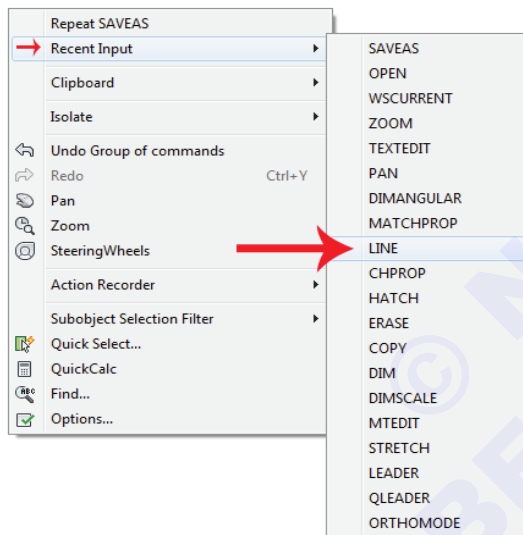
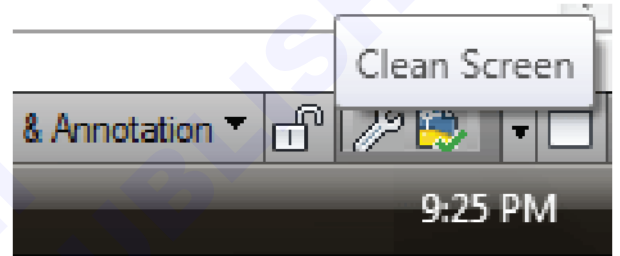


Fig 8



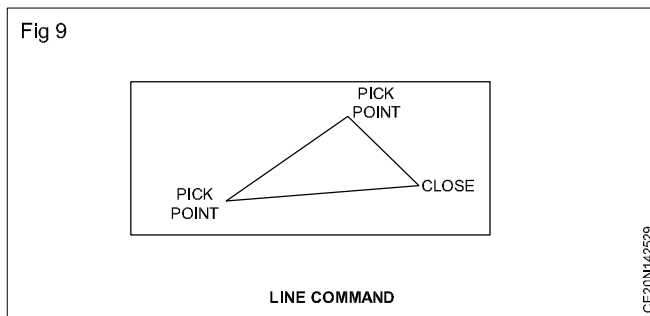
Symbol	Command	Purpose
	Erase	Delete object
	Move	Move object one place to other place
	Copy	Create one or more copies of object
	Stretch	Stretch, short, or move object
	Trim	Shorten object using other object

	Extend	Lengthen object using object
	Mirror	Creates a mirror image of objects.
	Rotate	Rotate objects around a specified point.
	Offset	Create a new object at a specified distance from an existing object or through a specified point.
	Array	Each object in an array can be manipulated independently.

Auto CAD Drawing Commands

Symbol	Command	Major option	Toolbar button	Draw men
	Line	Start, End Point	Line	Line
	Milne	Justification, Scale Style	None	Multiline
	Pline	Vertices	Polyline	Polyline
	Polygon	Number of sides, Inscribed / Circumscribed	Polygon	Polygon
	Rectangle	Two Corner	Rectangle	Rectangle
	Arc	Various methods of definition	Arc	Arc, submenu for definition methods
	Circle	Three point, two point, Tangent	Circle	Circle submenu for definition methods
	Donut	Inside, Outside Diameters	None	Donut
	Spline	Convert polyline or Create new	Spline	Spline
	Ellipse	Arc, center, axis	Ellipse	Ellipse, submenu for definition methods
	Revcloud	Arc Length	Revcloud	Revision cloud

Line command (Fig 9)



Create single straight line segments

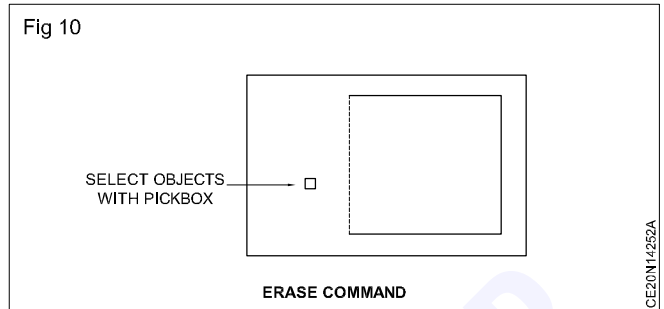
- 1 Choose draw, line
(or)
- 2 Click the line icon 
- 3 Type line from the command prompt command: line or L
- 4 Press enter
- 5 Pick from point: (point)
- 6 Pick specify next point or [Close/Undo]: (point)
- 7 Pick specify next point or [Close/Undo]: (point)
- 8 Press ENTER to end line sequence
(or)

- 9 Type U to undo the last segment to point: U (undo)
(or)

- 10 Type C to create a closed polygon to point: C (close)

Erase and selection sets

Erasing Objects (Fig 10)



- 1 Choose Modify, erase
(or)
- 2 Click The Erase icon 
- 3 Type Erase at the command prompt. Command: Erase or E
- 4 Pick Object at the select object prompt.
- 5 Press ENTER when you are done choosing objects. Select objects: ENTER

Knowledge of short cut key board commands

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

- describe the features of key board commands in detail.

Toggle general features

Ctrl + d	Toole coordinate display
Ctrl + g	Toggle grid
Ctrl + e	Cycle isometric planes
Ctrl + f	Toggle running object snaps
Ctrl + h	Toggle pick style
Ctrl + Shift + h	Toggle hide pallets
Ctrl + l	Toggle cords
Ctrl + Shift + l	Toggle infer Constraints

Toggle drawing modes

F1	Display Help
F2	Toggle text screen
F3	Toggle object snap mode
F4	Toggle 3DO snap
F5	Toggle Iso plane
F6	Toggle Dynamic UCS

F7	Toggle grid mode
F8	Toggle ortho mode
F9	Toggle snap mode
F10	Toggle polar mode
F11	Toggle object snap tracking
F12	Toggle dynamic input mode

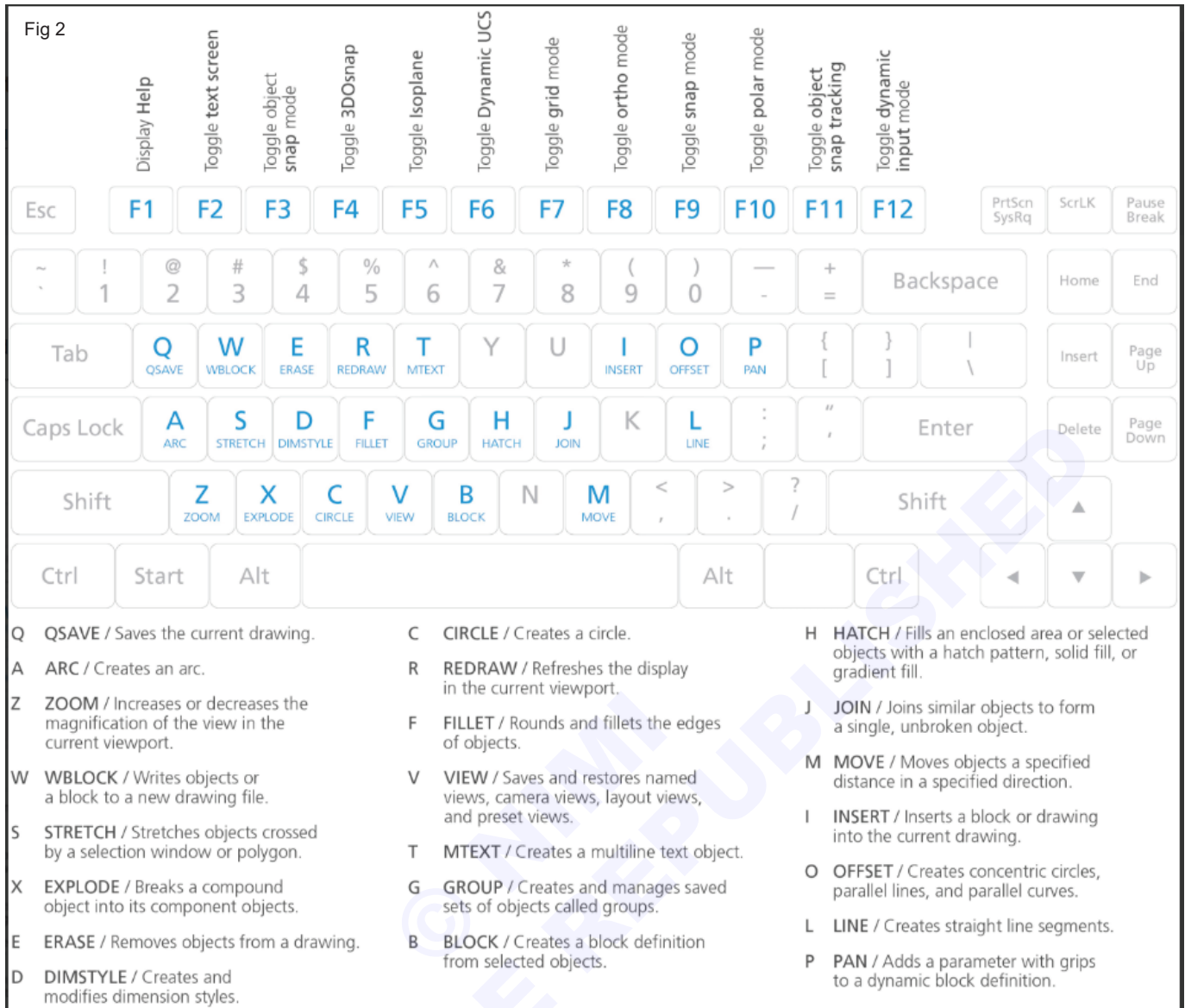
Manage screen

Ctrl + o(zero)	Clean screen
Ctrl + 1	Property palette
Ctrl + 2	Design center palette
Ctrl + 3	Tool palette
Ctrl + 4	Sheet set palette
Ctrl + 6	DB connect manager
Ctrl + 7	Markup set manager palette
Ctrl + 8	Quick calc
Ctrl + 9	Command line

Fig 1



Fig 2



Manage workflow

Ctrl + c	Copy object
Ctrl + x	Cut object
Ctrl + v	Paste object
Ctrl + Shift + C	Copy to clipboard with base point
Ctrl + Shift + V	Paste data as block
Ctrl + Z	Undo last action
Ctrl + Y	Redo last action
Ctrl + [	_Cancel current
	Command (or+ Ctrl +\)
ESC	Cancel current command

Manage Drawings

Ctrl + n	New drawing
Ctrl + s	Save drawing
Ctrl + o	Open drawing
Ctrl + p	Plot dialog box
Ctrl + Tab	Switch to next
Ctrl+shift+Tab	Switch to previous drawing
Ctrl +page up	_Switch to next
	Tab in current drawing
Ctrl + Q	Exit
Ctrl + a	Select all objects

Bar bending schedule

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

- explain bending of bars
- explain estimation of reinforcement
- explain bar bending and scheduling.

Introduction

Preparation of highly detailed reinforcement drawing and bar bending schedule is an essential requirement in the construction field, all over the world. With this we can achieve a high level of quality control at site and will be advantageous in various aspects of construction.

In the use of high grade concrete and steel, quality plays a major role. In order to prepare the bar bending schedule, the design office can have the information from site about the stock lists for bar diameters and their lengths available at the site. Fe 500 bars cannot be bend acutely as we bend the Fe 415 bars. Also there are rebinding considerations to be followed. Proper scheduling, & bending with a mechanized system ensures this required quality level.

Let us focus on the detailed drawing to be done for reinforcement detailing (rebar) in reinforced cement concrete construction. Here rebars are drawn to 5mm accuracy as per the detailing rules in IS or British codes.

The reinforcing material for concrete should have the following qualities:

- 1 The reinforcing material should be capable of developing a good bond with the concrete.
- 2 Coefficient of thermal expansion should be nearly same as that of concrete.
- 3 It should have high tensile strength.
- 4 It should be easy to cut as bend.
- 5 It should be cheap and easily available.

Mild steel is commonly used as reinforcing material to RCC. Reinforcing steel is provided on tension side of the concrete member. The density of the concrete may be taken as 2440 kg/m^3 and that of steel as 78.5 q/m^3 .

Bending of bars

In case of round bars used as reinforcement in concrete, hooks at the ends are provided.

Cover in reinforcement

The reinforcement bars are embedded in concrete so that it is fully covered. Minimum cover required for various structures as per IS - 456 - 1962 is as given below:

- 1 Clear cover at the end of bars = not less than twice the diameter of bars but minimum 2.5 mm.
- 2 Clear cover for slabs = 15 mm or diameter of bar whichever is more.

- 3 Clear cover for beams = 25 mm or diameter of bar whichever is more.
- 4 Clear cover for columns = 40 mm or diameter of longitudinal bar whichever is more.
- 5 Clear cover for foundation slabs and beams = 50 mm. When surfaces of concrete members are exposed to the action of harmful chemicals, acids, vapours, sulphurous smoke etc. the cover may be increased.

Purpose of distribution bars in slab

The distribution bars are provided in the slab for lateral distribution of loads on the slab and to take temperature and shrinkage stresses.

The percentage of reinforcement depends on the design of the structure. In the absence of detailed design the percentage of steel for concrete may be taken approximately as given below.

Lintel slab - 0.721%

Beam - 1 to 2%

Column - 1 to 5%

Foundation raft footing etc - 0.5 to 0.8%

Estimation of R.C.C

R.C.C work is usually estimated under two items:

The concrete in cubic metre and steel reinforcement in quintal. In structural members such as beams, lintels, slabs, etc steel bars are provided in the tensile zone. There are two types of reinforcement provided in a slab: Main reinforcement and distributors or temperature reinforcement. Main reinforcement is used for taking the loads (tensile load). These are provided in shorter span. In this, alternate bars are cranked for taking diagonal tension and are called cranked bars or bent up bars. Usually cranking is given at an angle of 45° . It varies from 30° to 60° . Generally cranking should be started at a distance of $3/4$ to $1/7$ of the span from the support. The diameter of main reinforcement may be 8mm to 12mm.

Distribution steels are provided at right angle to the main reinforcement, i.e: along the longer span.

In order to distribute the load and to reduce the temperature variation and shrinkage, distribution steels are also used. For distribution bars, 6 mm to 8 mm bars are used.

Hooks are provided at both ends of the reinforcement to get a proper anchorage (bond) with concrete. They may be at 'U' type or 'L' type. Generally 'U' type hooks are provided. Deformed bars (Twisted steel or tor steel) may be used without hooks. The length of one hook is approximately $\phi 9$ where ϕ is the diameter of the reinforcement.

The minimum cover is given as the greater of the following:

- 1 Diameter of rod
- 2 Size of coarse aggregate
- 3 Generally bottom and top cover should be given 20 mm and end cover should be 40 to 80 mm

Let 'L' is equal to the length of slab.

'l' is the effective length.

$l = L - 2 \text{ end cover}$

length of straight bar = effective length + length of two hooks.

$= l + 2 \times \text{length of one hook}$

$= l + (2 \times 9\phi) = l + \phi 18$

'D' is equal to depth of slab.

'd' is the effective depth = D - two cover - 1 dia of the main bar.

length of cranked bar = length of straight bar + two excess length (as shown in figure 1)

Excess length of the one side of the cranked bar

$= 0.414d = 0.42d$

length of cranked bar = length of straight bar + $2 \times 0.42d$
 $d = l + 18\phi + 0.84d$

length of distributor bar = $l + \phi 18$

(Where 'l' is the effective length in longer span)

Number of bars,

$$\text{Number of main bar} = \frac{l}{\text{Spacing}} + 1$$

Where l = effective length in longer span.

Number of main bars = no. of straight bars + no. of cranked bars.

Number of distributors = Number of distributors over straight bars no. of distributors under cranked bars.

$$\text{Number of distributors over straight bars} = \frac{l}{\text{Spacing}} + 1$$

(where l is the effective length in shorter span)

Number of distributors under cranked bars

$$= 2 \left[\frac{x}{\text{Spacing}} + 1 \right]$$

(Where 'x' is the length of cranked bar at top)

Therefore, total number of distributor bars

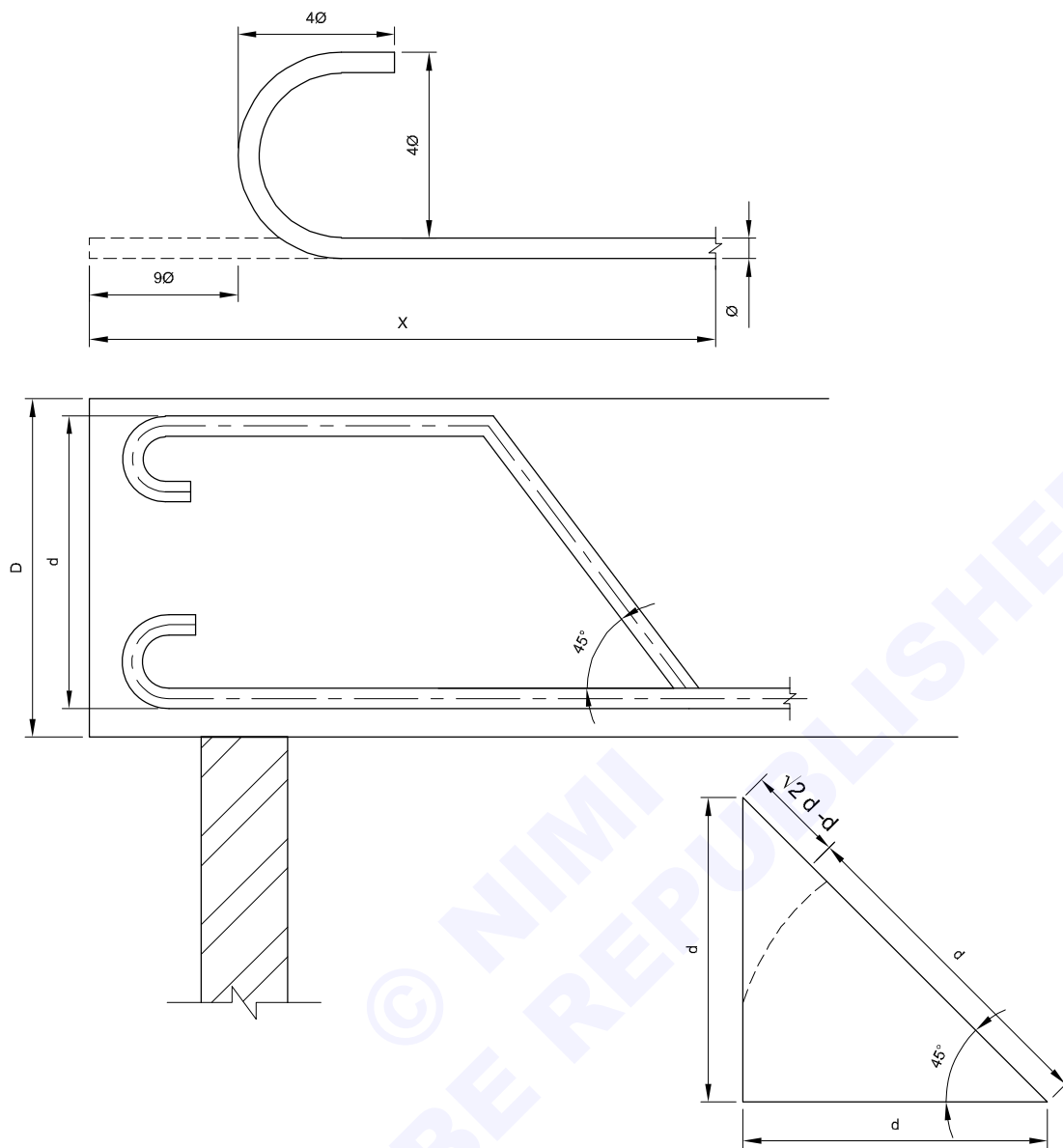
$$= \left[\frac{l}{\text{Spacing}} + 1 \right] + 2 \left[\frac{x}{\text{Spacing}} + 1 \right]$$

Bar bending schedule or schedule of bar (Fig 1)

The schedule of bar is the list of reinforcement bars in a tabular form giving the description of bar, shape of bending with sketch, number, length of each bar, total length, weight per metre length and total weight for each R.C.C work. For each type of RCC work, bartending schedule is prepared. From the schedule of bar the requirement of different sizes of bars may be known and may be arranged and built during the construction.

Sl. No	Description/ particulars	Shape of bars with sketches	No. of bars	Length of each bar	Total length	Weight metre	Total weight

Fig 1



BARBENDING SCHEDULE OR SCHEDULE OF BAR

CE20N142811

Weight / m of round bars

Diameter	Weight / m
6 mm	0.22 kg/m
8 mm	0.39 kg/m
10 mm	0.62 kg/m
12 mm	0.89 kg/m
16 mm	1.58 kg/m
18 mm	2.00 kg/m
20 mm	2.45 kg/m

This schedule can be used to cut and bend the bars to the required shape in a cut and bend factory and also in a site. As the steel can be cut and can be brought to the site in a readymade form, Author would like to call it ready mix steel as like our favorite ready mix concrete. Let us go through the different aspects of the preparation of BBS.

Bar bending scheduling (BBS) (Figs 2, 3 & 4)

Part drawing of slab bottom reinforcement details is shown. As more details are put in the drawing it is ideal to show top and bottom bar separately in the drawings. Every bar is also marked with a number called 'bar mark' (Examples-1, 2, 8 etc). This bar mark is the identifier for the bar in the BBS. Shape code defines the shape of the bar. For example, shape code 37 or as per the IS code is shown below. The shape code 3A (IS: 2502-1963) means that it is a straight bar.

Advantages of bar bending schedules (BBS)

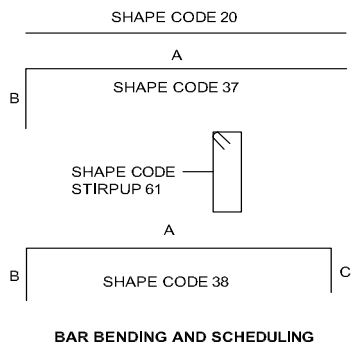
- 1 Scheduling and proper bending is strongly recommended for Fe 500. Fe 500 saves 10% compared to Fe 415 steel used presently.
- 2 Cutting and bending in a cut and bend factory avoids the wastage completely (5-7 %). With BBS, bars can be cut with planning to reduce the wastage in a site with even the present setup.

Fig 2

SLAB BOTTOM BAR

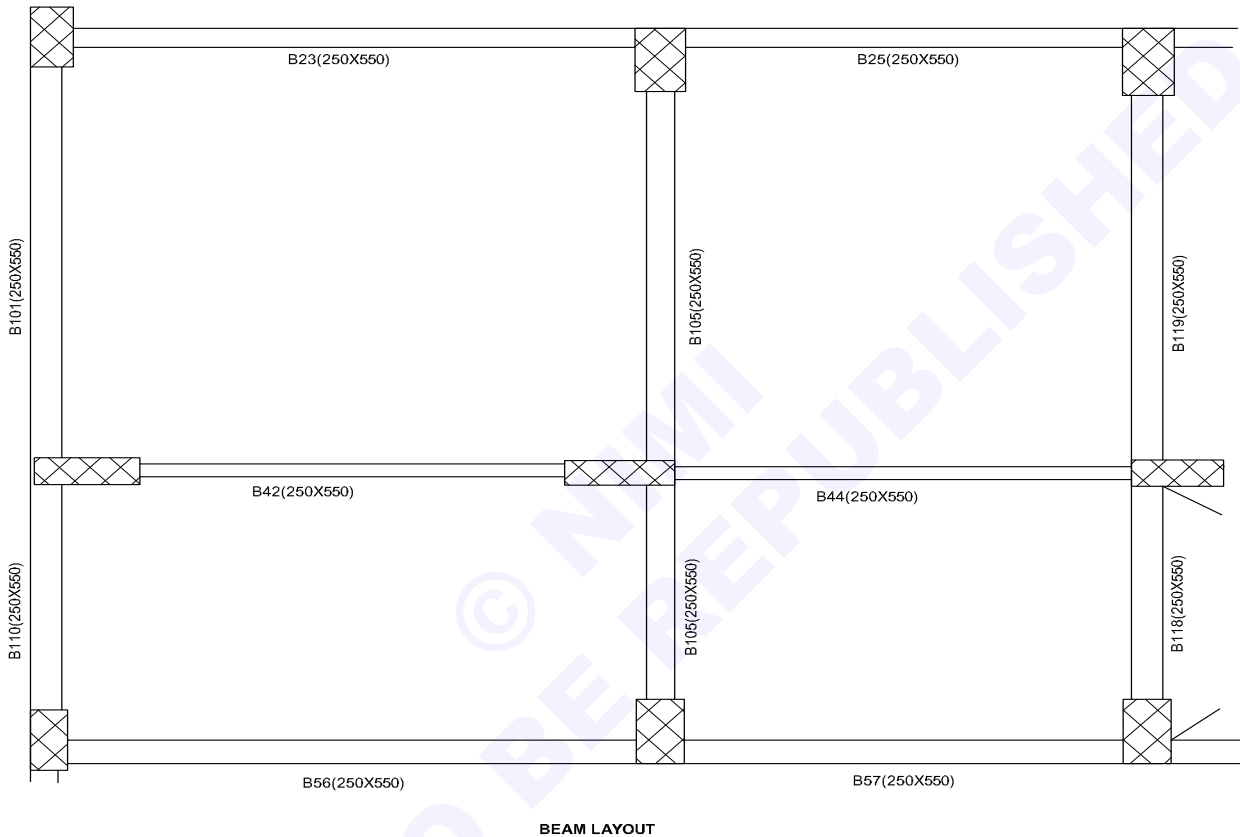
[illegible]

Fig 4

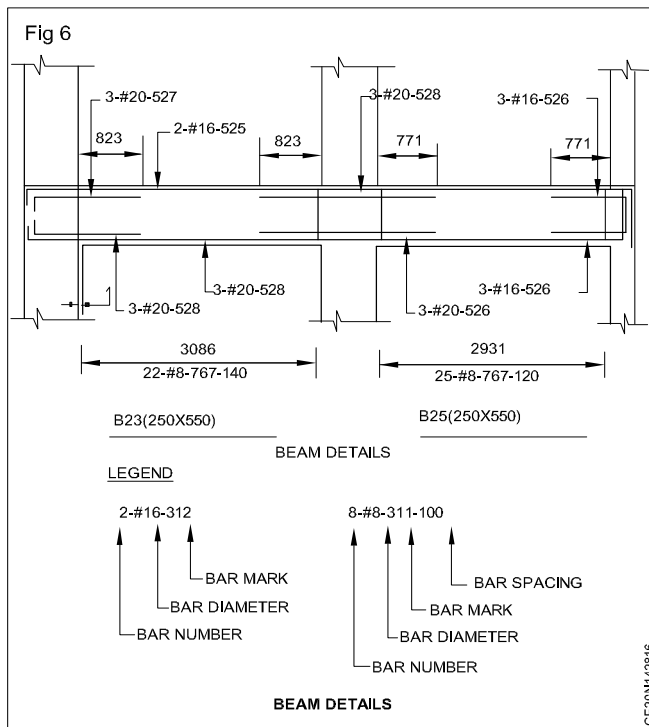


- 3 There is a general tendency to group slabs and beams in the usual design methods. In BBS, it is a must to detail every member separately to account finer geometry and different forces coming on the structure in the modern design methods. Instead of grouping members as all members are detailed separately gives reduction in steel as every member is individually reinforced to resist what it has to. Finer detailing saves about 5 to 15% steel. (Figs 5 & 6)

Fig 5



- 4 Better quality control at site.
- 5 Better estimation of steel.
- 6 Real time estimation data, with the design.
- 7 Better control on stock of steel actually required.
- 8 Theft and pilferage of steel can be reduced.
- 9 Economical order quantity for better project management
- 10 Bench marking quantity and quality requirements.
- 11 Optimize your design based on the quantity of steel.
- 12 Steel bending and cutting can commence even before the form work is done.
- 13 Steel bending can be done at a separate site, marked and then can be assembled at site, if there are space limitations.
- 14 Project time can be reduced as the bars can be cut and bend before form work is done.
- 15 What you see in the drawing is what you get at the site.
- 16 With a quality data set, other management softwares (ERP systems) can work on it.
- 17 A paperless office concept in the construction industry and associated advantages.



- 18 Total length of bars calculated using engineering formula, leaves nothing to approximation.
- 19 Mechanization of bending and cutting is possible. (Cut and bend systems) reduces labour and time but increases the reliability.
- 20 As the works gets organized, smaller contractors can work on the project at lesser rate.

R.C.C Retaining wall

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

- define the R.C.C retaining wall
- explain types of retaining walls.

Introduction

Retaining walls are structures constructed for the purpose of retaining earth or other materials like coal, ore, water etc. It may also be defined as a wall provided to maintain ground at two different levels. Provision of retaining walls become necessary in the construction of hill roads, embankments, bridge abutment, basement in buildings, water reservoir, in preventive measures against soil erosion, in landscaping etc. The material retained by the wall is generally known as backfill. The backfill may be horizontal i.e. levelled with the top of the wall or it may be inclined at certain angle to the top. The inclined fill is also known as surcharge. Besides loads due to retained material, the retaining wall may also be subjected to surcharged loads (due to automobile, railroad etc.) acting directly on the wall as well as on the backfill. The retaining wall should be stable enough to resist all type of forces acting on it.

Definition

A RCC wall used to maintain the ground surfaces at different elevations on its either faces by supporting filled earth is known as RCC retaining wall.

The structure of the same type, which supports natural earth bank, is called breast wall.

Types of retaining wall

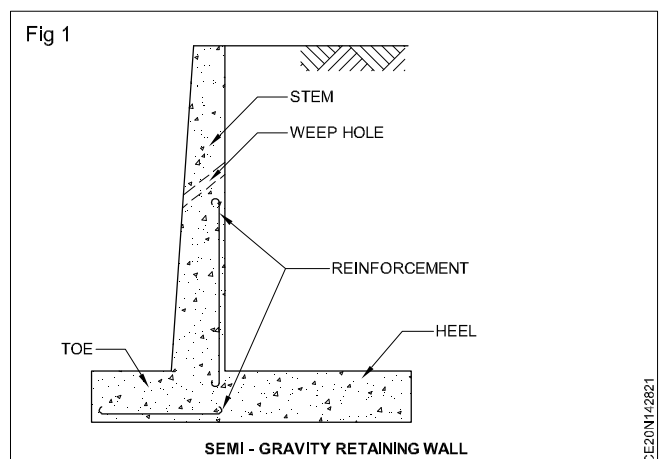
In general retaining walls are the following type.

- 1 Gravity walls.
- 2 Semi - gravity walls.

- 3 Cantilever walls.
- 4 Counter fort walls.

Among the above, first one is totally masonry wall with stone, brick or plain concrete. This wall withstands all the effects such as sliding, overturning etc. by its self - weight (gravitational force). So that these walls required heavy cross section and this may not be suitable for all conditions. Providing some reinforcements at appropriate positions can reduce the section of wall. This idea leads to the design and construction of different types of RCC retaining wall. In the general classification last three are the RCC retaining walls.

Components of retaining wall (Fig 1)



The important parts of a R.C.C retaining wall are the following.

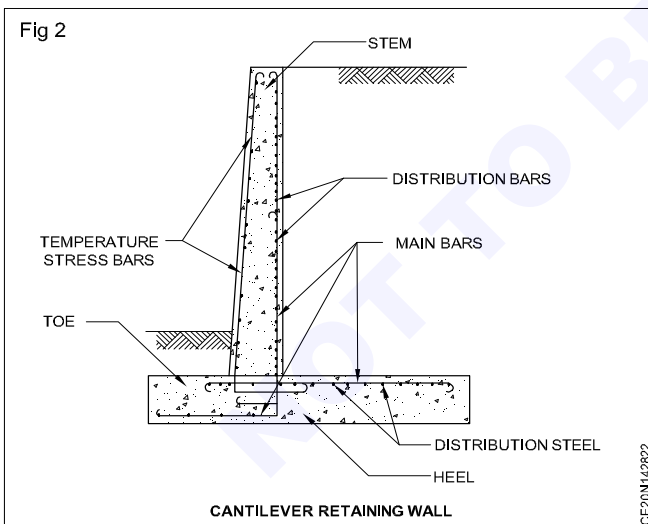
- 1 Stem - it is the upright part, which supports the earth.
- 2 Heel - portion of the base, which embedded below the supporting backfill.
- 3 Toe - portion of the base slab in front of the stem.
- 4 Heel beam (Shear key) - If the base slab width is not sufficient to with stand the shear force developed at the base of retaining wall a beam is provided below the stem projecting downward from the base slab.
- 5 Weep hole-These are the holes provided in the stem at regular interval from face to back to drain out the seepage.

Semi-gravity walls

These are very similar to gravity walls but to reduce the heavy cross section of gravity wall some reinforcements are provided at toe and stem as shown.

Cantilever retaining wall

All the components, stem, heel, and toe is designed and construction as R.C.C cantilevers structure. The junction of three components will be the fixed end of cantilever. On stem pressure of backfill acts out word so reinforcement provided near the inner face of stem. Load on heel is the deadweight of backfill and it acts down word so that reinforcements are provided near the top surface of heel slab. While on toe there is no backfill and the load will be only the upward soil pressure so the reinforcement are provide near the bottom face of toe. Detailed arrangement of reinforcement is given in the Fig 2. To resist the temperature stress at the outer face of stem, a minimum reinforcement shall be provided.



Proportion of various components of a cantilever retaining wall

Minimum thickness of stem wall

At top 20 cm

At base 35 cm.

Width of base slab

With surcharge 0.5H to 0.8H.

Without surcharge 0.5H to 0.6H.

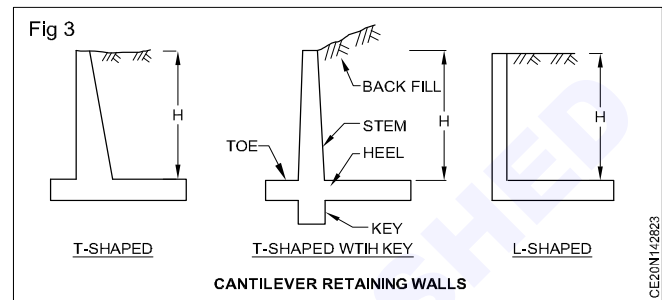
Thickness of base slab.

Minimum 0.1H.

Toe projection beyond the outer face of the stem.

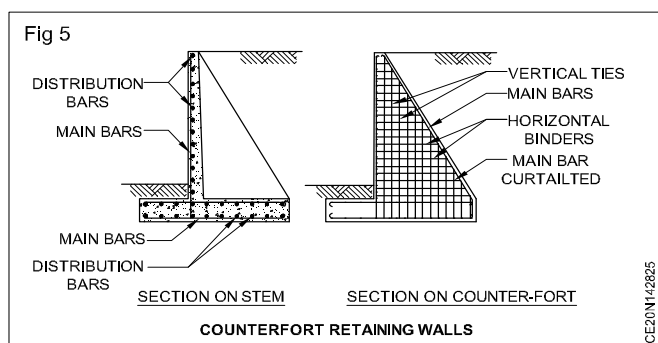
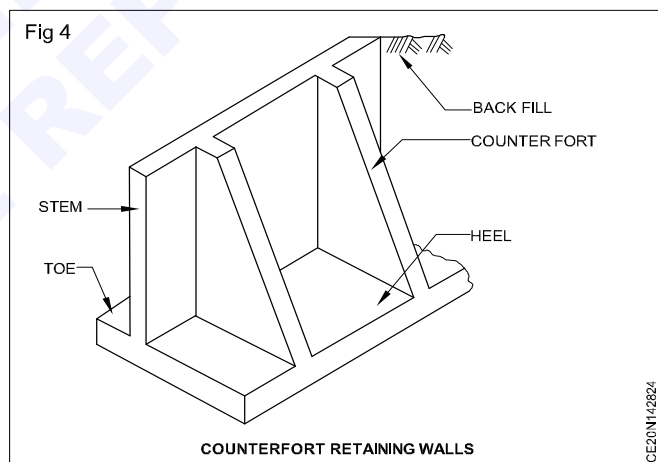
1/4 to 1/3 of the base width of slab.

Cantilever retaining walls are R.C.C. walls made in the form of an inverted T. This type of wall proves to be economical for moderate heights say 6 to 7 m. The wall consists of three components. (Fig 3)



the stem, the toe and the heel. Each of these components are designed as a cantilever. The stability of the wall is partially provided by the weight of earth on the heel. Sometimes the cantilever wall is constructed in the form of L.

Counter - fort retaining wall (Figs 4 & 5)



If retaining walls have height of filling more than 8m, is designed as cantilever type retaining wall, the thickness of stem wall becomes excessive and design proves uneconomical. Such walls should be designed as counter

fort type retaining wall. In the case of counter- fort type retaining wall, both stem and heel act as continuous slabs supported on counter - forts. The action of counter - forts is to tie the vertical wall slab with heel slab.

The economical spacing of counter - forts varies $\frac{1}{2}$ to $\frac{1}{3}$ of the height of the stem wall. Normal spacing of counter forts varies from 2 to 3m. Counter - fort is designed as a cantilever beam taking load from the stem portion between two counter - forts. The effective depth of the counter - fort is measured at right angles to its sloping side. Main reinforcement bars are provided on the inclined side.

Stem and heel slabs are designed as continuous slabs supported on counter - forts. Bottom most 1 m height of stem slab is designed and same thickness is provided for the entire height. Toe slab is designed as cantilever slab as in the case of cantilever retaining wall.

When the height of the retaining wall to be provided exceed 6 to 7m, counterfort retaining wall prove to be economical. In this type of wall the base slab as well as the stem of the wall span horizontally as continuous slabs between vertical brackets known as counterforts. The counterforts are provided behind the wall (on the backfill side) and are subjected to tensile forces. The spacing of the counterforts may vary from $\frac{1}{3}$ to $\frac{1}{2}$ of the height of wall. The more the height of the wall, the closer should be the spacing of counterforts.

R.C.C framed structure

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

- define portal frame
- explain method of portal frame
- illustrate advantages and disadvantages of portal frame
- explain R.C.C framed structure.

Introduction

Structurally a building may consist of load bearing walls and floors. The floor slabs may be supported on beams which in turn may be supported on walls or columns. But for a multi - storeyed structure, a building frame either of steel or reinforced concrete is made. This frame is designed for all the vertical and horizontal loads transmitted to it. The openings between the columns, where necessary, will be filled with thin brick walls. A frame of this type will consist of columns and beams built monolithically forming a network. This provides rigidity to the connections of members. By this arrangement the bending moments for the members of the structure are reduced. Earthquake loads and other horizontal loads due to wind etc. are evenly distributed to the whole structure. This makes the structure not only safe but economical.

We shall now discuss the frames used in various types of buildings.

Definition

A structure in which components such as beam, column and footing are monolithic in design and construction is called portal frame.

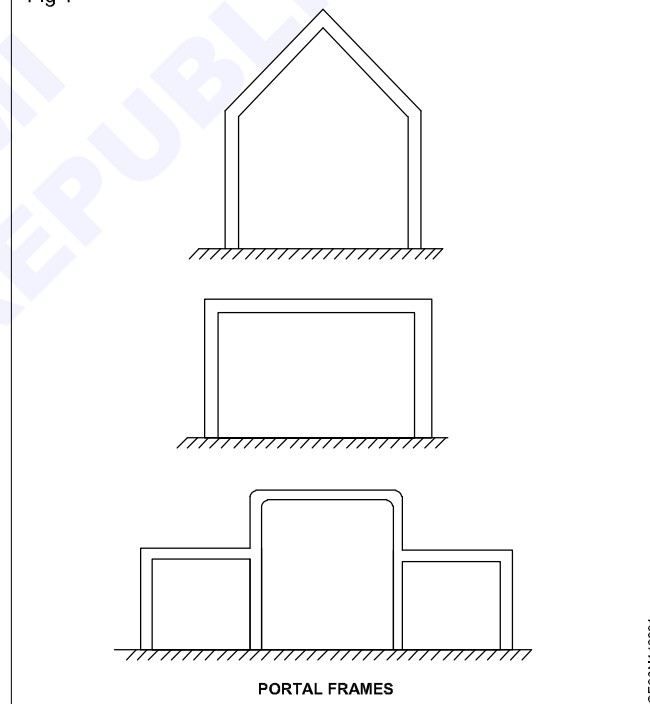
Frames for single storey buildings portal frames

A portal frame consists of a beam built monolithically with the columns. Such units are used when the span of a building or hall is large. Sometimes instead of providing a horizontal beam, the portal frame may be provided with ridged beams. Fig 1 shows the types of portal frames used for different occasions.

Other alternative structures used for similar conditions are steel trusses, concrete trusses, sheds and arches.

The portal frame may be analysed by any of the standard methods like the moment distribution method or column analogy method etc. The columns of the frame may be

Fig 1



designed either for hinged end or fixed end conditions. Footings are provided to the supporting columns.

Connection of frame with foundation

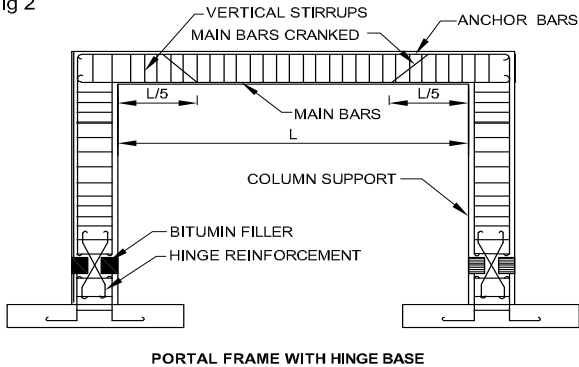
In a portal frame column base is connected in foundation by any of the following method.

Fixed connection.

Hinged connection.

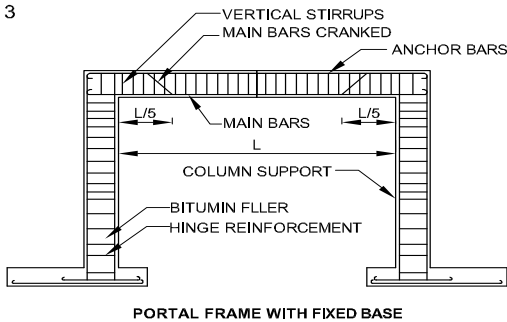
In fixed connection column is directly connected to footing as in the case of RCC column footing. But in design the BM at the base of column also should be accounted. Mostly footing will be an eccentric one because of this BM. A typical connection is given in the Figs 2 & 3.

Fig 2



CE20N142832

Fig 3



CE20N142833

As per theory of structure BM will be zero at hinged support and no BM will distributed to hinge from other ends. Taking advantages of the above an RCC hinge is introduced at the base of column to make a connection with the foundation. Hinge is designed to take the axial load and shear force developed at the base of column. Column reinforcements are terminated at the base of column and at hinge separate reinforcement is designed to with stand the shear force. These reinforcements are provides in the form of scissors as shown. Foundation is designed for the axial column load and the BM developed below the hinge. Reinforcements are provided as usual in RCC column footing. Dowel bars from footing are extended up to the bottom of hinge.

Advantages

There are following advantages of portal frames.

- Portal frames are easy to construct than walls or any other structures. It require less time to construct the portal frames.
- They are economic in nature. The cost of maintenance is low.
- They provide good floor to ceiling heights.
- Portal frames saves time and money.
- Portal frames are easily available at all the places.
- It is easy to carry the portal frame's equipment's from one place to another place. The material is easy to carry from one place to another place.
- Portal frame structures provide good ventilation and lighting.

Disadvantages

Following are some limitations of the portal frames.

- It is not easy to build the portal frame anywhere. They can be constructed only in hill, valley, and sloppy areas.
- Sometime, they also depends on the type of structure. Building shape should be square, rectangular only.

- Roof pitch should be shallow, steep, mono - pitch.
- We cannot construct any structure above the portal frames. It is very difficult to construct structure above the portal frame, due to its sloppy head.
- Only skilled workers are required to construct the portal frames.
- The strength of portal frame structure is less than RCC structure. It is very difficult to compare it with the reinforcement structure.
- More accuracy required to build these types of structures. The portal frames are placed at regular intervals.

Requirement of portal frames

The portal frames are commonly used in the construction of industrial areas. Due to industrial growth more.

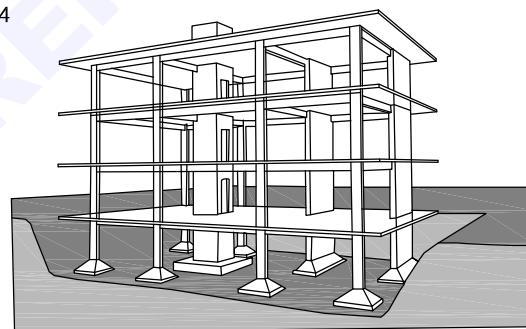
Material required, more man power required. If the requirement of material and man power increased then the requirement of portal frames also increase. It also increases due to increasing construction work. Portal frames are easy to construct, so they are commonly used at all places.

Conclusion

Portal frames are used where we want economy. They are also used for construction of ware houses. Rigid portal frames are used in the ware houses. They provide good ventilation and lightening. Now a days, most of portal frames structure are used in the industries. Portal frames save money and time.

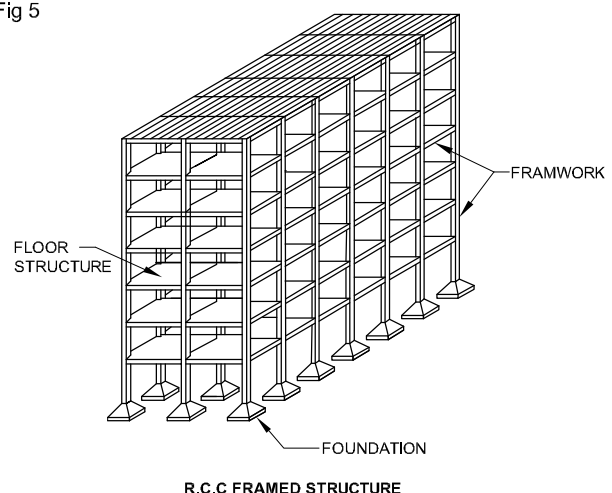
R.C.C framed structures (Fig 4 & 5)

Fig 4



CE20N142834

Fig 5



CE20N142835

Concrete frame structures are a very common, or perhaps the most common, type of modern building. As the name suggests, this type of building consists of a frame or skeleton of concrete. Horizontal members of this frame are called beams, and vertical members are called columns. Humans walk on flat planes of concrete called slabs. Of these, the column is the most important, as it is the primary load - carrying element of the building. If you damage a beam in a building, it will usually affect only one floor, but damage to a column could bring down the entire building.

When we say concrete in the building trade, we actually mean reinforced concrete. Its full name is reinforced cement concrete, or RCC. RCC is concrete that contains steel bars, called reinforcement bars, or rebars. This combination works very well, as concrete is very strong in compression, easy to produce at site, and inexpensive, and steel is very strong in tension. To make reinforced concrete, one first makes a mould, called form work, that will contain the liquid concrete and give it the form and shape we need. Then one looks at the structural engineer's drawings and places in the steel reinforcement bars, and ties them in place using wire. The tied steel is called a reinforcement cage, because it is shaped like one. Once the steel is in place, one can start to prepare the concrete, by mixing cement, sand, stone chips in a range of sizes, and water in a cement mixer, and pouring in the liquid concrete into the formwork till exactly the right level is reached. The concrete will become hard in a matter of hours, but takes a month to reach its full strength. Therefore, it is usually propped up until that period. During this time the concrete must be cured, or supplied with water on its surface, which it needs for the chemical reactions within to proceed properly.

So the structure is actually a connected frame of members, each of which are firmly connected to each other.

In engineering parlance, these connections are called moment connections, which means that the two members are firmly connected to each other. There are other types of connections, including hinged connections, which are used in steel structures ([/steel - frame - structures. html](#)), but concrete frame structures have moment connections in 99.9% of cases. This frame becomes very strong, and must resist the various loads that act on a building during its life.

These loads include

- **Dead loads** the downwards force on the building coming from the weight of the building itself, including the structural elements, walls, facades, and the like.
- **Live loads** the downwards force on the building coming from the expected weight of the occupants and their possessions, including furniture, books, and so on. Normally these loads are specified in building codes and structural engineers must design buildings to carry these or greater loads. These loads will vary with the use of the space, for example, whether it is residential, office, industrial to name a few. It is common for codes to require live loads for residential to be a minimum of about 200 kg/m², offices to be 250 kg/m², and industrial

to be 1000/m², which is the same as 1T/m². These live loads are sometimes called imposed loads.

- **Dynamic loads** these occur commonly in bridges and similar infrastructure, and are the loads created by traffic, including braking and accelerating loads.
- **Wind loads** This is a very important design factor, especially for tall buildings, or buildings with large surface area. Buildings are designed not to resist the everyday wind conditions, but extreme conditions that may occur once every 100 years or so. These are called design wind speeds, and are specified in building codes. A building can commonly be required to resist a wind force of 150 kg/m², which can be a very significant force when multiplied by the surface area of the building.
- **Earthquake loads:** in an earthquake, the ground vigorously shakes the building both horizontally and vertically, rather like a bucking horse shakes a rider in the sport of rodeo. This can cause the building to fall apart. The heavier the building, the greater the force on it. Its important to note that both wind and earthquake impose horizontal forces on the building, unlike the gravity forces it normally resists, which are vertical in direction.

The concrete frame rests on foundations, which transfer the forces - from the building and on the building - to the ground.

Some other important components of concrete frame structure are shear walls are important structural elements in high - rise buildings. Shear walls are essentially very large columns they could easily measure 400 mm thick by 3m long making them appear like walls rather than columns. Their function in a building is to help take care of horizontal forces on buildings like wind and earthquake loads. Normally, buildings are subject to vertical loads - gravity. Shear walls also carry vertical loads. It is important to understand that they only work for horizontal loads in one direction - the axis of the long dimension of the wall. These are usually not required in low-rise structures.

Elevator shafts are vertical boxes in which the elevators move up and down - normally each elevator is enclosed in its own concrete box. These shafts are also very good structural elements, helping to resist horizontal loads, and also carrying vertical loads.

Walls in concrete frame buildings

Concrete frame structures are strong and economical. Hence almost any walling materials can be used with them. The heavier options include masonry walls of brick, concrete block, or stone. The lighter options include drywall partitions made of light steel or wood studs covered with sheeting material. The former is used when strong, secure, and sound - proof enclosures are required, and the latter when quick, flexible lightweight partitions are needed. When brick or concrete blocks are used, it is common to plaster the entire surface - brick and concrete - with a cement plaster to form a hard, long - lasting finish.

Cladding of concrete frame structures

Concrete frame buildings can be clad with any kind of cladding material. Common cladding materials are glass, aluminum panels, stone sheets, and ceramic facades.

Building stones and bricks - manufacturing, characteristics, types & uses

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.

Introduction

Stones are obtained from rocks, which may be classified according to geological, physical, chemical and practical classifications. A particular building stone may be selected depending on the requirements of the structure to be built.

Definition:

The solidified 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 is 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 than 100N/mm^2 . All igneous rocks have around 100N/mm^2 and some 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 specific gravity, not less 2.6. The more specific 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 too 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.

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 metamorphosis rocks.

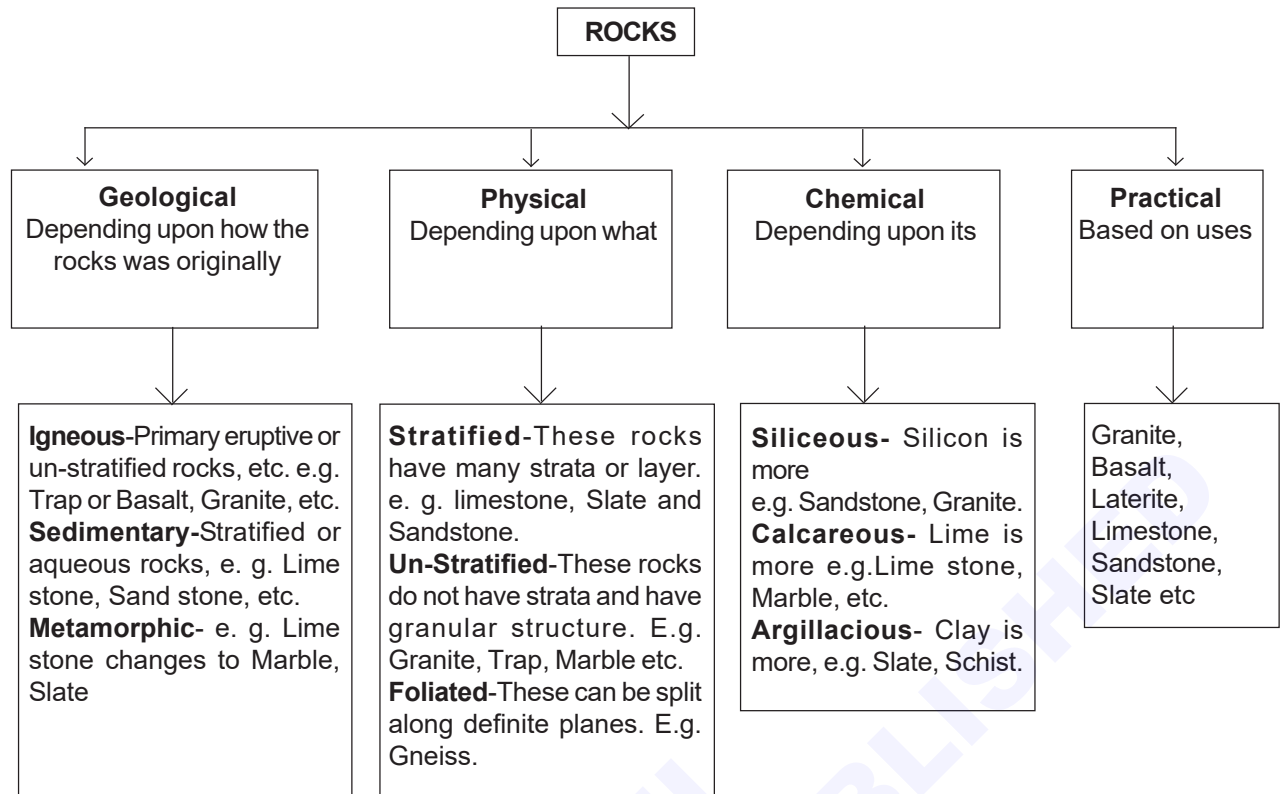
Igneous rocks: These rocks are formed by cooling and solidifying of the rock masses from their molten magmatic condition of the material of the earth. Generally igneous rocks are strong and durable. Granite, trap and basalt are the rocks belonging to this category, Granites are formed by slow cooling 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 stratified structure in general. Sand stones, lime stones, mud stones etc. belongs to this class of rock.

Metamorphic rocks: previously formed igneous and sedimentary rocks undergo changes due to metamorphic action of pressure and internal heat. For example, due to metamorphic action granite becomes gneiss, trap and basalt changes to schist and laterite, lime stone changes to marble, sand stone becomes quartzite and mud stone becomes slate.

Classification of rocks



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 possess 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 quartz 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	Characteristics	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 colourous. 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 polish 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. Its 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/mm ² .	Roofing work, sills, damp proof courses, etc.	U.P., M.P., Bihar, Madras, Mysore and Rajasthan.

Bricks manufacturing, type and uses

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.

Comparison 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 be Shaped 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)

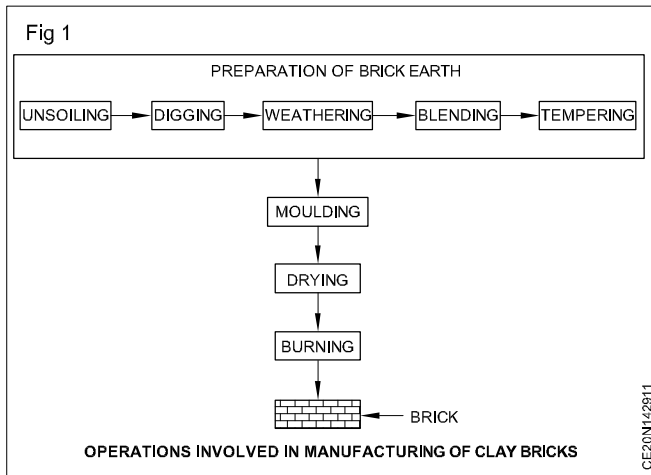
The process of manufacture can be described the following steps:

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)

- 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 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.

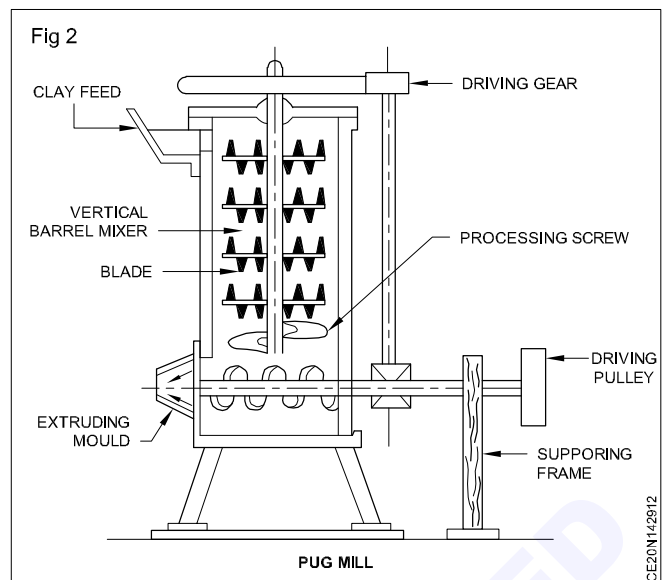
Blending: The clay is made loose and any ingredient to be added to it, is spread out at its top. The blending indicates intimate or harmonious mixing. It is carried out by taking small portion of every time and by turning it up and in vertical direction. Blending makes clay fit for next stage of tempering.

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)

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 i.e. manually. It is adopted 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 strikes 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:

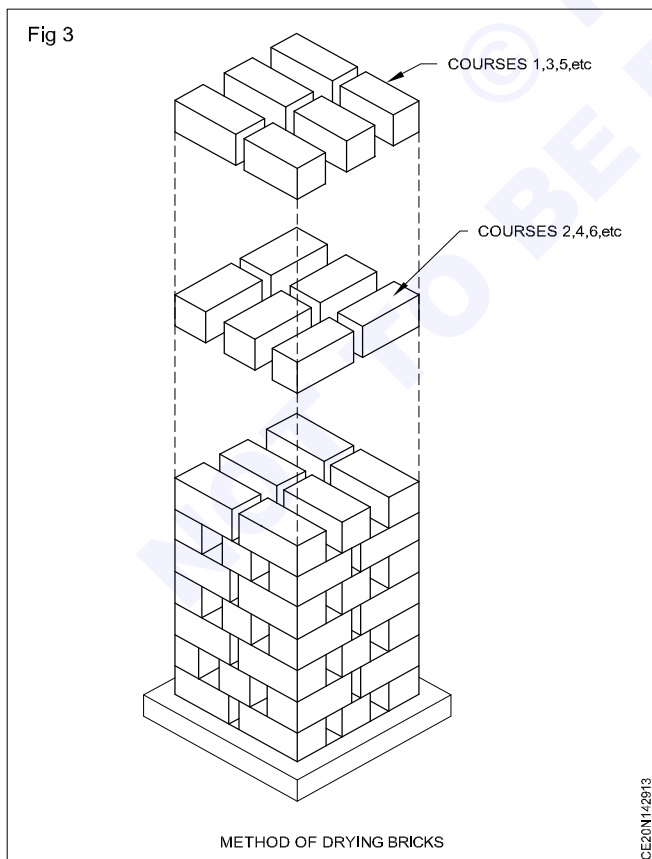
- 1 Plastic clay machines
- 2 Dry clay machines

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 burning.

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 burning. 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 dried 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.

In the former case, the bricks are filled, dried and emptied in rotation. In the latter case, the loading of bricks is done at one end and they are taken out at the other end. The temperature is usually less than 120°C and the process of drying of bricks takes about 1 to 3 days depending upon the temperature maintained in the dryer, quality of clay product etc.

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 over burnt, they will be brittle and hence break easily, if they are under burnt, they will be soft and hence, cannot carry loads.

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

When the temperature of about 1100°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

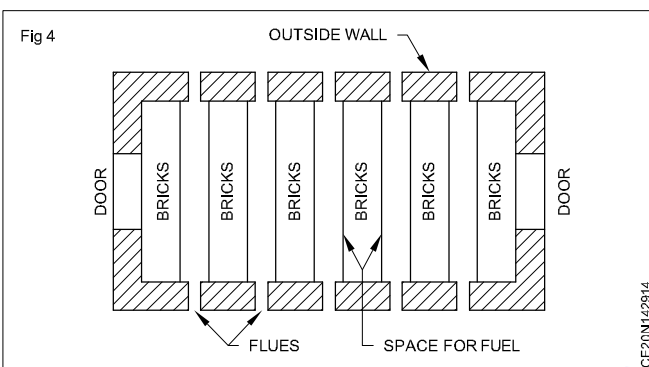
Continuous kilns

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 over ground 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.



The kiln is allowed to cool down gradually for at least 7 days 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 unloading 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 is 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 over ground 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. The chambers 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	6 Porosity
2 Color	7 Strength
3 Structural	8 Resistance of fire
4 Hardness	9 Efflorescence
5 Soundness	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 soaked in cold water for 24hrs
- 5 Toughness:** Should not break when dropped from a 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 divided 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 **1ST Class bricks:** R.B. work, following, as blast R.C. work arches etc.
- 2 **2nd Class brick:** Un-important situation and for internal walls.
- 3 **3rd Class brick:** Temporary building
- 4 **4th Class brick:** Foundation and Floor etc.

Special bricks

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

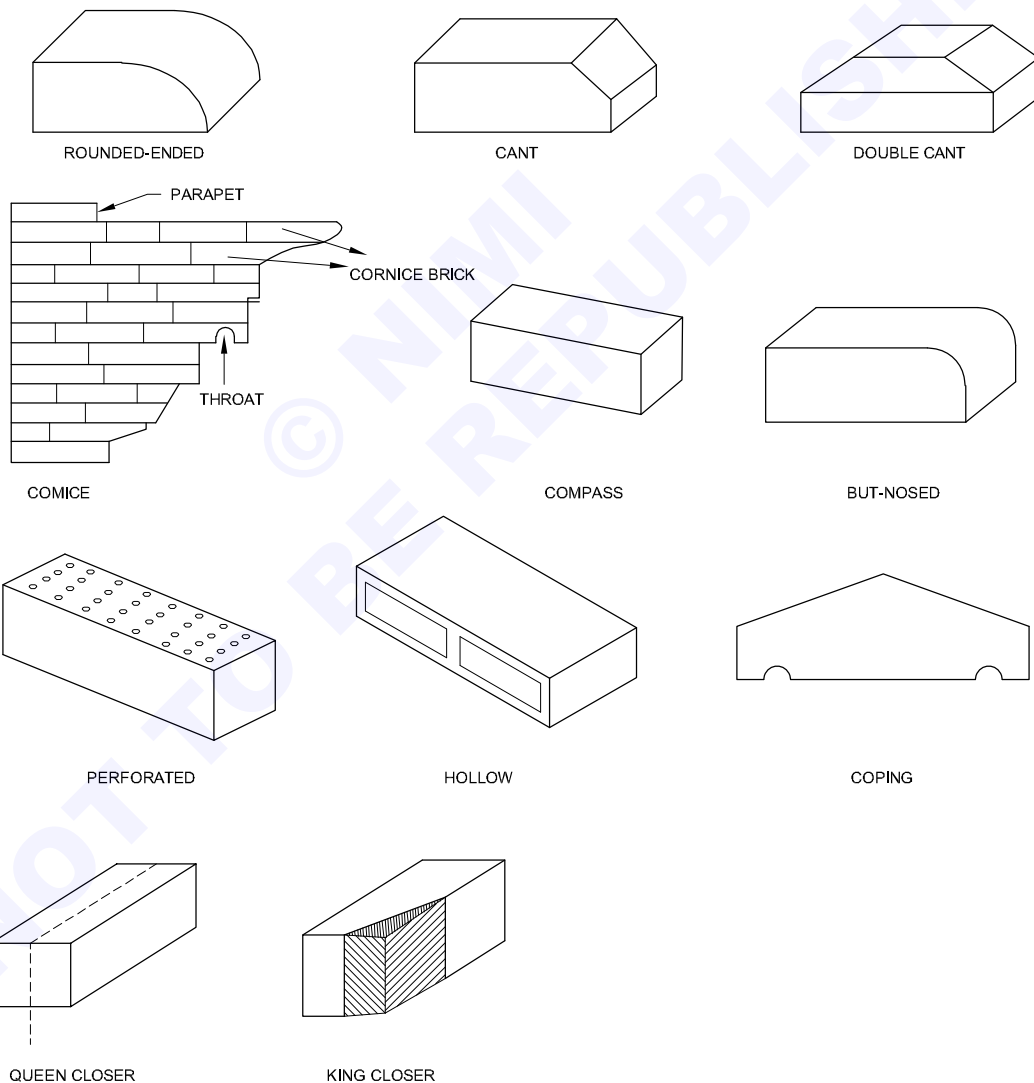
Hollow bricks

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

These bricks are used in 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 5



FORMS OF BRICKS

CE20N142915

Clay products (Tiles) and types

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 reapers, 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.

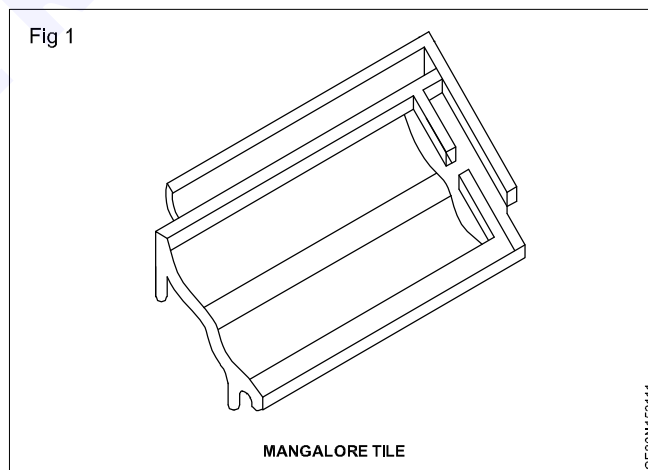
Fully-vitrified tiles: These tiles bridge the gap between ordinary ceramic tiles and marble floors. These tiles are especially used in kitchen floors as ordinary ceramic tiles are brittle and the full of any heavy object is liable to chip the ceramic tiles.

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)

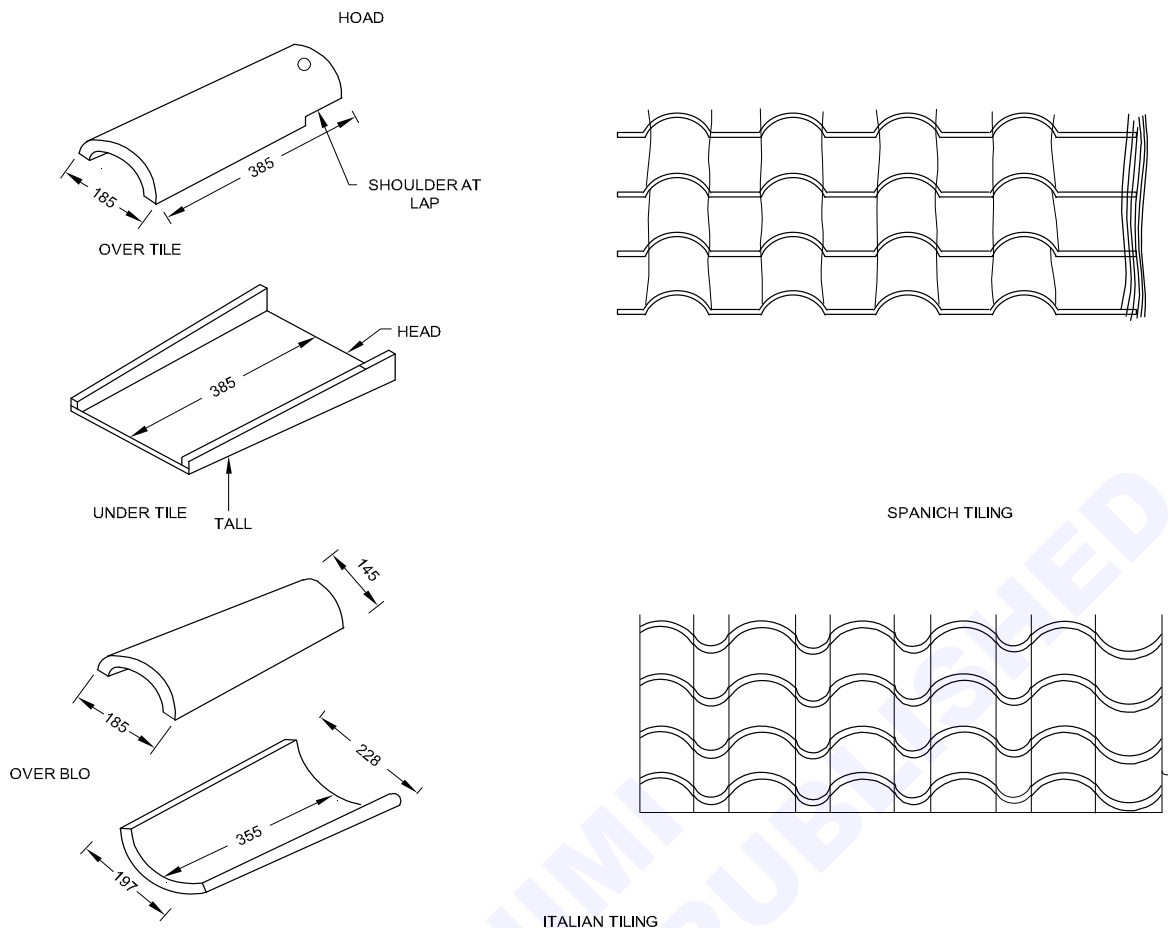
Mangalore pattern roofing tiles (Fig 1): (IS: 654-1972) These are available in various shape and dimensions. They overlap on the tile below and also lock with the adjacent tile.



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 2)

Fig 2



CE20N153112

Terra - cotta : The terra means earth and cotta means baked. Hence terra-cotta means baked earth. It is thus a type of earthenware or porous pottery made from local clays and glazed with glazes containing galena. It is soft enough to be scratched by a knife.

Varieties 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 burnt and they leave pores in the articles. The porous terra-cotta is a fire-proof and a sound-proof material. It can be chiseled, 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 is burnt at a lower temperature of about 650°C. This first burning 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°C. The faience is available 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 can be easily cleaned
- It can be easily moulded in to 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 cannot be fixed during the progress of work. But it is to be fixed when the work is in final stage of completion.
- It may be twisted due to unequal shrinkage 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 fluids 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 porce These bricks are known as pressed bricks and they do not practically require drying. They can be sent directly for the process of burning

lain is used to indicate fine earthenware which is white thin and semi-transparent. Since the colour of porcelain is white, it is also referred to as white ware.

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, feldspar.

Refractories: The term refractories is used to indicate substances that are able to resist high temperature. The desired properties of refractories are as follows:

It must possess excellent resistance to rapid change 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

Cement manufacturing, properties, types and uses

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.

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 port land cement (Fig 1)

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

The corrected slurry is injected at the upper end of kiln. Fig 1 shows the rotary kiln for the wet process. The hot

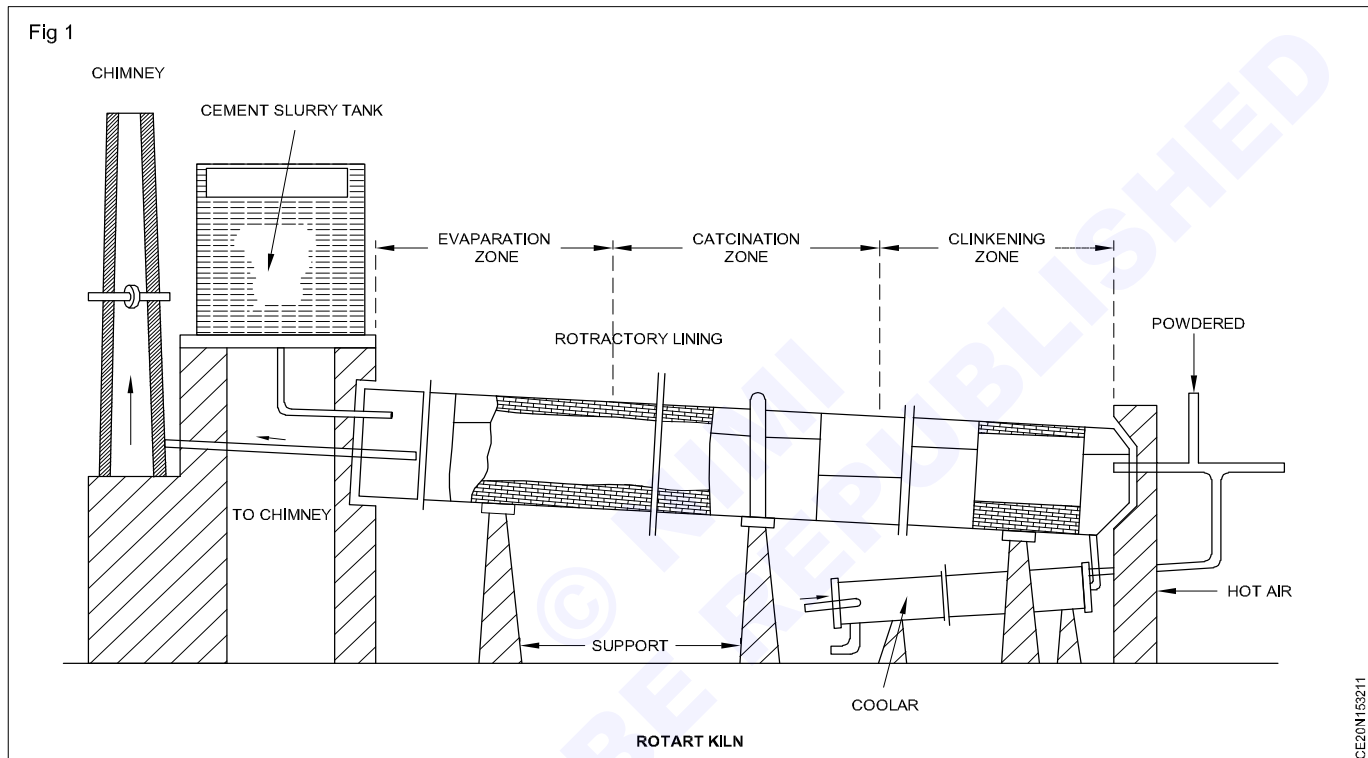
gases or flames are forced through the lower end of kiln. The portion of the kiln near its upper end is known as dry zone and in this zone, the water of slurry is evaporated. As the slurry gradually descends, there is rise in temperature and in the next section of kiln, the carbon dioxide from slurry 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°C to 1500°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 burning zone of kiln. The clinker temperature at the outlet of kiln is nearly 1000°C to 1500°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 to be 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 $\pm 200g^3$ 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 burning and grinding operations.



Types of cement: The following are the IS specifications:

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

- 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
- 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)

- 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 chemical 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 furnace cement	Mass concrete structure	Initial setting time not less than 30 minutes, final setting time 10 Hrs
5	Expanding 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 pozzolana.
- 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 portland cement and port land pozzolana cement.

Table

Compressive strength of portland pozzolana cement and ordinary portland cement

Age in days	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/cm ² - 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

Sand-characteristics, types and uses

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. Decoding 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 dampness, 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 in sand increases the volume of sand is called bulking of sand.

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.

Lime-properties, types and uses

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

- define lime, types, properties and uses
- compare fat lime and hydraulic 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 unless procured fresh in the form of a paste before it dries up or is treated properly.
- 2 Lime containing more than 30 percentage impurities like clay is called poor limes.

Properties of lime

- 1 Easily workable and possesses good plasticity
- 2 Stiffens early and Provides strength to the masonry.
- 3 Offers good resistance to moisture.
- 4 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 accompanied by sound and heat.	It slakes slowly. Its volume is 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.

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.

Introduction : 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, alkalies 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

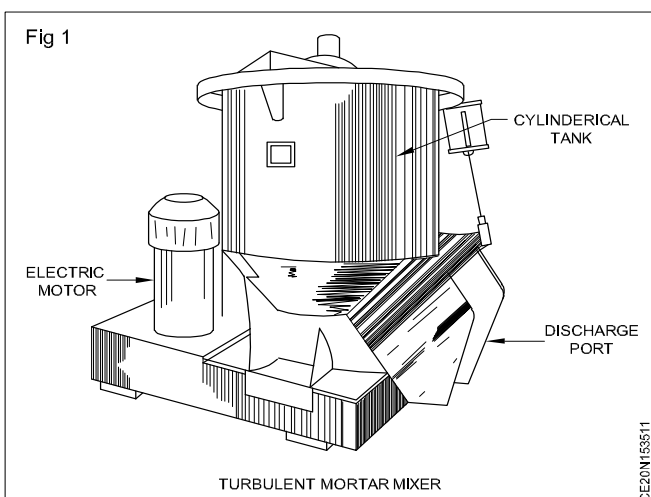
- It should be capable of developing good adhesion with the building units.
- It should be easily workable
- It should be cheap and durable.
- It should be capable of resisting penetration of rain water
- It should be capable of developing the design stresses.
- It should be durable and should not affect 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: It may be prepared by Hand mixing or Machine mixing. When a small quantity of mortar is required, hand mixing method is adopted. When large quantity of mortar is required continuously at a faster rate, it is prepared by mixing of the ingredients in mechanical mixtures. (Fig 1)



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

SELECTION OF MORTARS FOR DIFFERENT ENGINEERING WORKS

S. No.	Nature of Work	Mortar - Type and Composition
1	Thick joints in stone masonry	Hydraulic lime 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 3 hydraulic 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 members 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 material such as stones screenings burned clay or surkhi ashes from coal, coke dust it may be used to prepare mortar. The steps screenings are obtained by screening crushed stones. They are sharp and impart more strength to the mortar. 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 use the stone dust. The surkhi is the popular substitute for sand. It is obtained by finally grinding burned clay it is clean and free from any impurities. It gives strength and improves hydraulic property of mortar. Mortar with surkhi should not be used for external plaster or pointing work etc it disintegrates under the action of air and humidity.

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 mortar in dry state there are two ways of mortar.

1 Heavy mortar 2 light weight mortar

The mortar having bulk density of 15KN/MM³ or more are known as heavy mortar. If it is less than 15kn/mm³ known as light weight mortar.

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 residue should not exceed more than 10% by weight. Surkhi mortar is used for ordinary masonry work of all kinds of foundations and super structure. But it cannot be used for plastering or pointing. Since surkhi is likely to disintegrate after some time.

Cement mortar: In this type of mortar 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 determined 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 lime 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 objectives of pounding or grinding.

To crush the particles of unsalted lime if any so as to and ensure slaking

To make an intimate mixture 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 their side and bottom. The pits are 180cm long 40 cm wide at bottom and 500mm wide at top and 50cm deep. The dry mixture is then placed in pits. Small quantity of water is added and 4-5 persons with heavy mortar wooden poundings or beaten as work on mortar. They turn mortar up and down and required quantity of water is added at intervals. 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 lime 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 a 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 ingredients are thoroughly turned 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 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 within 2 hrs of the addition of cement.

Staking of building units : The presence of water in mortar is essential to cause its setting action of mortar. Hence the building units should be soaked in water before mortar is applied. If 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 sprinkled for about 7-10 days.

To avoid rapid drying of mortar the exposed surfaces are some times covered to give protection against sun.

Workability : The excess mortar from joints should be neatly taken off by a trowel. The mortar should not contain excess water and it should be as stiff as it 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
- 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:

- Arbitrary method
- Fineness modulus method

- Minimum voids method
- Maximum density method
- 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 fine 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.

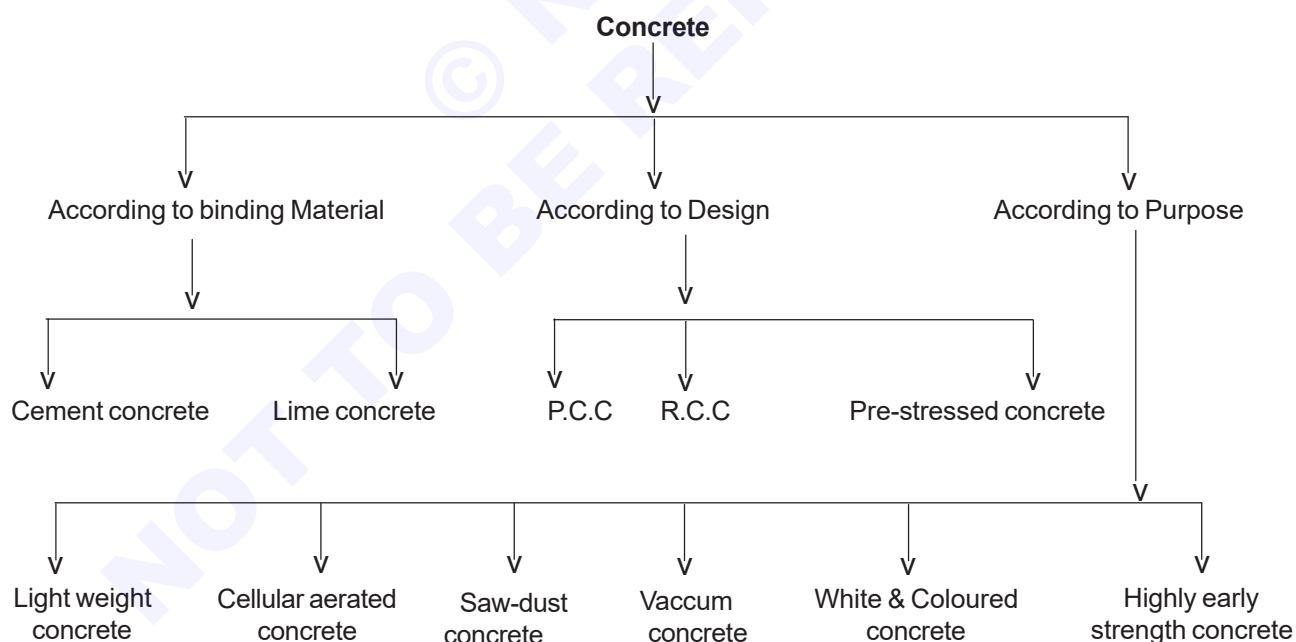
Durability of concrete

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

S.No.	Proportion of concrete mix	Maximum size of aggregate	Maximum size of aggregate
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 1:2/3:3 1/3	20 mm	Water tank, concrete deposited under water, bridge construction and sewers. For all general RCC work in building
6	1:2:1 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 / mm ²
	M15	1:2:4	Compressive strength 15N / mm ²
	M20	1:1:5:3	Compressive strength 20N / mm ²
	M25	1:1:2	Compressive strength 25N / mm ²

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

- 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 thoroughly 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 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 to 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 possible 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 be 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, tamping, 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 curing depends atmospheric condition and type of cement

Methods of curing

By ponding : Employed for flat surface

By using wet sacks/sprinkling water frequently :
Columns 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

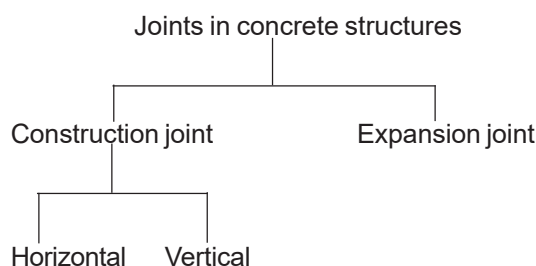
Compressive and structural strength decreased

Weathering resistance decreased

Resistance to atmospheric chemicals and chlorides decreased

Shrinkage cracks are formed

Thermal cracks are formed

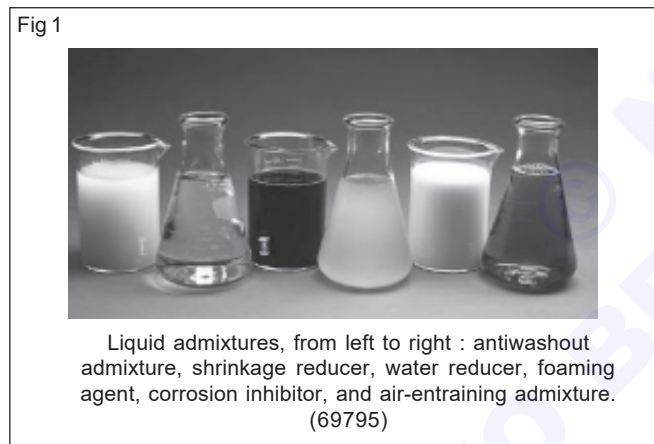


Admixtures of concrete and application

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

- state the classification of admixture by function and uses.

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:



- 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, damp proofing, permeability reducing, grouting, gas-forming, anti washout, foaming, and pumping admixtures.

1 Air - entraining admixtures : Air-entrained concrete contains minute air bubbles that are distributed uniformly throughout the cement paste. Entrained 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.

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.

4 Retarding admixtures : Retarding admixtures 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.

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.

9 Chemical admixtures to reduce alkali-aggregate reactivity (as 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.

11 Damp proofing admixtures : The passage of water through concrete can usually be traced to be 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 moist curing period and reduce the water- cement ratio to less than 0.5.

Pumping aids : Pumping aids are added to concrete mixtures to improve pump ability. Pumping aids cannot cure all unpumpable concrete problems; they are best

used to make marginally pumpable concrete more pumpable. These admixtures increase viscosity or cohesion in concrete to reduce dewatering of the paste while under pressure from the pump.

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.

Grouting admixtures : Portland cement grouts are used for a variety of purposes: to stabilize foundations, set machine bases, fill cracks and joints in concrete work, cement oil well, fill cores of masonry walls,

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.

Foundation-purpose, causes of failure and bearing capacity of soils

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

- **define foundation**
- **purpose of foundation.**

Introduction

Every structure consists of two parts, namely foundation and super structure. Foundation is the lowest part of a structure which transmits the weight of the structure, together with the effect of live loads and pressure, to the material on which the structure rests in such a manner that the underlying material is not stressed beyond its safe bearing capacity.

Definition

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.

Purpose of Foundation

- 1 To distribute the load of the structure over a large bearing area so as to bring the intensity of load within the safe bearing capacity of soil.
- 2 To load the bearing surface at 9 uniform rate to avoid differential settlement
- 3 To prevent the lateral movement of supporting materials
- 4 To attain a level and firm bed for building operations
- 5 To increase the stability of the structure as a whole.

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 keeping the Foundation rest on rock or hard moorum.

- Proper design of the base of footing. So that it can 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 up to 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 at 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 shrubs

The roots of trees planted near a building may extent up to the foundation 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 affect 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.

Bearing capacity of soil (Dead and live loads)

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:

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:

Sl.No	Material Load	kg/m ²
1	Residential building, hospital room and ward and hotel, bed room etc	250
2	Office building, church, school building, art galleries, 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 is 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.

$$P = 0.007502$$

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.

- It must have some specified safety against ultimate failure.
- 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,

$$Q_f = r_0 \frac{(1 + \sin \theta)^2}{(1 - \sin \theta)^2}$$

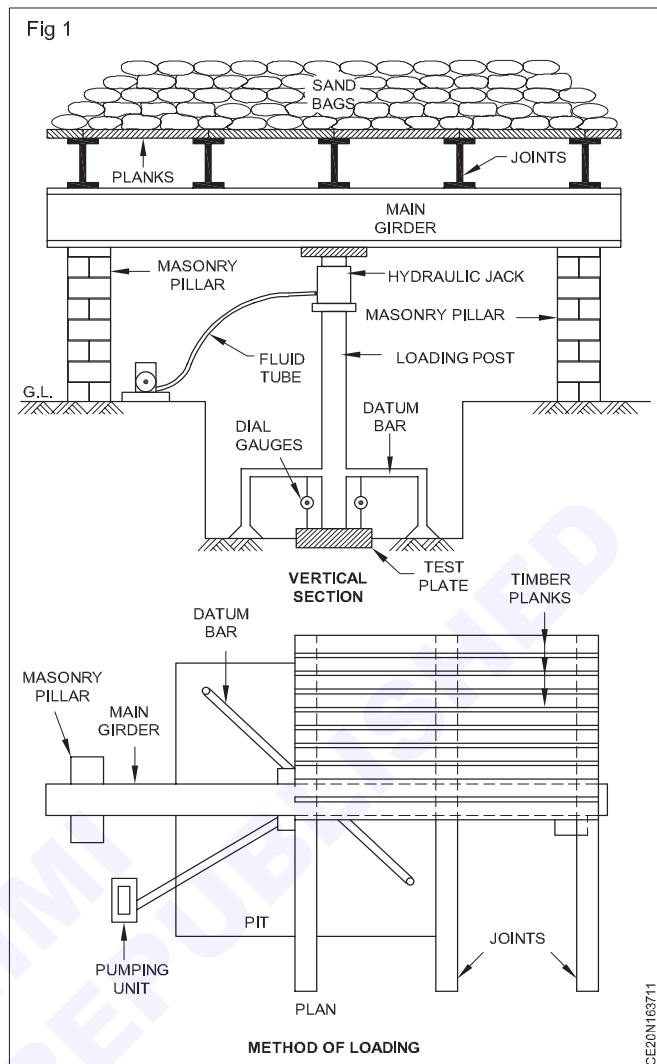
Where Q_f = Ultimate bearing capacity
 r_0 = density of soil at depth D
 θ = The angle of internal friction of soil.

Method of loading (Fig 1)

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



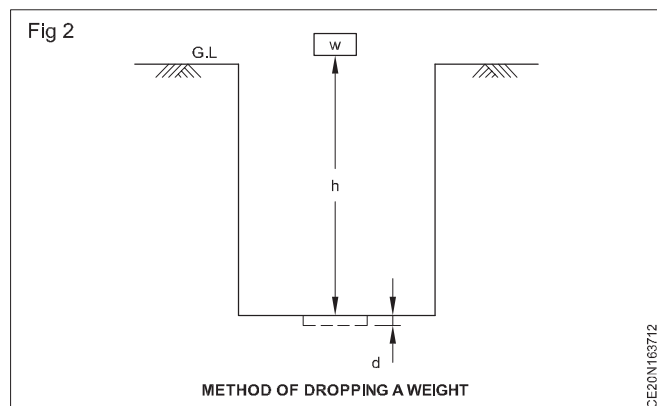
Method of improving bearing capacity

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 stratum 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 2).



This layer of rubble is well rammed. If the material is buried completely, another layer of depth about 15-25 cm 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.

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 result 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.

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Examination of grounds and types of foundation

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

- define site exploration and method of site
- state the purposes exploration
- types of foundation
- setting out of foundation.

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 nearby construction or by examining the open side of a nearby 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

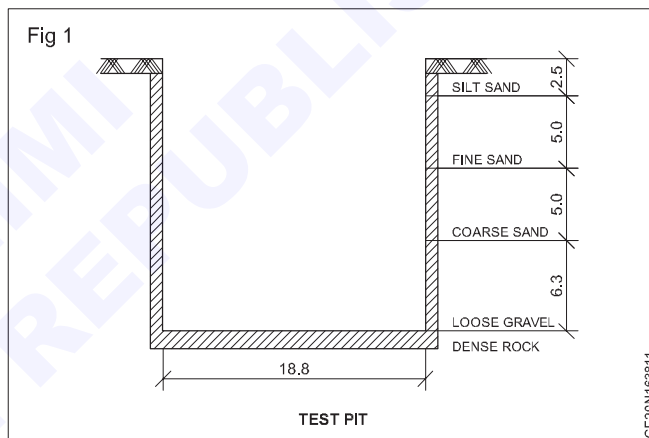
The following information regarding the proposed site should be collected.

- 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.

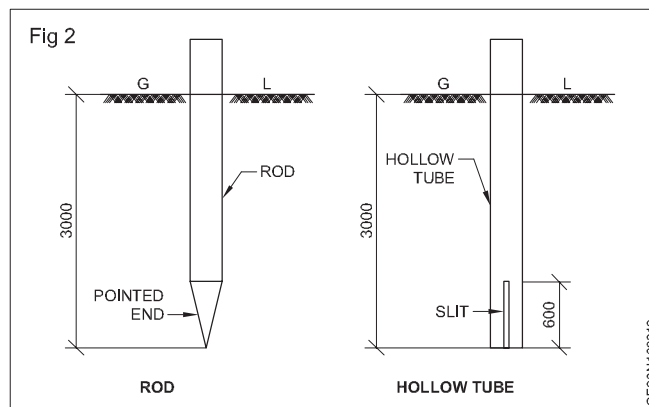
Methods of site exploration

1 Open excavation (test pits) (Fig 1)



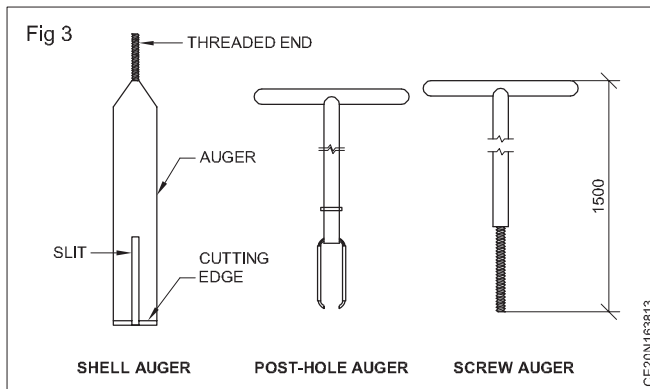
- 1 This method is useful when hard soil is available within a maximum depth of 1.5 m
- 2 A square pit, with side as about 1.50m, is excavated up to a depth at which sufficiently hard soil is available
- 3 A sufficient number of test pits should be dug on the site to know the variation of the ground.

Probing (Fig 2)



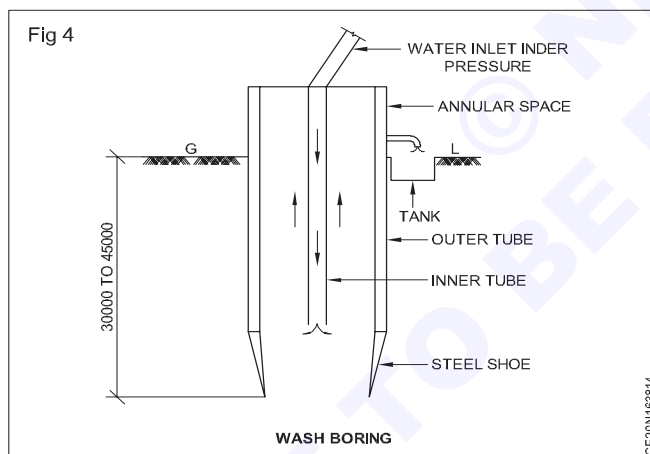
- 1 Probing consists of driving either a hollow tube or a steel rod or an iron rod into the ground
- 2 This method is possible to examine the ground for a maximum depth of 3 m.

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.

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 penetrometer 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 ascertain 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.

Types of Foundation (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 to its width are known as shallow foundation. Since such foundations are constructed by open excavation.

Hence those foundations having their depth even greater than their 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.

Types of shallow foundation

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)

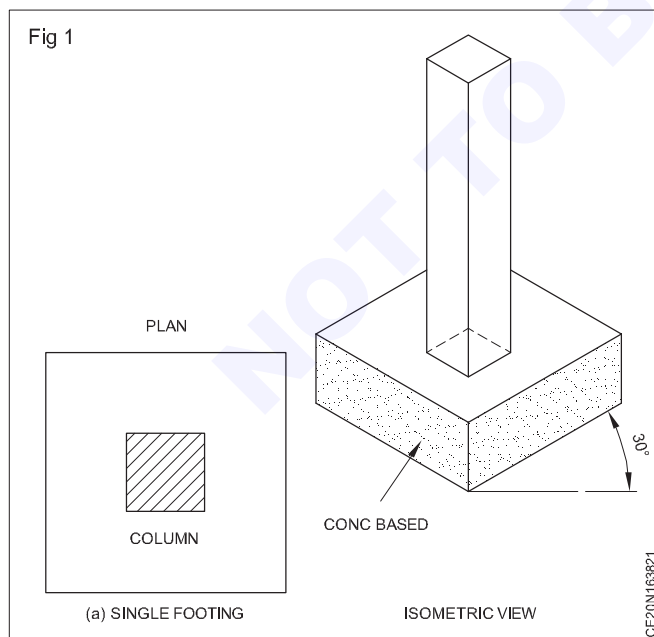
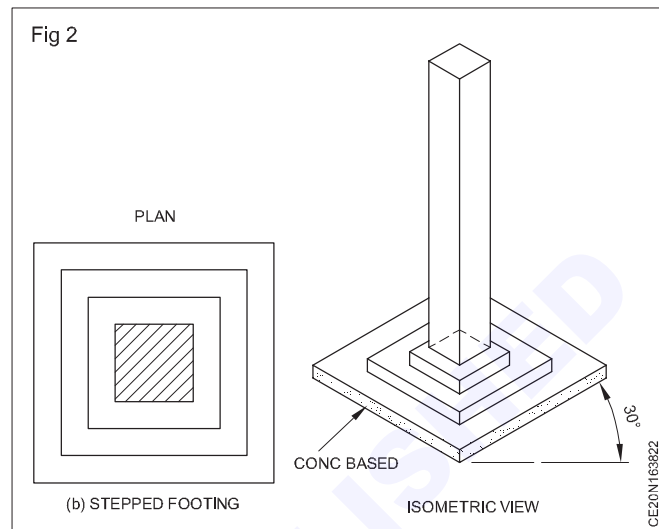
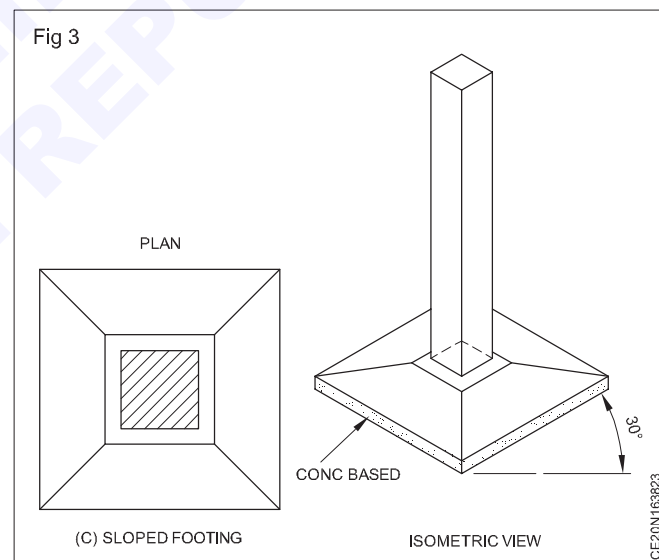


Fig 1 shows the single footing for a column in which the loaded area (bxb) of the column has been spread to the size (BxB) through a single spread.

- ii **Stepped footing:** The Fig 2 shows the stepped footing for a heavily loaded column which requires greater spread. The base of the column is made of concrete.

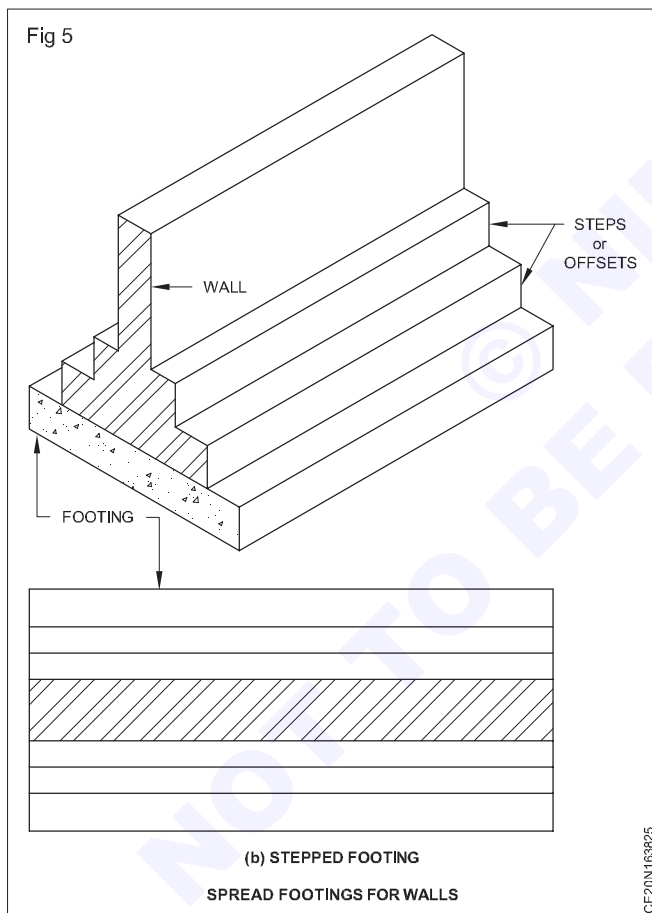
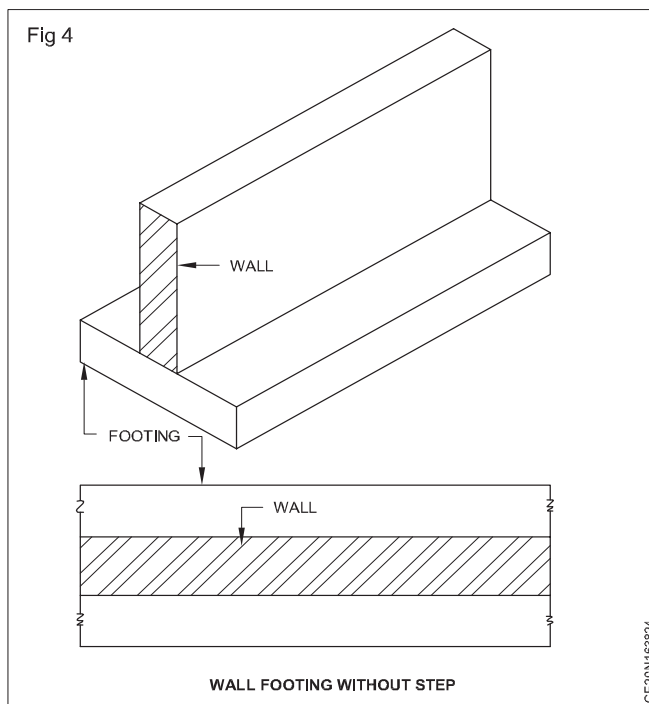


- iii **Sloped footing :** Fig 3 shows the sloped footing made in concrete base of non uniform thickness. Greater thickness at its bottom, smaller thickness at the top.



- 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.

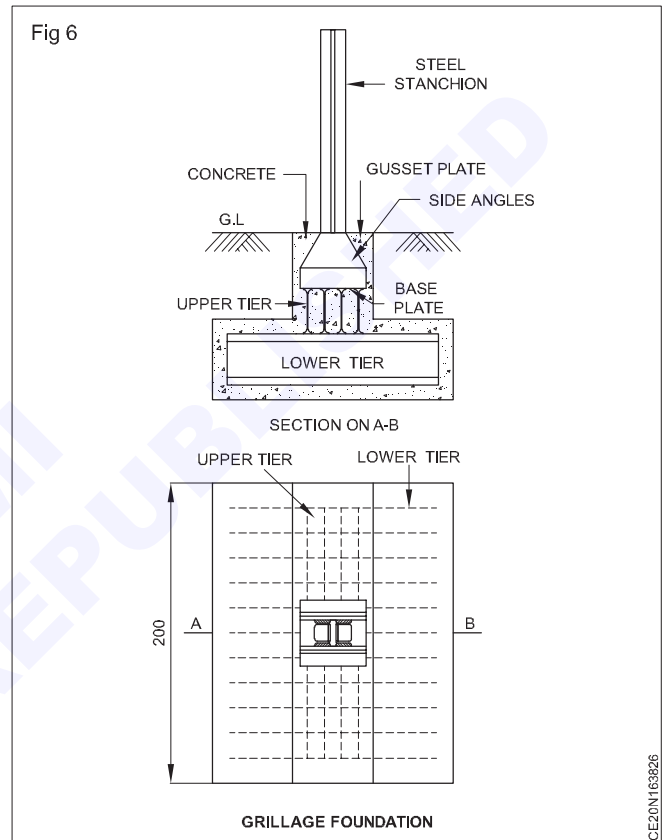


vi Grillage foundation : A grillage foundation is a special type of isolated footing. Generally provided for heavily loaded steel stanchions or column, specially in those location where bearing capacity of soil is poor. The depth of foundation is limited from 1-1.5m. The load of the column or stanchion 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

- 1 Steel grillage foundation
- 2 Timber grillage foundation

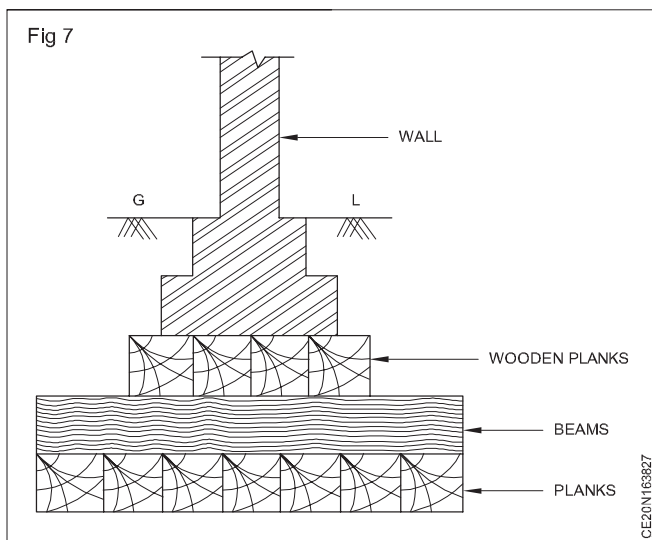
Steel grillage foundation : Steel grillage foundation is constructed of steel beams, structurally known as rolled steel joist (RSJ) provided in two or more tiers. In case of double tier grillage (which is commonly provided) the top tier of grillage beams is laid at right angle to the Bottom tier. The joists or beams of each tier are held in position by 20mm diameter pipe separators (tie rod 20mm diameter) as shown in Fig 6.



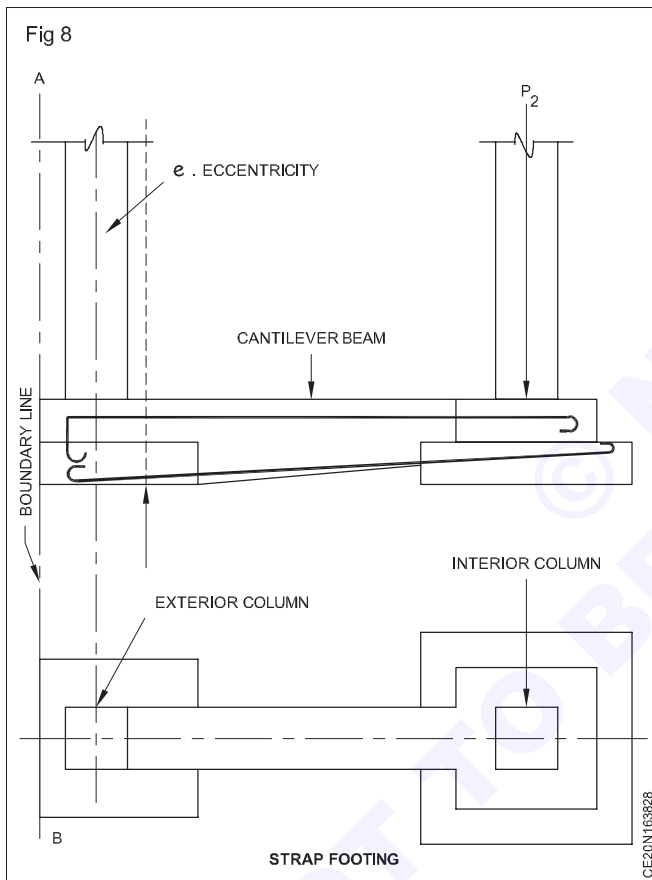
The grillage beams are embedded in concrete. Generally, the minimum clearance of 8cm is kept between the grillage beams. So that the concrete can be easily poured, properly compacted. However, the distance between the flanges should not exceed 30cm or $1\frac{1}{2}$ times the flange width. So that the filled concrete acts monolithically with the beams. It should prevent their corrosion. A minimum concrete cover of 10cm is kept on the outer side 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.



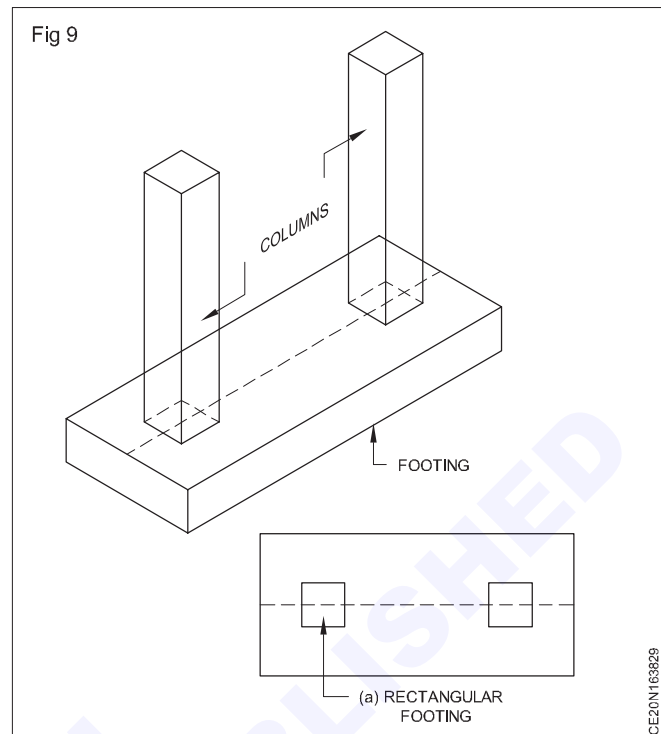
Strap footing or cantilever footing (Fig 8)



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 be extended beyond the property line, and if the distance between this column 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 does not remain in contact with soil and does not transfer any pressure to the soil. The function of the strap beam is to transfer the load of the 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.

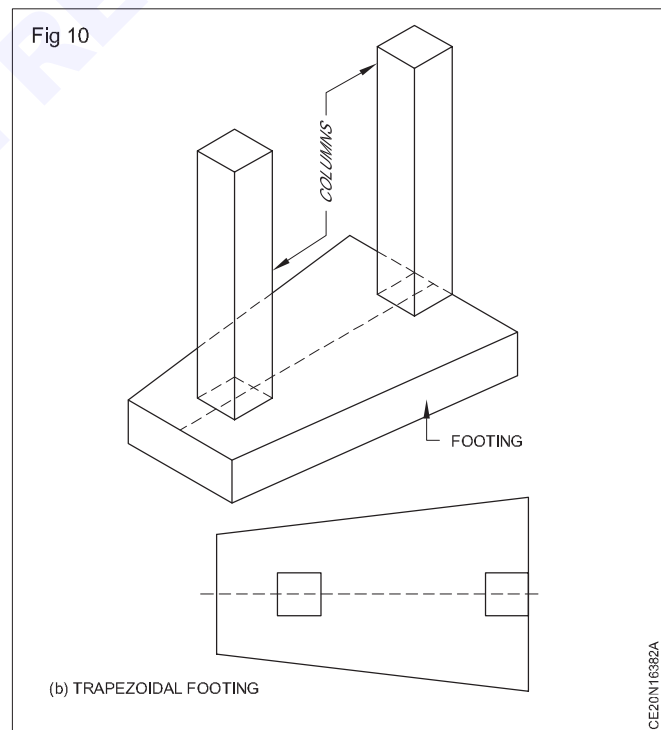
iii Combined footing

Rectangular footing (Fig 9)



A spread footing which supports two columns is termed as combined footing. If the footing supports more than two columns, it is known as continuous footing.

A combined footing is provided under the following circumstances. (Fig 10)



- 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 property 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 preferred.

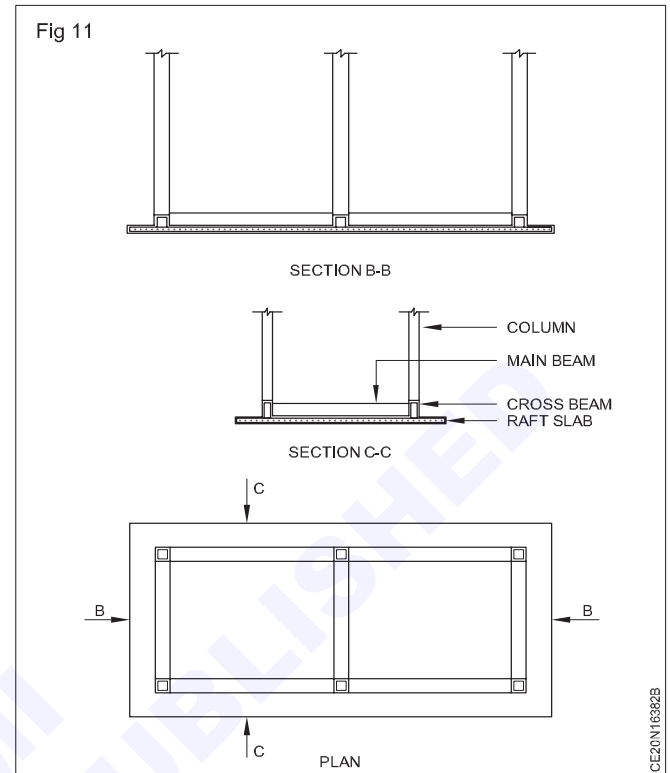
iv Mat or raft foundation (Fig 11)

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 consists 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 neutralize the hydrostatic uplifts.

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 $1/5^{\text{th}}$ - $1/10^{\text{th}}$

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 day this type of foundation is rarely used in India.



Deep foundation

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

- definition and classification of deep foundation
- explain pile foundation and various types of piles
- describe pile 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.

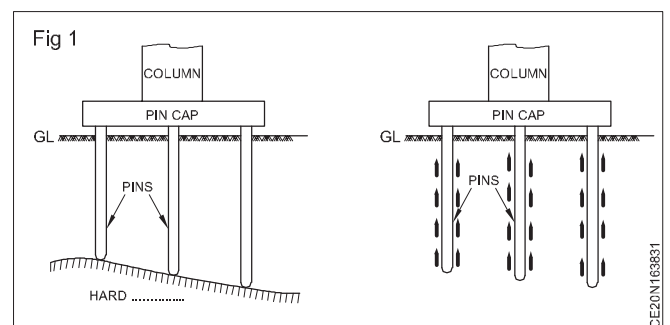
Classification of deep Foundation



A Pile Foundation (Fig 1)

Pile is a long vertical load transferring member which may be of timber, steel or concrete.

- 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

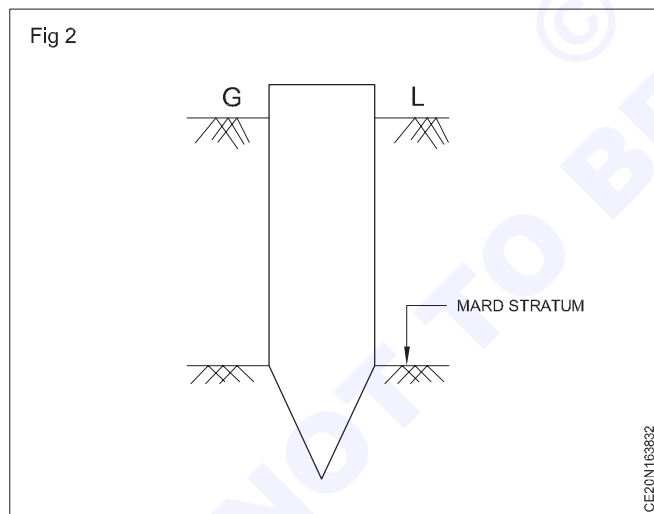
Following are the situation in which a pile foundation is preferred:

- 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 nearby area, which causes seepage of water in the foundation.
- f When hard bearing strata is at a greater depth.

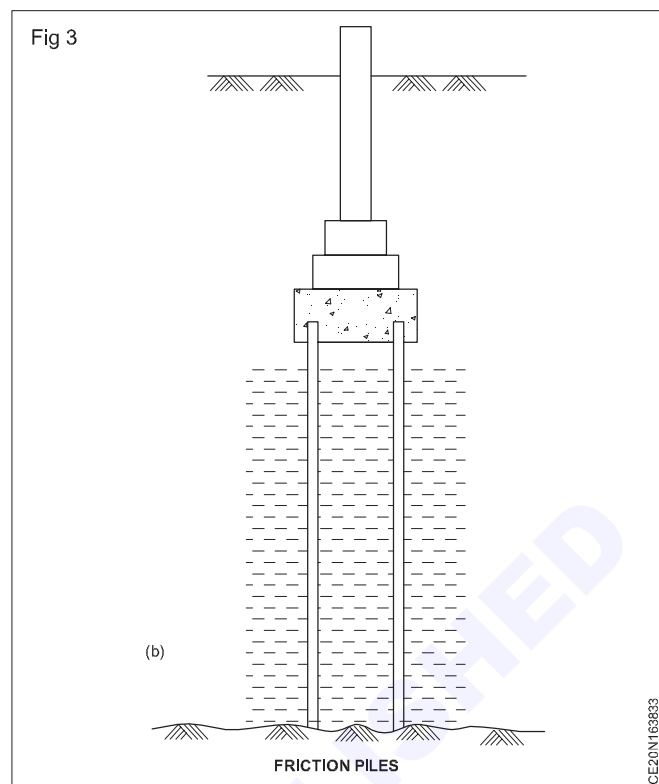
Classification of piles

- a Classification according to foundation:

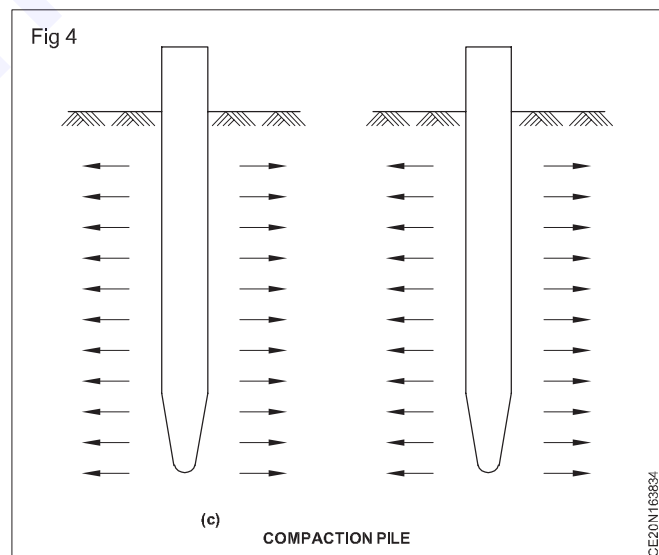
- 1 **End bearing piles (Fig 2):** Piles whose lower end rest on hard rock (hard stratum) is known as end bearing piles. These piles are used to transfer heavy load through water or soft soil to a suitable hard stratum.



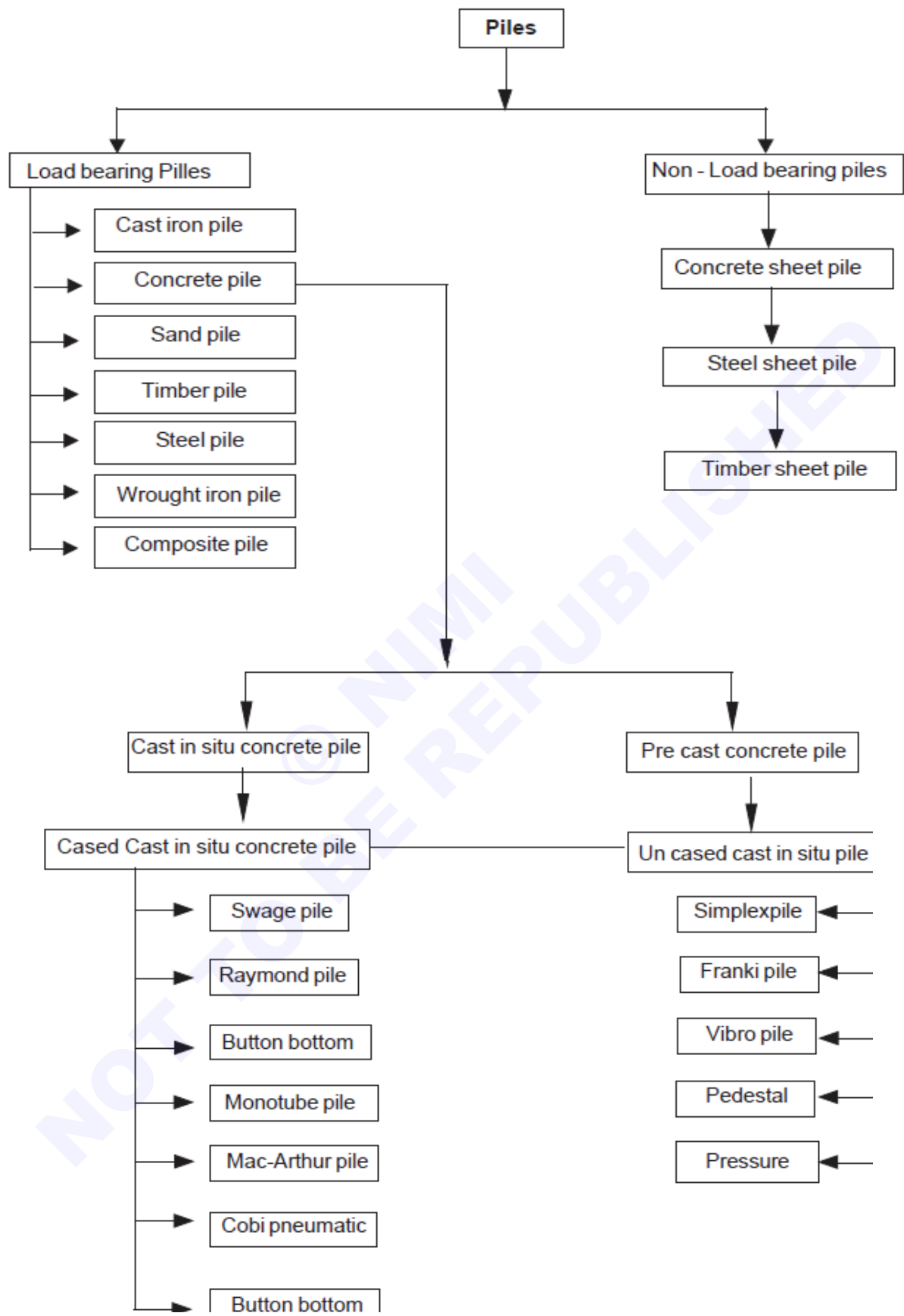
- 2 **Friction piles (Fig 3):** The piles which support the structure load due to friction between the piles and surrounding soil are known as friction piles. Such piles are generally use in granular soil when the depth of hard strata is very great.



- 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



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 differing 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.

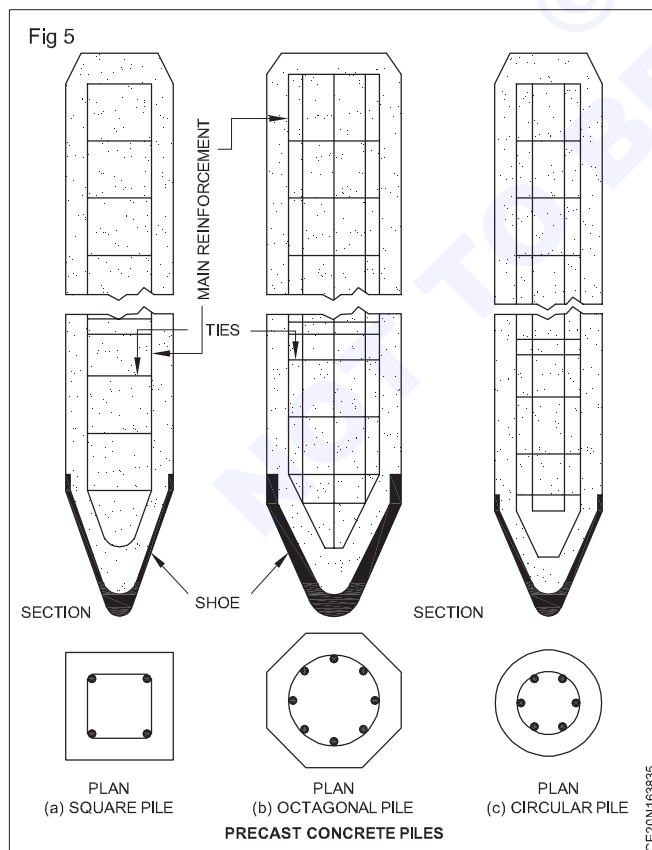
8 Batter piles

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

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.

i Pre cast concrete piles

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 more.

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 thinner 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.

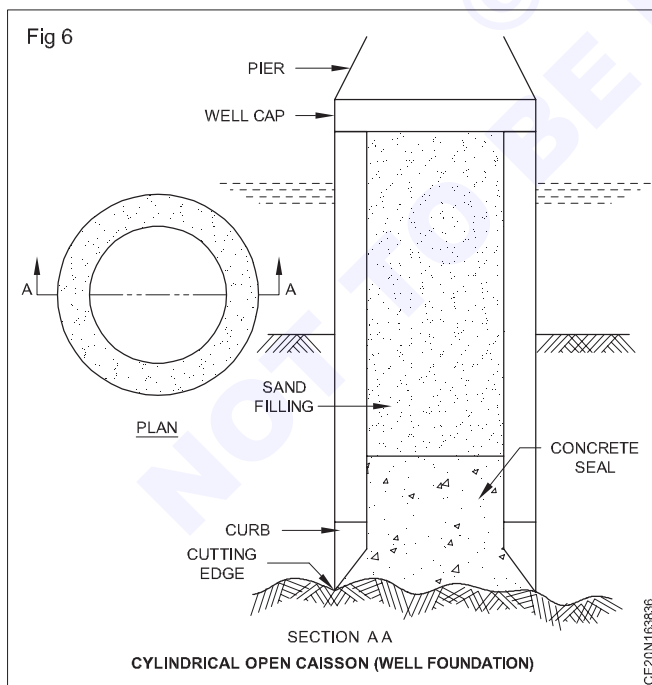
Advantages of cast-in-situ concrete piles

- Light weight shells are used in cast-in-situ concrete piles and these shells are easy to handle and to drive in the ground.
- No extra reinforcement is necessary to resist stresses developing during handling or driving operation only.
- There is no wastage of materials as the piles of required length is constructed.
- The pile are sound in construction as they are not driven into the ground by a hammer.

Disadvantages

- It is difficult to maintain the reinforcement in correct position during construction of piles.
- These pile cannot be constructed under water.
- The dry ground may absorb, moisture from the wet concrete. The piles are then weakened.

Well foundation (caissons) (Fig 6) : 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.



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.

- Strip or pad foundation
- Pier foundation
- 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.

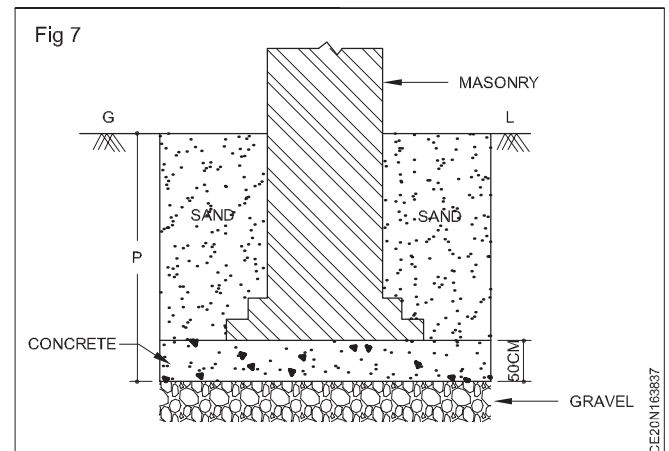
1st method

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.

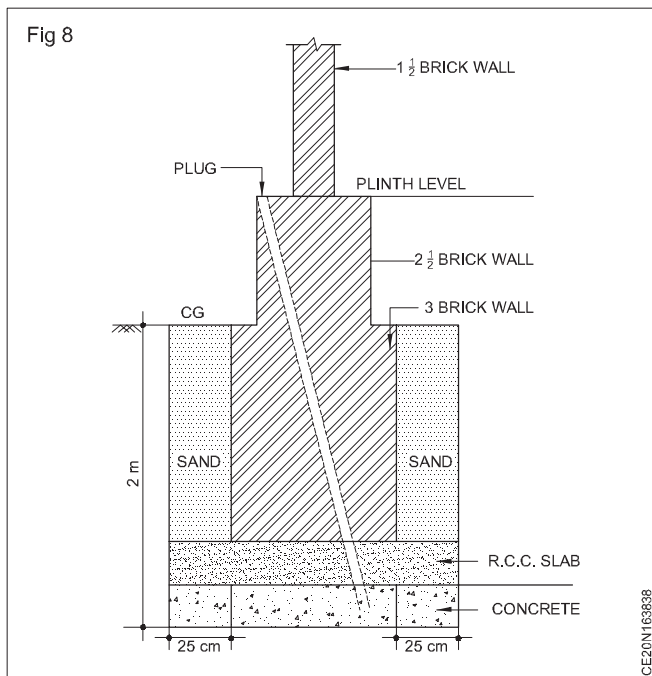
The procedure is as follows

- The foundations trenches are excavated to a depth given by the equation.
 $d = \text{maximum depth of crack} + 30\text{cm}$
- The width of the trenches is kept such that the allowable bearing capacity of the soil does not exceed 15 tone/m^2 .
- Gravel is spread for the face width of the trench and well rammed.
- A layer of concrete of 50cm depth is laid on the gravel.
- The masonry work is started on the top of the foundation soil and it is carried out up to the plinth level.
- The side of the trenches are filled with sand as shown in Fig 7.

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. (Fig 8)



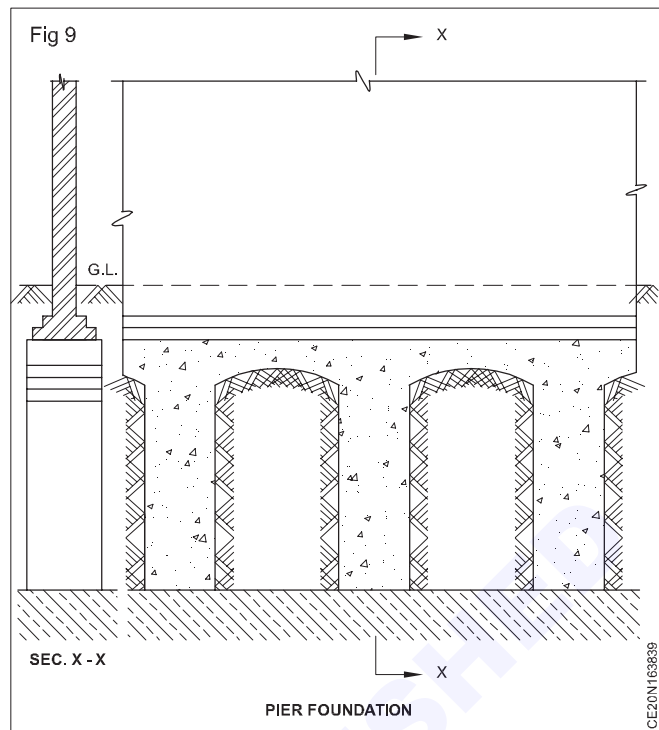
The procedure as follows

- The foundation trenches are excavated to a depth of 2m.
- The side portion of the trenches are filled with concrete having a section of 25cmx25cm as shown in fig 11 and the hollow space equal to 1st layer of masonry is filled with sand.
- 12cm-15cm thick R.c.c slab covering the face width of the trench is laid.
- The masonry work is started on the top of R.c.c slab and it is carried up to the plinth level.
- 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 up to plinth level and filled with sand. A plug is provided at the plinth level. These piles are inspected periodically if required.

2 Pier foundation

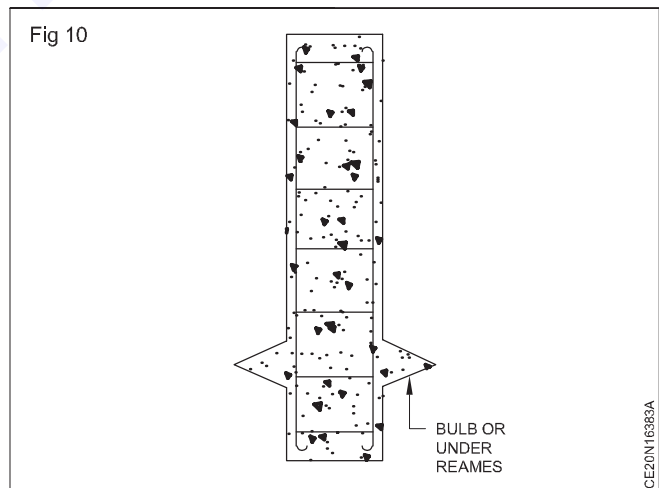
When a heavy loaded building is situated in a sandy soil, black cotton soil or soft soil, over lying hard bed at reasonable depth pier foundation are sometimes used to transfer the load the building to the hard bed below. This method consists in sinking vertical shaft up to hard bed and filling them 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 up the shaft with concrete. The shaft is connected to each other by an arch or reinforced cement concrete or steel grillage cap. (Fig 9)



3 Under reamed pile foundation

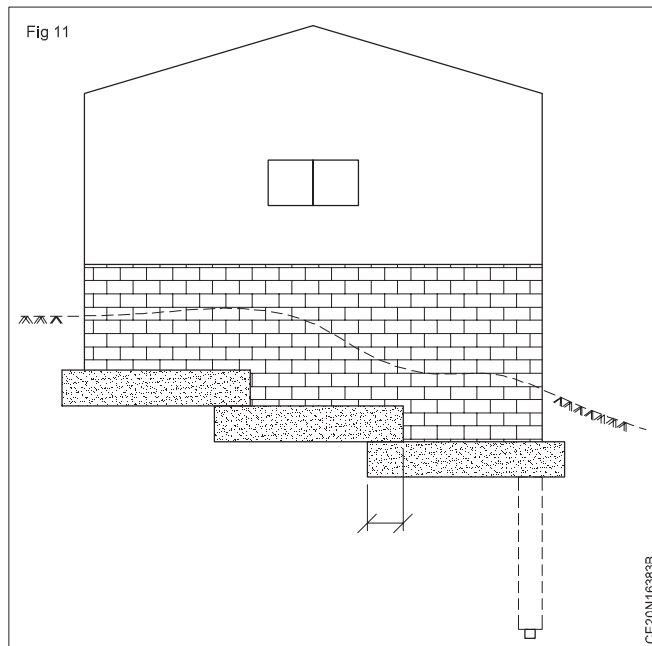
These piles are developed for serving as foundation for black cotton soil. An under reamed pile is a bored concrete pile having one or more bulbs in its lower portion. The bulbs or under-reams are formed by under reaming tools. The foundation will be anchored to the ground, and it would not move with the movement of the soil. The diameter of an 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 10).



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 sloping ground (Fig 11)



When the ground is sloping it becomes un-economical to provide foundation at same level along the length of the wall, in such cases stepped or benching foundation may be provided. The foundation trench 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.

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 access to a deep shaft or tunnel.
- 4 To provide an enclose 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 setting out of foundation trench

Setting out or ground tracing is the process of laying down the excavation lines and centre lines etc. on the ground.

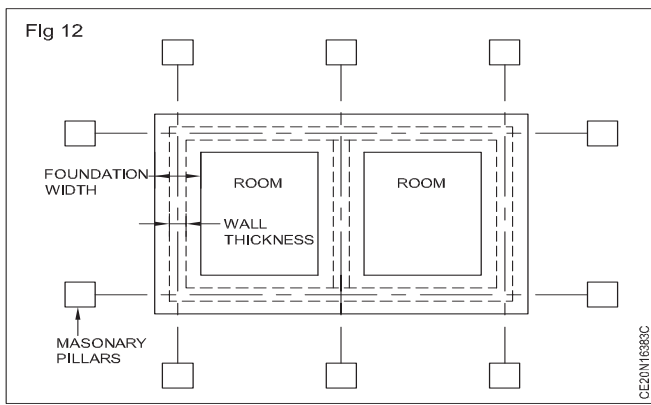
The process for setting out of foundation trenches as follows :

- 1 From the site plan of the building one line which can be easily established on the ground is selected.

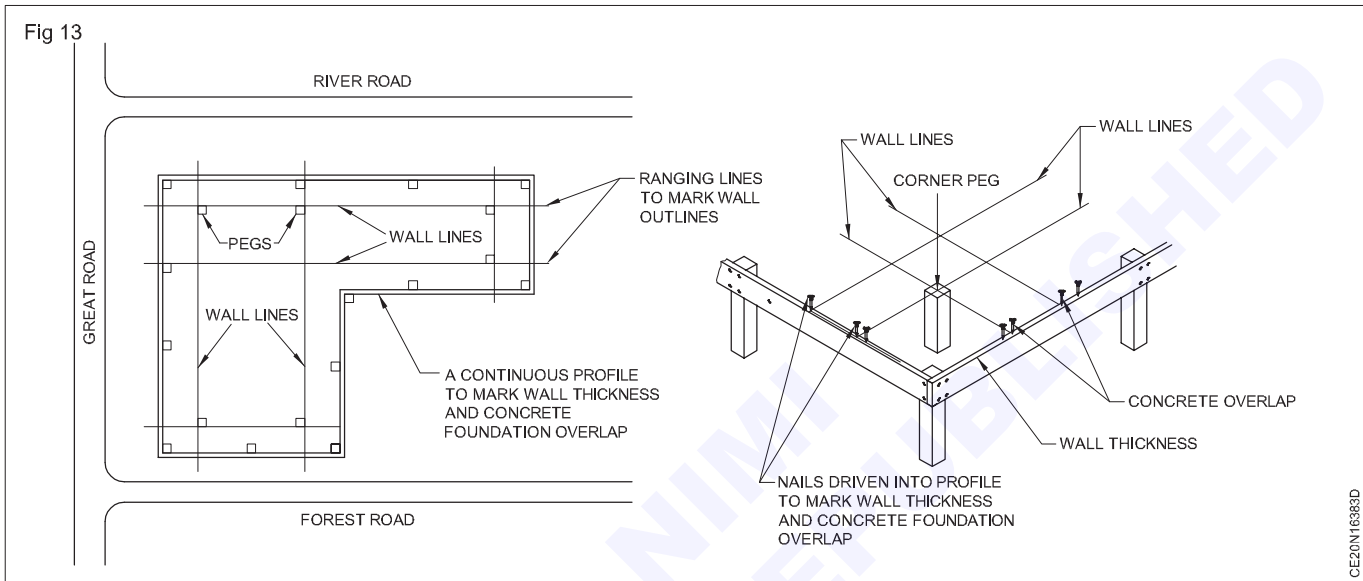
For example as per Fig 16 the point 'A' can be easily located on the ground and its co-ordinates are completely defined. With the help of point 'A' line 'AB' can be demarcated on the ground.

Thus line 'AB' will be the base line and from this base line the entire 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 trench. (Fig 12)
- 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 up to plinth level height. The top surface of the pillar 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 checked 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 overcome 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 holds the machine firmly to the ground and preventing the machine, shift or move or dislocation from its positions.

Types (Fig 1 & 2)

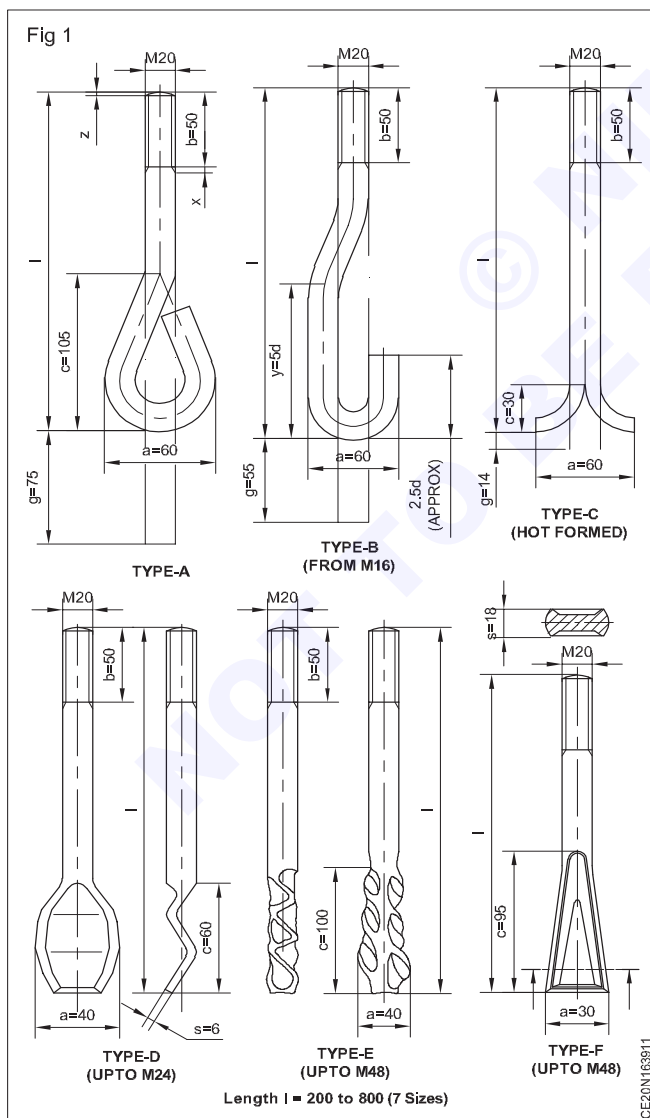
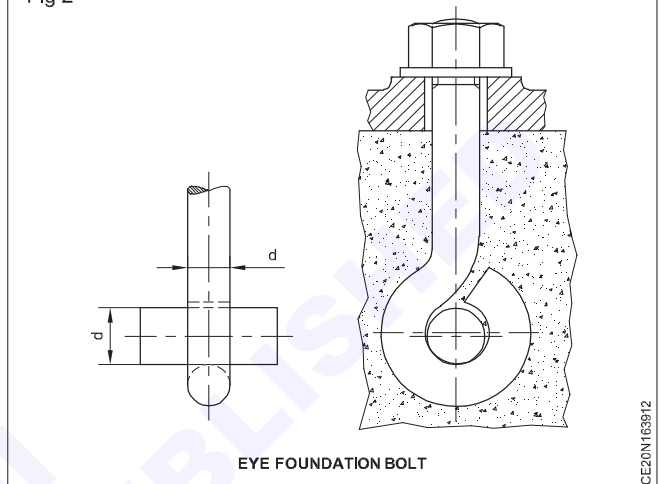


Fig 2



As per IS: 5624-1971 there are six types designated as type A, B, C, D, E & F Fig 1 shows the same. These bolts are available in 13 dia sizes from M8 to M75, length 80mm to 320mm. These bolts are designated by the shank's dia and length without nut. The ends are formed by forging.

There are other non-standard forms which are generally used are

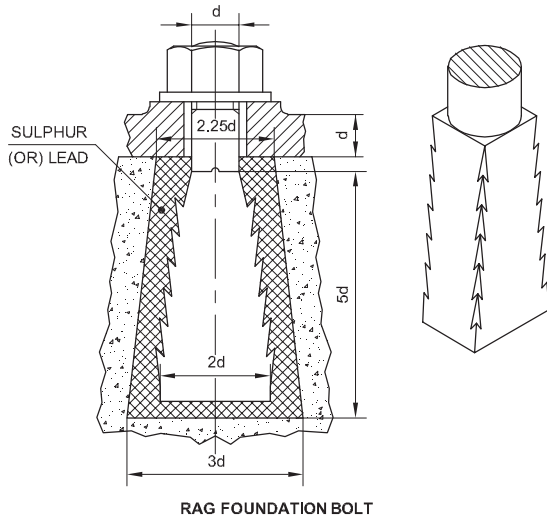
- Eye foundation bolt
- Rag foundation bolt
- Lewis foundation bolt

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 end 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 held in aligned. After this, the machine is placed in position and nuts are tightened 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 bolts are placed in the foundation cavity in position as done in previous case and then molten lead or sulphur is poured 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.

Fig 3

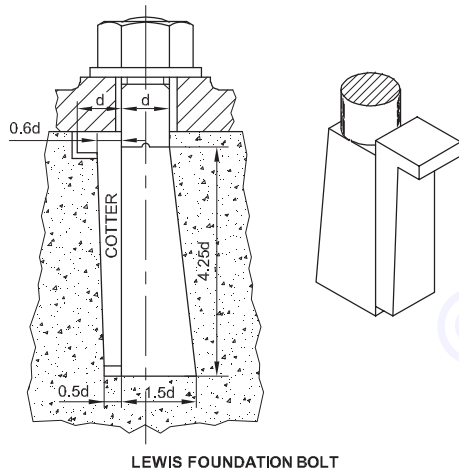


CE20N163913

By melting the lead or during the sulphur the bolt can be removed.

Lewis foundation bolt (Fig 4)

Fig 4

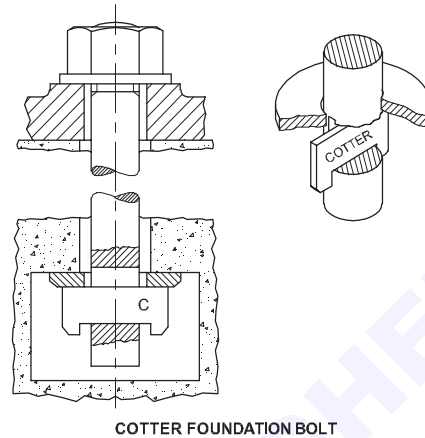


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This is a rectangular shank bolt with one side taper. A GIB headed key is placed on the other side of the taper and concrete is panned around it if it is aligned. The foundation bolt can easily be withdrawn by removing the gib headed key first and then the bolt.

Cotter foundation bolt (Fig 5)

Fig 5



CE20N163915

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.

Sequence of construction of building and name of different parts of building

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

- parts of a building and sequence of construction
- explain the levels of different parts of building.

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 from 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.

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 provides a good ventilation. Windows are constructed for providing light and ventilation in the building.

6 Lintel

A horizontal member of stone, wood, brick, steel, reinforced 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.

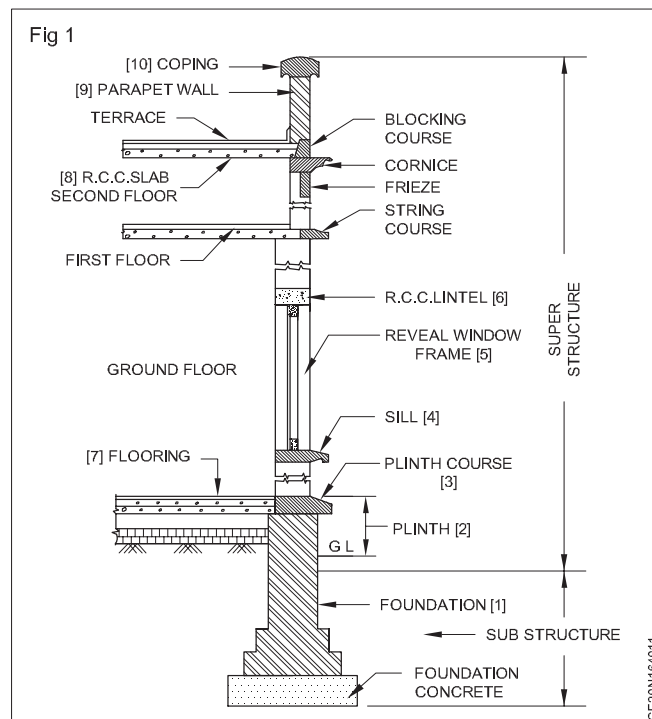
9 Parapet

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)



Brick masonry - terms, use and classification

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

- define and explain the different technical terms used in brick masonry, necessity of bonding brick.

Masonry is the art of construction in brick or stone

- From the very early ages of civilization few know the art of construction though the method were crude.
- But the advancement of age, the technique of construction has appreciably developed.

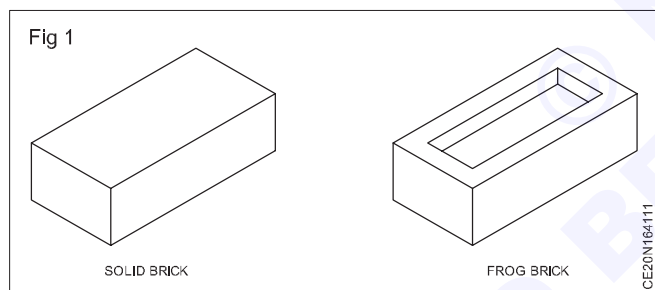
Masonry broadly divided into two parts

- Stone masonry
- Brick masonry
- Stone masonry is that in which stone is used as a construction material
- Brick masonry is that in which brick is used as a construction material.

Technical terms used in Brick masonry

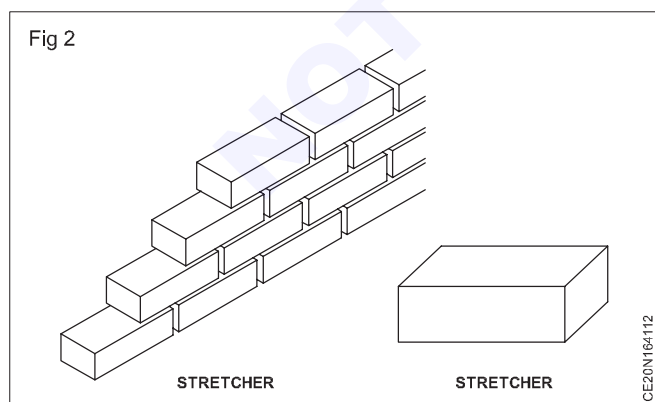
Brick

- Brick is artificially manufactured. It is in rectangular shape and size is 230 mm x 110mm x 70mm as shown in (Fig 1) (in ISI 200x100x100mm)



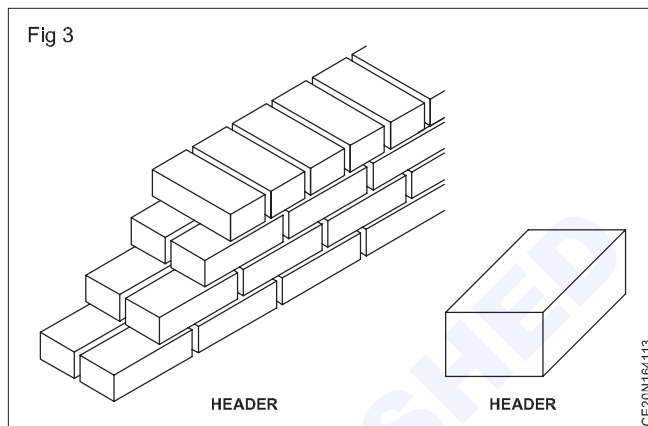
Stretcher

These are the bricks or stones laid long in a wall as shown in (Fig 2)



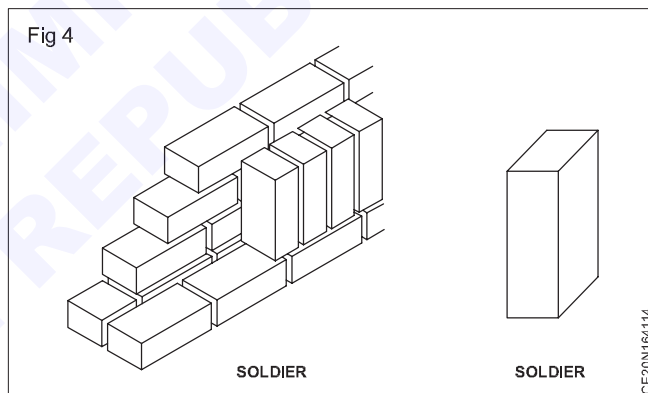
Header

These are bricks or stone blocks laid breadth wise or their headers length of the wall as shown in (Fig 3)



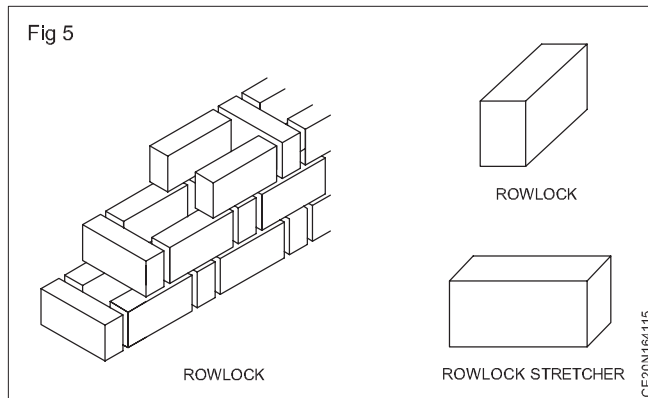
Soldier

These are bricks, laid stretcher face in vertical position as shown in (Fig 4)



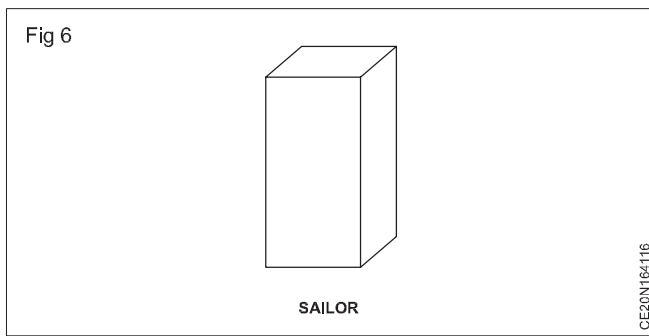
Row lock

These are bricks which are laid on its edge as shown in figure. This is also called Brick-on-edge as shown in (Fig 5)



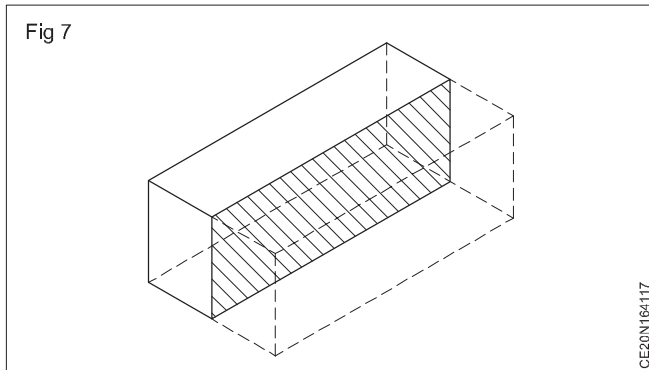
Sailor

These are bricks which are laid in vertical position with bed of the brick is placed in elevation shown in (Fig 6).



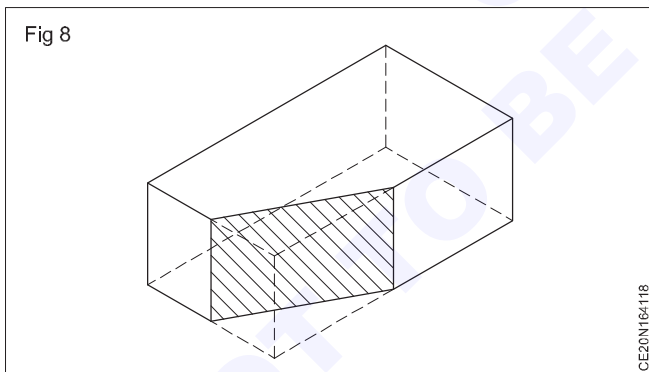
Queen closer

These are half bricks cut length wise. It is used along the length of a quoin for staggering joints of alternate course see (Fig 7).



King closer

It is a brick which is cut in such a manner that the width of one of its ends is half a full brick. It is formed by cutting a triangular portion of one of the corner of a brick between the centre of one end of the centre of the other end as shown in (Fig 8).

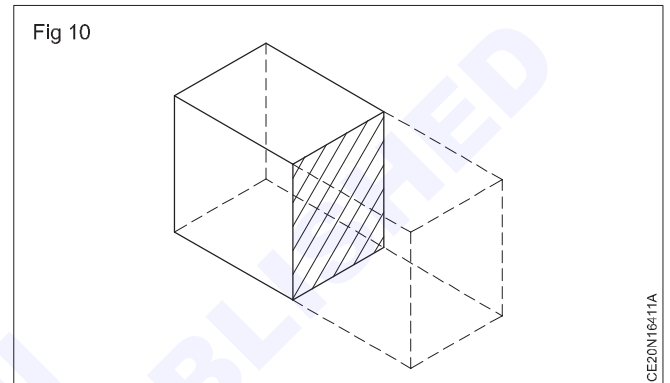
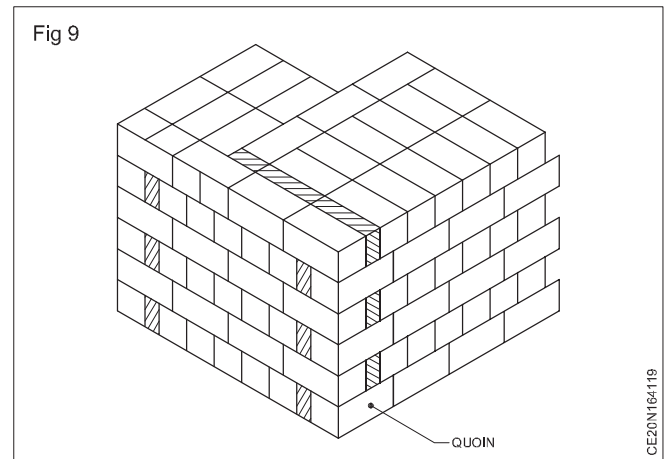


Quoin (or) Quoin header

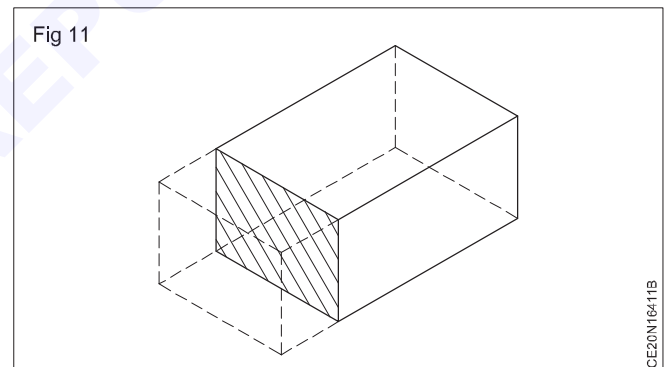
It is the brick or block of stone used at the corner of two walls. This bricks or block of stone will look as header from one side and stretcher from the other side as shown in (Fig 9).

Bats

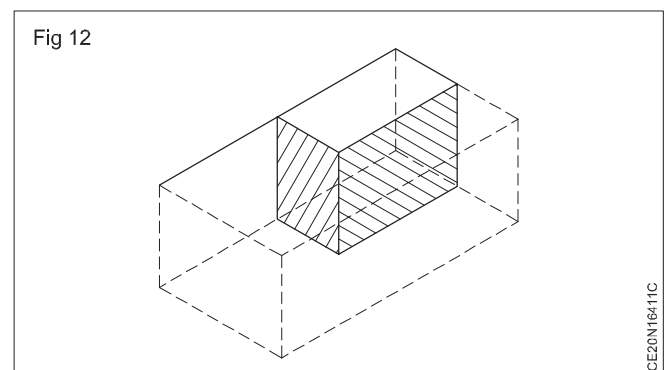
These are bricks which are cut length wise into two half bats, which are known as half brick as shown in (Fig 10).



If the full brick is cut into $\frac{3}{4}$ then it is called as $\frac{3}{4}$ th bat as shown in (Fig 11).



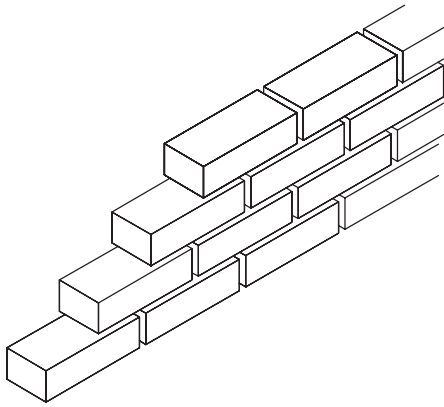
If the full brick is cut length wise into two half portion is queen closer, and again cut into two half is known as $\frac{1}{4}$ brick as shown in (Fig 12).



Course

A horizontal layer of Bricks or stones laid in mortar or without mortar in a systematic way is called as course. see (Fig 13).

Fig 13

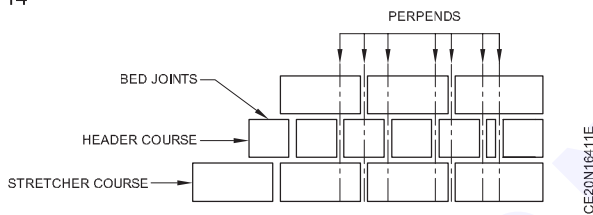


Bed joints

These are horizontal joints of a brick or stone masonry.

Perpends These are imaginary vertical lines, containing the vertical joints of masonry (Fig 14).

Fig 14



Jambs

These are vertical sides of a door or window openings on the backside. These may be squared or splayed and are provided with recess to receive the door or window frame.

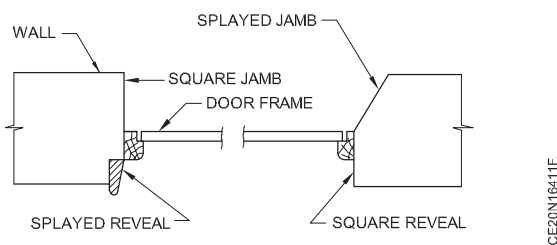
Reveal

These are exposed vertical surface of walls on the outside of an opening of a door or window. The function of a reveal is to protect the frame and to keep privacy of the room.

Panel and Pilaster wall

These are boundary walls consisting of pillars at regular intervals and thin partition walls. The function of a panel and pilaster wall is to increase the transverse strength of the long boundary wall. (Fig 15)

Fig 15



Necessity of bonding bricks

According to their uniform size and shape the bricks are arranged in various pattern.

Bonding is essential to eliminate continuous vertical joints both in the body as well as in the face of the wall to give the strength to masonry.

A wall having continuous vertical joints does not act as a homogeneous mass to distribute the super impost load.

Back

The wall surface which is not exposed to weather is called (inner surface) back or backing.

Face

The exterior wall surface which is exposed to weather is called face or facing.

Hearting

The portion between the inner and outer portion of wall.

Side

This is the surface formed by boundary of bricks or stones in a direction transverse to the face and bed.

Joint

It is the junction of two or more bricks or stones in a course then it is termed as bed joint. The joints which are perpendicular to bed joint. The joints are known as vertical joints or joints.

Bond

The method of arranging bricks in a masonry so that the individual / each brick or stone tied together. Bonding is may important to eliminate continuous vertical joints in both in body as well as on the face of wall.

Spalls

These are the chips of stones used for filling the cavity between two surfaces of walls.

Quoins

These are the stones / bricks used in corners of a wall.

Frog

It is an indentation or cavity or depression on top face of a brick made to forming a key for the mortar.

Cornice

It is an ornamental projecting course near the top of building or at the junction of wall and ceiling.

Blocking course

A top most course of stone masonry provided immediately above the cornice to prevent the tendency of the cornice to our turn.

Pier

It is an intermediate vertical support in stone or brick masonry and if it projecting beyond to support the ends of beam or truss or roof slab and then it is called pier.

Corbel

The extension of one or more course of stone or brick from the face of wall to act as a support for wall plate.

Weathering

The upper surface of stones used for sill, cornice and coping is dressed in a sloping way so that the water may flow off easily this is termed as the weathering.

Throating

A groove is provided on the underside of sill, cornice and coping so that the rainwater can be discharged clear of the wall surface, this is known as the throating.

Toothing

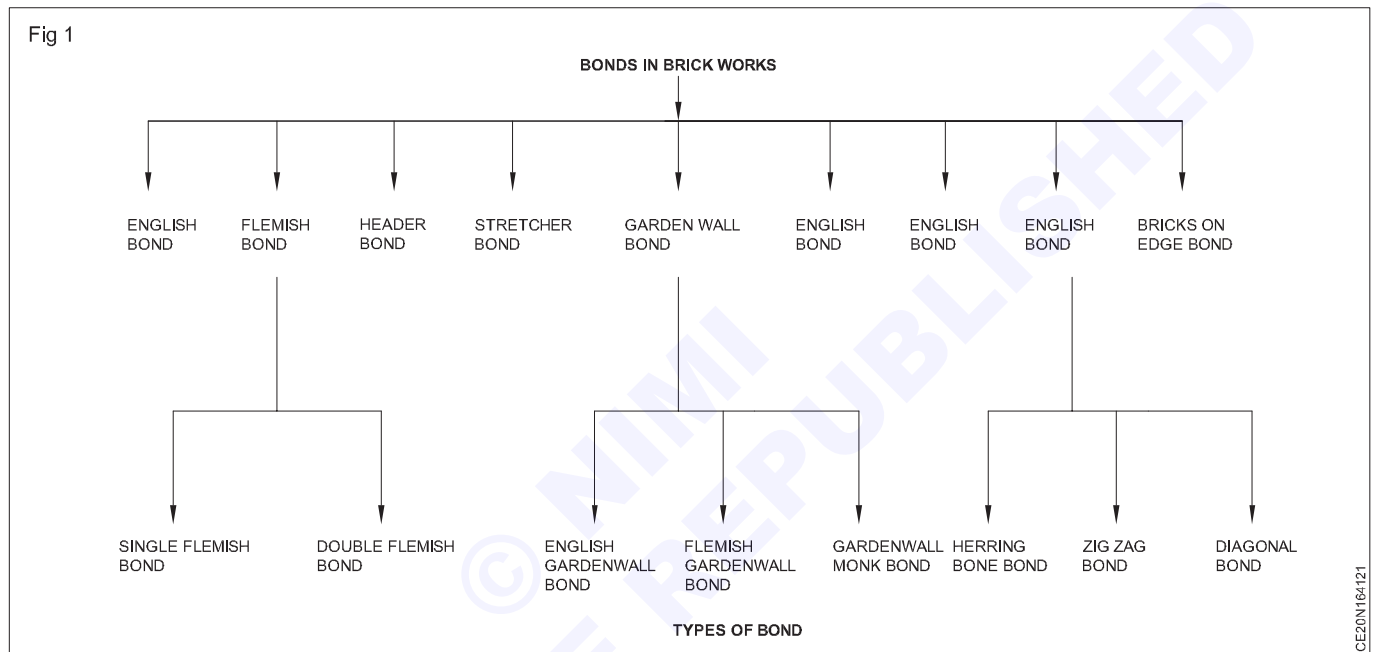
The termination of a wall in such a fashion that each alternate course at the end projects is known as the toothing and it is adopted to provide adequate bond when the wall is continued horizontally at a later stage.

Racking back

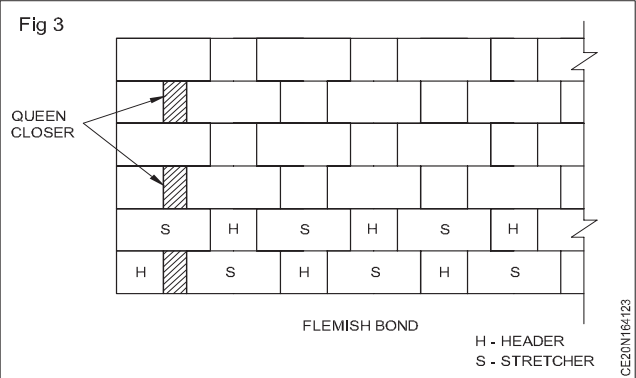
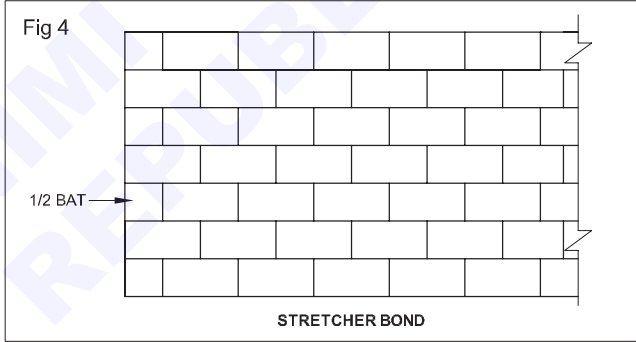
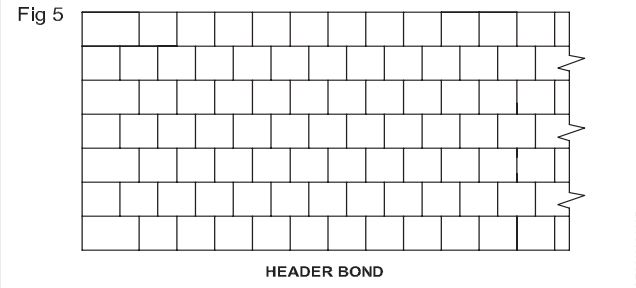
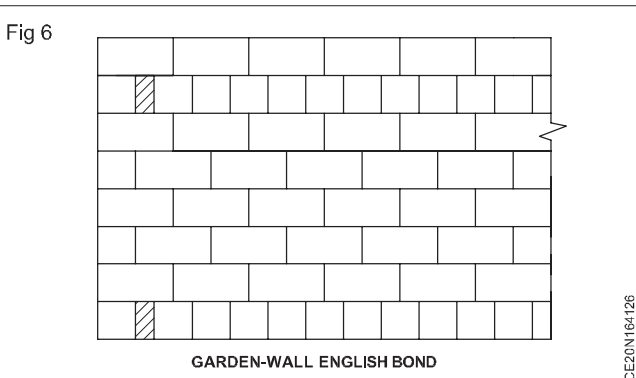
The termination of a wall in a stepped fashion is known as the racking back.

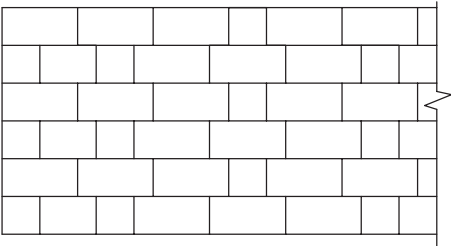
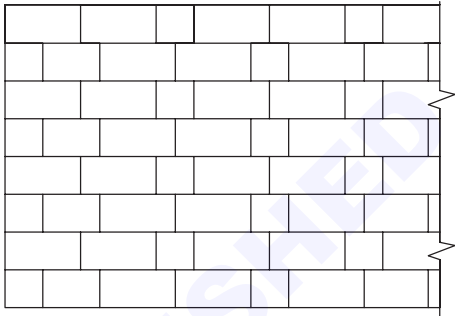
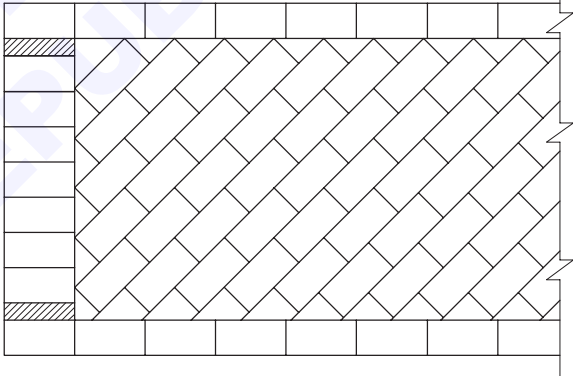
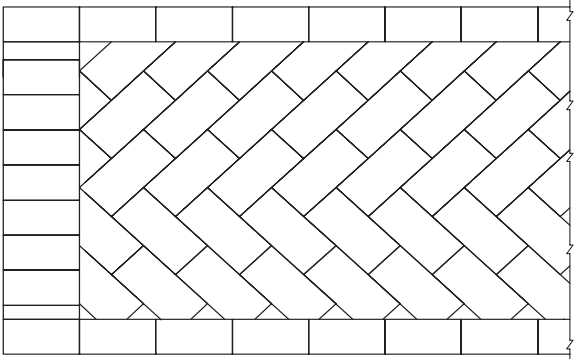
Types of Bond

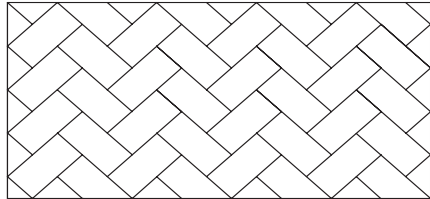
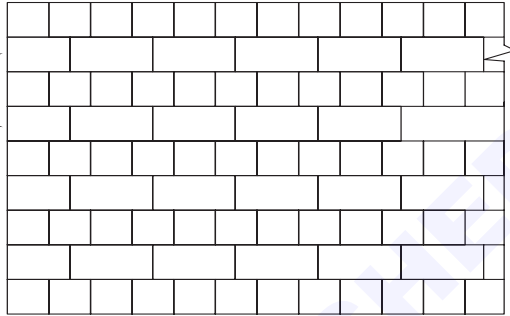
Bonds in brick works (Fig 1)



Name of bond	Features and uses	Figure
English bond	Alternate courses consists of headers bond 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 stretcher course. Minimum lap should be $\frac{1}{4}$ 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.	Fig 2 ENGLISH BOND CE20N164122

Flemish bond	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.	Fig 3 
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	All the bricks are arranged in stretcher bond course. (Fig 5) It does not develop proper internal bond Introduce a $\frac{1}{2}$ bat alternate course to get proper lap.	Fig 4 
Header bond	All the bricks are arranged in header course. (Fig 6) Overlap is kept equal to half brick width achieved by using $\frac{3}{4}$ bats. Uses : For circular wall For circular manhole	Fig 5 
Garden wall a English garden wall bond	One header course is provided to two or five stretcher course. Quoin headers are placed in alternate bond course and queen closer is placed next to the quoin header in header course to develop lap 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 6 

b Flemish garden wall bond	Each course contain one header to three or five stretcher A $\frac{3}{4}$th bat is placed next to the quoin header. A header is placed centrally over each middle stretcher.	Fig 7  GARDEN-WALL FLEMISH BOND CE20N164127
c monk bond	Each course contains one header to two stretchers The header rest on the joint between two headers. A $\frac{3}{4}$th bat is placed next to the quoin header. (Fig 9)	Fig 8  MONK BOND CE20N164128
6 Raking bond	Courses are inclined Inclination should be in opposite direction in alternate courses. Brick are laid at 45°	Fig 9  PLAN SHOWING ARRANGEMENT OF BRICK IN DIAGONAL BOND CE20N164129
a Diagonal bond	Bricks are laid longitudinally, Useful for 2-4 brick thick. (Fig 10)	
b Herring bone bond	Brick are laid at 45° from the centre in both the direction, Useful for ornamental finish. (Fig 11)	Fig 10  HERRING BONE BOND CE20N16412A

c Zig-zag bond	Bricks are laid at 45° in zig-zag fashion and used for flooring (Fig 12)	 Fig 11 ZIG-ZAG BOND CE20N16412B
Dutch bond	Alternate courses of headers and stretchers. (Fig 13) The quoin of stretcher course is 3/4 bat A header is introduced next to the 3/4 bat in every alternate stretcher course. Uses:- Corner of wall can be strengthened.	 Fig 12 DUTCH BOND CE20N16412C

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.

Strength and stability - walls

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 is 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 and principles of construction of bonds

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

- explain compressive strength of masonry
- principles of construction of bonding.

Verifying compressive strength of masonry

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).

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. (Fig 1)

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.

Principles of construction of Bonding

- 1 The amount of lap should be minimum of $\frac{1}{4}$ th brick along the length of the wall and $\frac{1}{2}$ 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.

Fig 1



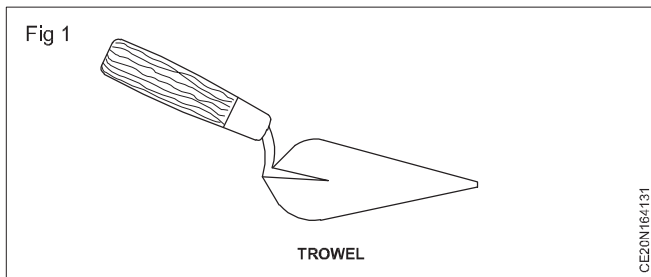
Tools and equipments used in brick masonry

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

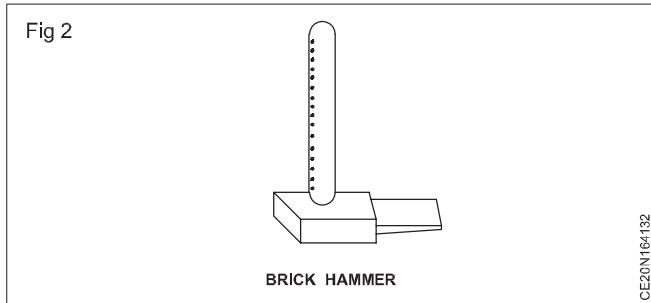
- state the various tools and equipment used in brick work.

- 1 **Trowel:** It consists of a blade and shank in to which a wood handle is fixed. It is used for lifting and

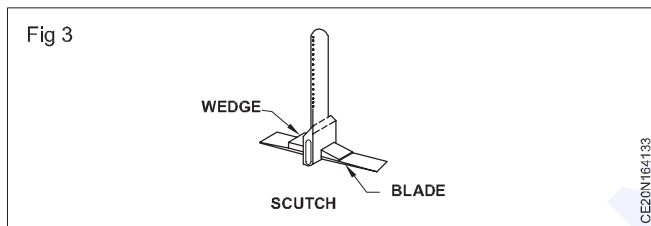
spreading mortar on to a wall cutting the brick and forming joints (Fig 1)



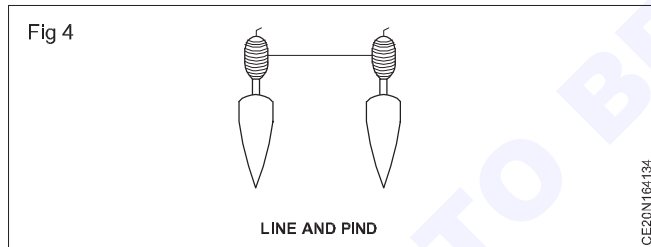
- 2 Brick hammer:** This hammer is used for cutting the bricks to the required shape. One edge of hammer is sharp and the other is square. (Fig 2)



- 3 Scutch:** It is used for cutting soft bricks and dressing the surface of the brick (Fig 3)



- 4 Line and pin :** The line is wood round two pins. It is used to maintain the correct alignment of courses. (Fig 4)

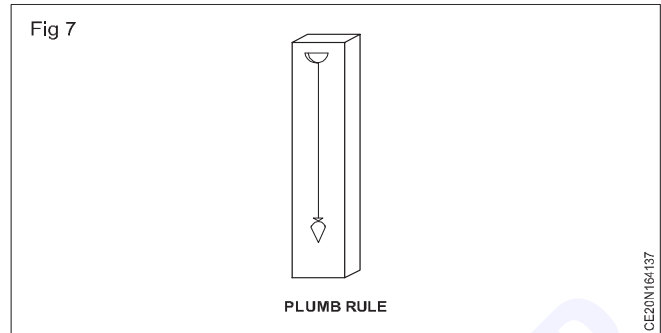
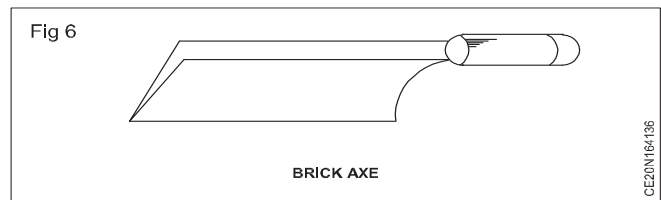


- 5 Spirit level :** Sprit level for getting horizontal surfaces. (Fig 5)

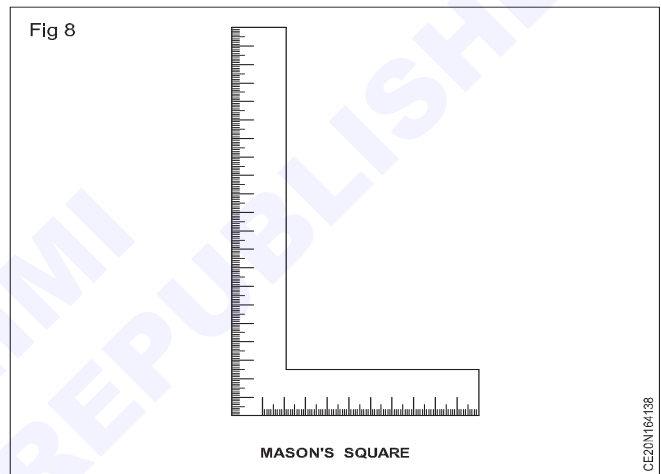


- 6 Brick axe :** Its purpose is similar to brick hammer. (Fig 6)

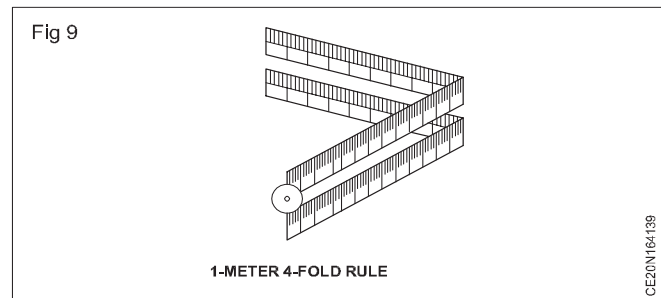
- 7 Plumb rule :** Plumb rule is used to clock verticality of brick work or stone wall. (Fig 7)



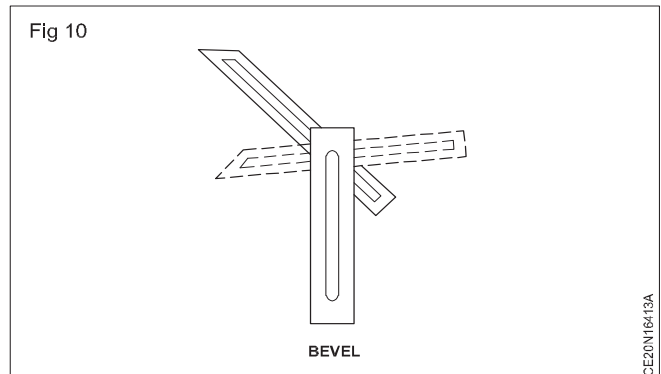
- 8 Mason's square :** It is made of steel or wood is used for checking right angle of the wall. (Fig 8)



- 9 Four folded foot rule :** It is used for taking measurements (Fig 9)



- 10 Bevel square :** It is used for setting out angles (Fig 10)



Plastering, types, thickness, position and materials

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

- **state plastering**
- **types and thickness in different position**
- **materials used in plastering.**

Plastering

Masonry structures after their construction require interior and exterior finishings. This finishing is known as plastering.

Types of plastering

- 1 Plastering with lime mortar
- 2 Plastering with cement mortar

1 Plastering with lime mortar

- The mortar shall be of proportion as specified in the work and shall be prepared as per the specification on lime mortar.
- The plaster shall be laid on with somewhat more than the required thickness and levelled with wooden float or wooden rule.
- The finished thickness shall be sufficient to cover by minimum 12mm the surface of wall in brick masonry and by 20mm all the projections in the case of Random rubble masonry.
- The plaster shall be well pressed into the joints and surface rubbed smooth with a wooden straight edge or plaster Trowel sprinkling as much water as is necessary.
- During the process of rubbing an addition of lime and water of the consistency of thick cream is to be applied to give a smooth and even surface.
- The completed plaster shall be allowed to rest for 24 hours and then sprinkled with water at short intervals and kept damp for at least seven days.

2 Plastering with cement mortar

- Mortar shall conform to specification on "Cement mortar"
- It must be freshly mixed for immediate use and in such quantities as to permit the whole batch being used in the work before the mortar has commenced to set.
- The plaster shall be laid on with somewhat more than the required thickness and levelled with a wooden rule or straight edge.
- The finished thickness shall be sufficient to cover by 10mm the surface of the wall in brick masonry and by 6mm all the projections in the case of rubble stone masonry.

- The plaster shall be well pressed into the joints and surface rubbed smooth with a floating coat about 3mm or pure portland cement.
- The finishing coat must be applied while the base coat is still fresh.

Thickness in different position

Thickness

- The thickness of plaster specified shall be measured exclusive of the thickness of key le grooves or open joints in brick work.
- The average thickness of plaster shall not less than the specified thickness (12mm).
- The minimum thickness over any portion of the surface shall not be less than specified thickness by more gauges or level dots.
- Extra thickness required in dubbing behind rounding corners at junctions of wall or in plastering of masonry cornices etc will be ignored.

Materials used in plastering

Materials

- Cement
- Cement shall be ordinary port land cement or portland blast furnace cement or portland pozzolona cement as specified.

Lime

- Lime shall be semi hydraulic lime class B or fat lime class c.

Sand

- Sand shall consist of natural sand, except where crushed stone sand or crushed gravel sand or a combination of any of these are indicated. The sand shall be hard and durable, clean and free from adherent coating and organic matters and shall not contain any appreciable amount of clay balls. Sand shall be obtained from approved sources.

Water

- Water used for mixing and curing shall be clean, free from deleterious matter and sea water or blackish water shall not be used. Water fit for drinking is normally suitable.

Plastering - tools used, defects and remedies

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

- state plastering tools / mason tools
- defects and remedies.

Block laying and plastering tools consists of tools normally used by the brick layer plus a few additional tools which have been developed to meet the specific demand of the work involved.

The Block layer and concrete is often also a plasterer, a tiler and drain layer.

we shall discuss some of the most important tools under the headings that follow.

Laying tools

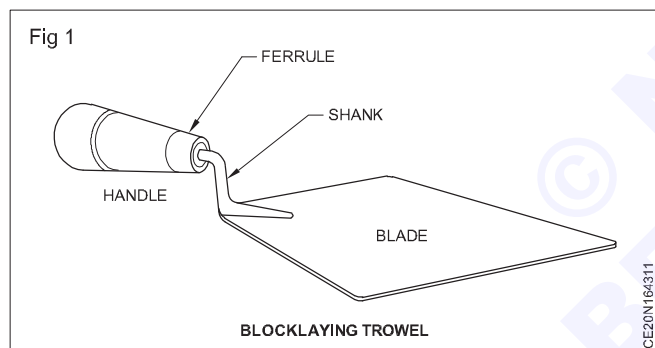
Wall straightening tools

Cutting and Trimming tools

Finishing tools.

Laying tools

Block Trowel (Fig 1)



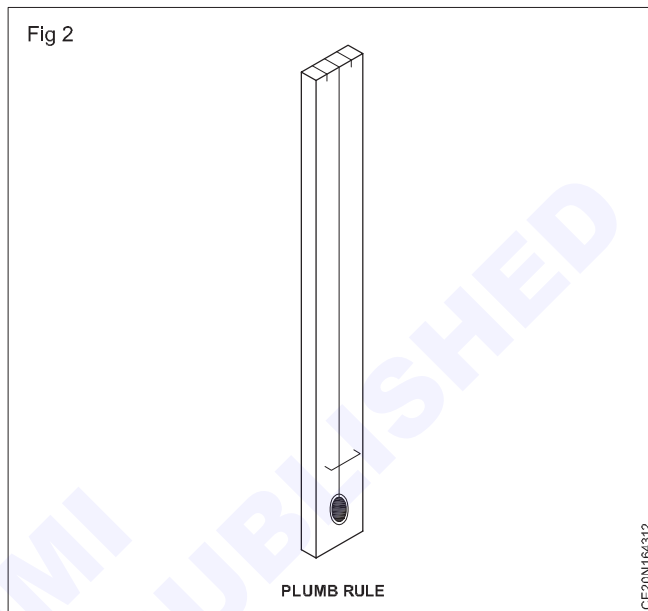
This is a tool which every block layer and concreter must possess used for picking up mortar from the mortar board, spreading it on the wall for bed joints, forming cross joints on blocks, cutting of excess mortar and consolidating cross joints. It is also used for tapping down laid blocks and for rough cutting of blocks.

Plumb rule

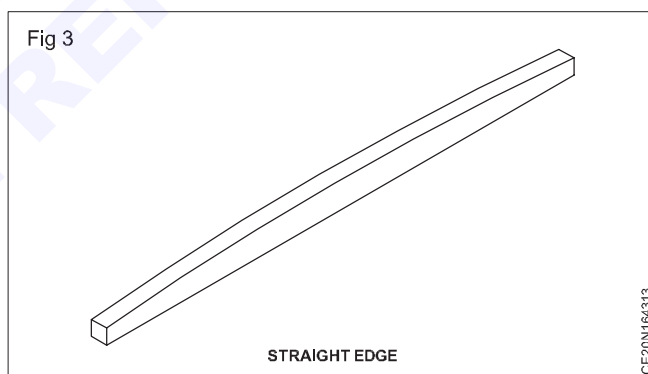
This is a straight edge with a cut line running down the centre from the top to with in about 150mm from the bottom edge where a hole is made slightly larger than the plumb bob.

The plumb bob is an egg shaped angle piece of steel or lead held in position by a plumb line.

This tool ensures a very accurate vertical check as shown in (Fig 2).



Straight edge (Fig 3)



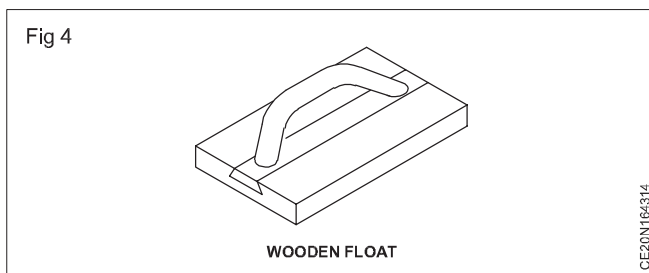
This is a piece of timber or Aluminum hollow piece of a length to suit its purpose, a convenient length for the brick layer or Block layer being 2 metres. It is beveled at both ends to reduce the overall weight in the case timber.

The straight edge is used to check the flatness of a newly laid piece of wall and ensure that all blocks or bricks are laid to the same level in each course.

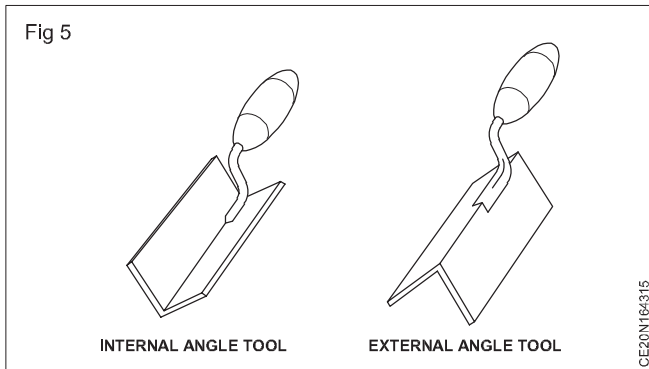
Wooden float (Fig 4)

The cross grained wooden float, as the name implies, has grains running across the sole.

It is used for scouring of excess mortar on the surface of the wall finishing coats and making angles square and clean.



Angle tool (Fig 5)

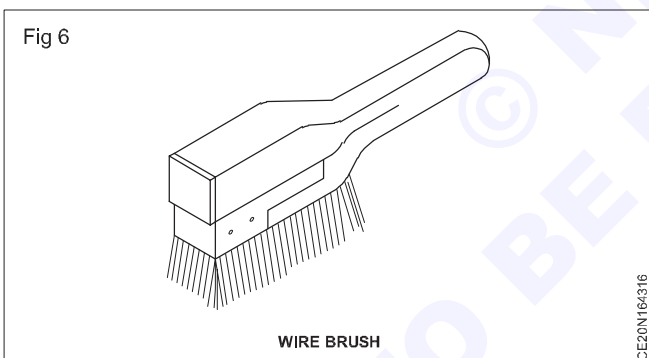


These are made with either wooden or steel plate bent into angle of 90°. It is used for finishing angles in neat and square form.

A Internal angle Tool

B External angle Tool

Wire brush (Fig 6)



Used for multi purposes such as cleaning the joints of Brick work or block work, before pointing operations removing dirt from plastered surfaces before a painting operation and cleaning tiled work etc. (Fig 7)



Joint cluster

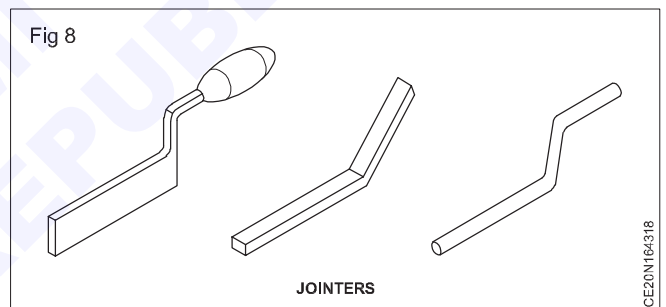
The job of pointing in brick work and jointing block wall is much improved by finally using a joint cluster.

It is used to remove the excess mortar pieces from the finished work.

It is a convenient tool to use in wetting the joints before and as the work proceeds.

Jointing tools

These are popularly called jointers. They are of three main shapes as shown in the (Fig 8).



Defects in plastering

- 1 Blistering
- 2 Cracking
- 3 Instability
- 4 Foam pushing
- 5 Snow drop formation
- 6 Skin peeling
- 7 Crater explosion
- 8 Rusting
- 9 Unequal surface

Preparation for rendering & wall cladding, special materials used in plastering

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

- **define rendering**
- **special materials in plastering.**

Sciography is the knowledge of rendering, light and shade & shadow principles.

Architectural graphics involves a number of techniques to render the shapes and masses of buildings and structures on a plane sheet.

At the initial stage of project the architect makes the drawings with rendering, shade, shadow surroundings, perspective pictorial views, which defines form from space and also to make it easy to understand graphical language to client.

Architecture

The architectural renderer, known as a delineator or perspectives, when faced with the rendering of a building has one of the most complexes of all rendering problems.

Must be competent at rendering materials such as brick, stone, steel, concrete, glass and plastics tress, landscapes, people, cars. All of this he must be able to carry out within the overall framework of a correct perspective drawing on which the precise shadow shapes are constructed together with atmospheric effect and contrast, etc., introduced according to optical reality so that the final rendering presenting the true intent of the design. He must also be competent at rendering materials such as ceiling, flooring (carpet) & furniture.

Rendering

Definition

- Rendering is a process of showing the different material textures by using strokes of soft pencils 2B, 4B, 6B giving different pressure.
- Rendering is a technique to show finished illustration texture in a natural and appealing form.

Need of rendering

- 1 Rendering gives a touch of reality in an artistic way.
- 2 Rendering is an important task for the architect to produce presentation drawings for client final approvals.

Special materials used in plastering

- 1 Asbestos marble plaster
- 2 Acoustic plaster
- 3 Granit silicon plaster

- 4 Gypsum plaster
- 5 Martin's cement plaster
- 6 Basium cement plaster
- 7 Keene's plaster
- 8 Scagliola plaster.

Types of plaster finishes

- Rough coat plaster.
- Pebble dash plaster.
- Stucco plaster.

1 Rough coat plaster

- This type of plastered surface is prepared by throwing coarse aggregate and cement mixed together over the wet plastered surface.
- The rough cast mixture shall consist of sand or gravel or crushed stones of uniform colour from 2.5m to 12mm or as specified.
- It shall be ensured that the base surface which is to receive rough cast mixture is in plastic state
- The mixture shall be wetted and shall be dashed on the plaster base in plastic state by hand scoop so that the mix get well pitched into the plaster base.
- The mix shall again be dashed over the vacant spaces if any so that the surface represents a homogeneous surface of sand mixed with gravel. Rough cast surface is water proof durable and resistant to cracking.

2 Pebble dash plaster

- The rough finish of rendering coat of cement and sand mortar 1:3 shall be laid on to a thickness of not less than 10mm and shall be lightly pressed over to straighten it.
- The aggregate used for dashing or crushed stones or pebbles of suitable size generally from 10mm to 20mm
- shall be well washed, drained and thrown wet on the rendering coat while it is still plastic, rough covering material being partially embedded in the surface.

- To ensure satisfactory bond between the dashing and the mortar the aggregate may be lightly tapped into the mortar with wooden float or the trowel.
- After completion of finishing coat, the plaster shall be kept wet for atleast seven days and shall be protected during that period from extremes of temperature and weather
- Therefore, proper curing shall be done.

3 Stucco plaster

- Stucco plaster finished surface resembles very much marble finishes

- Stucco plaster can be used for external as well as internal surfaces
- Stucco plaster is applied in three coats and total thickness of the plaster should not be more than 25mm
- The first coat is called stretch coat second as brown coat and third as finishing coat
- Stucco plaster consists of lime plaster in which finely ground white marble is mixed
- If hydraulic lime is used the plaster can be applied on the exterior surfaces also.

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Paints and Varnishing, types, characteristics and uses

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

- define paint
- characteristic, types and uses
- varnish - characteristics and uses.

Paint : Paint is any pigmented liquid liquefiable or solid mastic composition that after application to a substrate in a thin layer converts to a solid film. It is most commonly used to protect colour or provide texture to objects. Paint is typically stored sold and applied as a liquid. Paint can be made or purchased in many colours and in different types, such as water colour or synthetic. Most paints are either oil based or water based and each has distinct characteristics.

Types of paints: There are different types of paints available in the market as per our requirement. They are as follows.

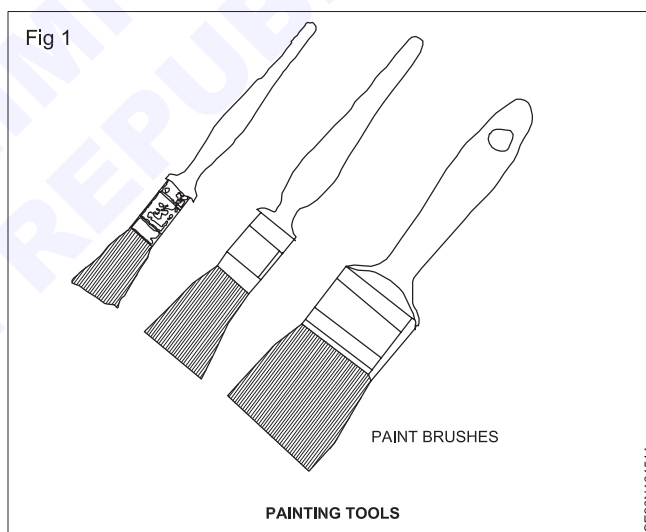
- 1 **Synthetic Enamel:** It is a solvent based paint which gives a long lasting glossy finish. It is recommended for interior usage on wood, metal and cement plaster surfaces.
- 2 **Acrylic Emulsion:** Acrylic emulsion paint is a water soluble fast drying paint made up of pigment suspended in acrylic polymer emulsion.
- 3 **Distemper:** Distemper is a decorative paint and a historical medium for painting pictures and contrasted with tempera.
- 4 **Epoxy:** Epoxy coatings are used over concrete floor in a variety of commercial and industrial applications such as in manufacturing plants, commercial and retail stores industrial plants, ware house, hospital, showrooms, garage, airplane, hangers etc.,
- 5 **Nitro cellulose:** The nitro cellulose paint is one of the longest lived modern pigments. It promoted the mass production of the automotive industry.
- 6 **Metallic paint:** Metallic paint is also called metal flake or polychromatic is a type of paint that is most common. On new automobiles.
- 7 **Texture paint:** Texture paint of heavy consistency and coarse grain consisting usually of gypsum and sand with water thinned binder and used for creating a rough patterned effect on a wall.
- 8 **Lime wash paint:** Lime wash is a finish that gets its textural veneer from added sand stone aggregate.
- 9 **Exterior paint:** Exterior house paint is made for painting the shingles or siding of your home not the walls of your living room. The best exterior paint for your project can improve your homes appearance.

Characteristics of an ideal paint

- It should possess 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.

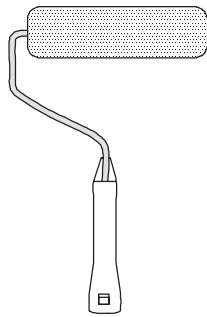
The different type of painting techniques are followed some of the familiar painting techniques are given below

By brush: The main brush techniques are (Fig 1)



- Use your little finger as a guide for straight confident lines.
 - Let the brush rest lightly on your finger then drag it towards you without any downward pressure.
 - Move the brush quickly and lightly in all directions.
- 2 **By roller (Fig 2):** The painting technique of using roller provides thin uniform and even coats and is an ideal tool for painting large, smooth and well prepared walls, ceilings and large furniture.
 - 3 **By spray gun (Fig 3):** The pneumatic sprayer are the best paint sprayer. It is very simple to use. They are cheaper than air less sprayer. While spraying base coat clear coat system the pressure to be maintained between 26-29 PSI.

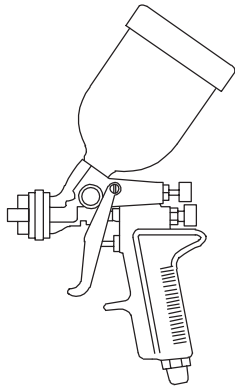
Fig 2



PAINT ROLLER
PAINTING TOOLS

CE20N16/512

Fig 3



GRAVITY FEED GUN WITH CUP ON TOP

CE20N16/513

surface forming a protective barrier varnishes provide wood with additional durability. So they are often used on areas that get plenty of wear and tear.

This type of varnish used for polishing wood work not exposed to the weather.

Types of varnishes

- 1 **Sprit varnish:** Sprit type of varnish gives a translucent finish thus showing the grains of the timber.
- 2 **Polyurethane varnish:** These type of varnish give a really hard surface and are often used for floors and areas which are going to get a lot of wear and tear.
- 3 **Oil varnish:** These type of varnishes are made by dissolving hard resins like amber or copal in oil.

They are suitable for exposed surfaces requiring polishing or frequent cleaning and for superior works.

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.

Varnish: Varnish provide protective coatings for window surfaces. Paintings and various decorative objects. Varnish protects and enhances the appearance of window floor interior wood paneling and trim, and furniture varnish requires on the outside of your

Damp proofing, materials, function and types

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

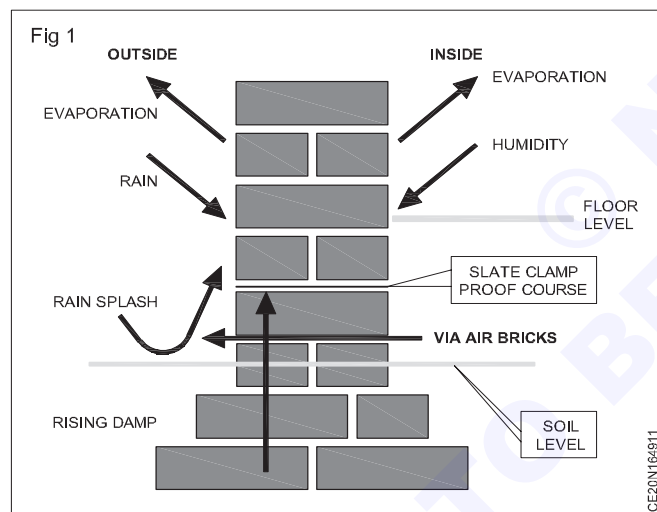
- define damp proofing, sources and effects of dampness
- describe the requirements of ideal damp proofing material and uses
- explain the function and types.

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.



Sources 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.

Materials for damp proofing

- 1 Bitumen
- 2 Mastic asphalt
- 3 Bituminous felt
- 4 Metal sheets (Lead, Copper, Aluminum)
- 5 Combination of sheets and felts
- 6 Stones
- 7 Bricks
- 8 Mortar
- 9 Cement concrete
- 10 Plastic sheet.

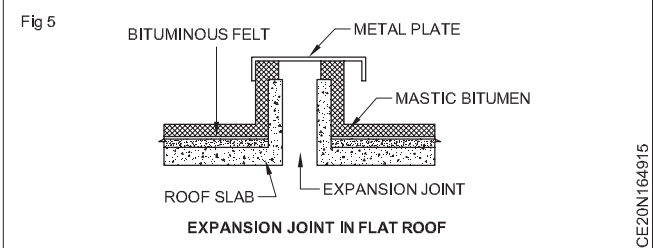
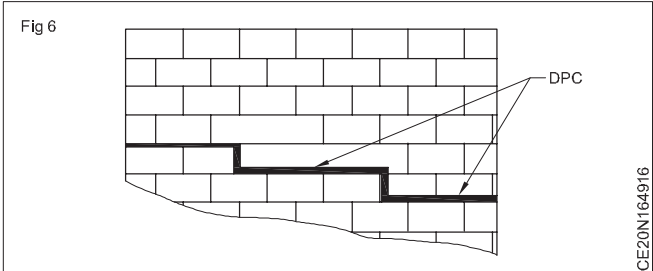
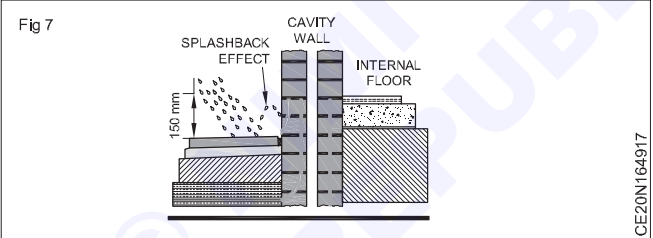
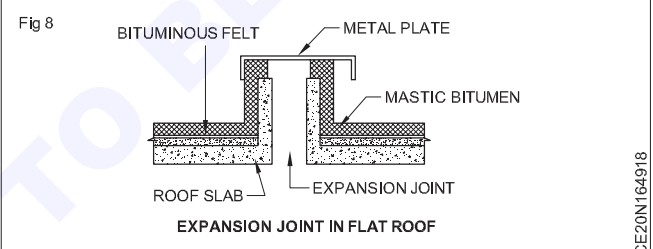
Damp proofing materials properties

- 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.

Function and types 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, talc 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 EXTERNAL WALL FLOOR CONCRETE DPC FLOORING GL 0000 FLAT BRICKS COURSE LEAN CONCRETE C.C. FILLET DAMP PROOFING OF AN EXTERNAL WALL CE20N164912
(ii)	Treatment to internal walls	Fig 3 FLOORING 300 COURSE OF FLAT BRICKS FLOOR CONCRETE 100 75 75 100 FLOORING C.C. FILLET C.C. CONC. FLOORING DPC FOR INTERNAL WALL CE20N164913
b	Treatment to foundations against gravitational water	Fig 4 INNER WALL C.C. CONC FLOORING 200 50 100 WALL TIES OUTER WALL DPC CAVITY GROUND LEVEL 300 500 600 700 800 100 100 100 200 1100 C.C. CONC FLOORING CAVITY WALL CE20N164914

c	Treatment to basements	Fig 5  CE20N164915
d	Treatment to sloping ground	Fig 6  CE20N164916
e	Treatment In pitched	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.
4	Cavity wall construction	Cavity in between two walls prevents the moisture from reaching the inner wall Cavity wall prevent the entry of dampness Fig 7  CE20N164917
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  CE20N164918
6	Grunting	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

Types of flooring

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

- **define the floor and purpose**
- **flooring materials & factors affecting the choice of flooring material and components of floor**
- **types of floors, method of claying, grinding, polishing of floor.**

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 it 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 and easy to give maintenance**
- 8 **Noiseless while using the floor.**
- 9 **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.

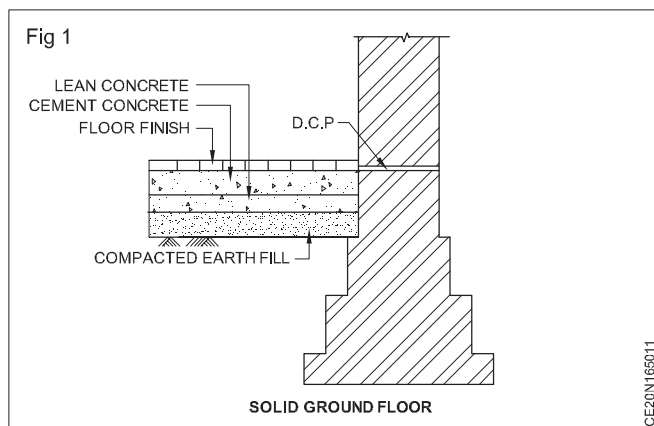
Floor covering: It provides a smooth, clean, impervious and durable surface.

Types of floor is mainly divided in to two:

- 1 Ground Floor
- 2 Upper floor

Ground floor (basement floor) (Fig 1)

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

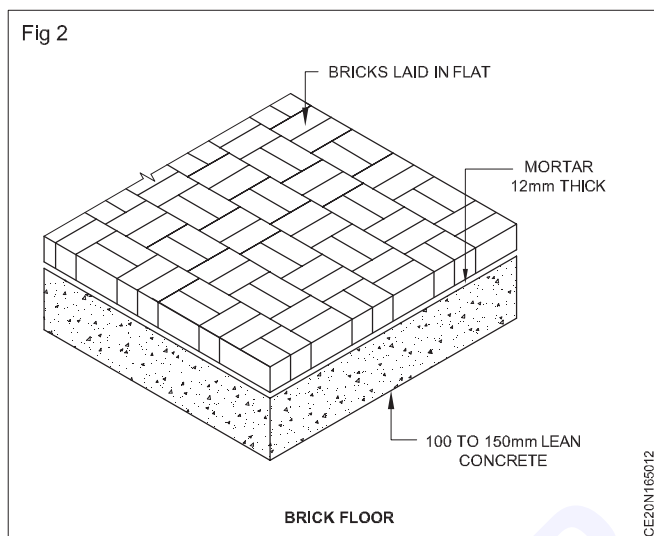
- 1 Such flooring is cheap, hard and fairly impervious.
- 2 Easy to construct and easy to maintain.
- 3 It has good thermal insulation property.
- 4 Over a well-prepared ground, a 25 cm thick selected moist earth (mostly impervious) is spread and is then rammed well to get a compacted thickness of 15 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.

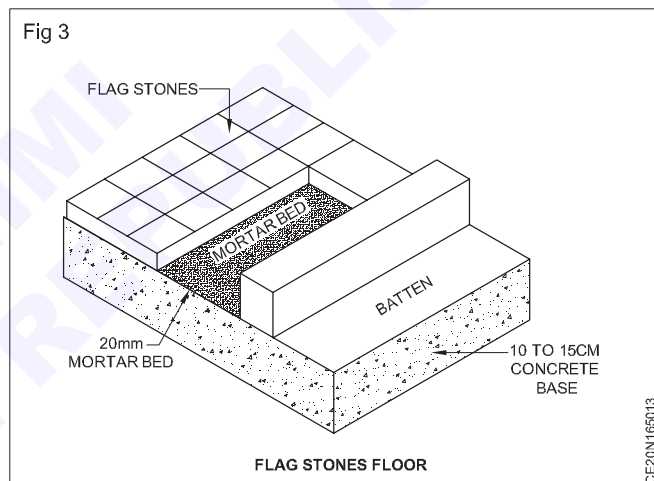
Brick floors (Fig 2)

- 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

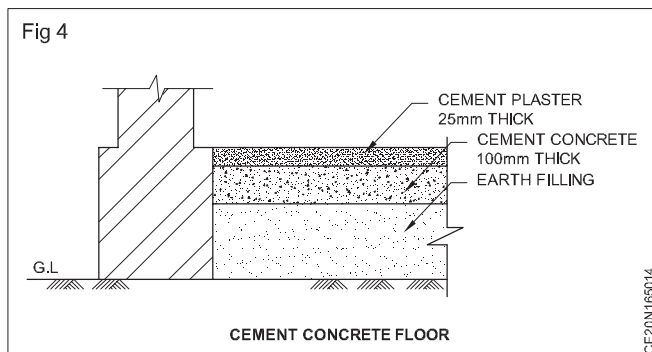
Flag Stone Floor (Fig 3)



- 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.

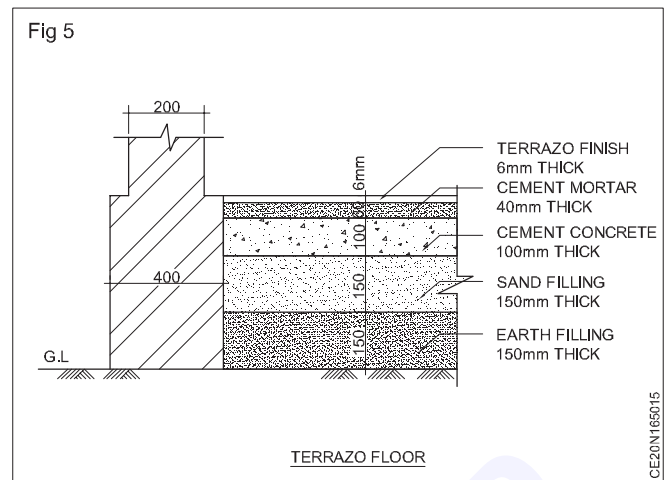
- 9 When the stone slabs are properly set, mortar in the joints is raked out to a depth of about 15 to 20 mm and then flush pointed with 1:3 cement mortars.
- 10 Proper slope is given to the surface for drainage.
- 11 The work is properly cured.

Cement Concrete floor (Fig 4)



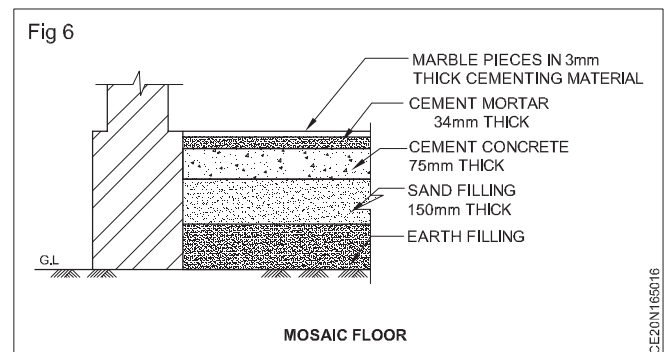
- 1 This is commonly used for residential, commercial and even industrial buildings.
- 2 It is moderately cheap, quite durable and easy to construct.
- 3 The floor consists of two components (1) base concrete, and (2) topping or wearing surface.
- 4 The base course may be 7.5 to 10 cm thick, either in lean cement concrete (1:3:6 to 1:5:10) or lean concrete containing 40% mortar of 1:2 lime – sand (or 1 lime: 1 Surkhi: 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, with the use of either glass or plain asbestos strips or with the 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)



- 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 marked 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 carbo random stone, second coat is done by finely grained carbo random stone.
- 7 Wax is applied as a final coat of polishing to get glossy surface
- 8 This floor is generally used for residential buildings, bath room, Clock rooms, etc.

Mosaic floor (Fig 6)



- 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.

- On this, a 3 mm thick cementing material, in the form of paste comprising two parts of slaked lime, one part of powdered marble and one part of puzzolana material, is spread and is left dry for about 4 hours.
- Small pieces of broken tiles or marble pieces of different colours are arranged in definite patterns and hammered into the cementing layer.
- The surface is gently rolled by a stone roller.
- Sprinkle water over the surface.
- Surface is allowed to dry for 1 day, and is thereafter, rubbed with a pumice stone.
- The surface is polished smooth.
- The floor is allowed to dry for two weeks before use.

Tiled floors

- Firstly, levelled hard bed or 15 cm thick P.C.C is prepared.
- Over this bed, a thin layer of cement mortar 1:1 is laid.
- Then pre cast tiles of cement concrete or pottery are laid over it carefully, filling the joints with mortar, which are generally paper thick.
- Extra cement is wiped off and joints cleaned with saw dust. After curing the surface is rubbed and polished.

Marble

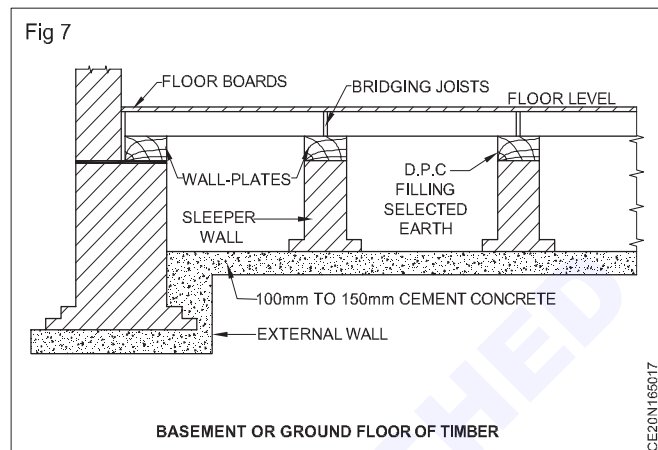
- It is a superior type of flooring, used in residential buildings, hospitals, sanatoriums, temples etc., where extra cleanliness is an essential requirement.
- Marble slab may be laid in different sizes, usually in rectangular or square shapes.
- The base concrete is prepared in the same manner as that for concrete flooring.
- 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.
- The marble slab is then lifted up, and fresh mortar is added to the hollows of the bedding mortar.
- 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.
- It is gently pushed with wooden mallet so that cement pastes oozes out. This is cleaned with cloth.
- The paved area is properly cured for about a week.

Granolithic floors

- It is a finished coat, which is provided over a concrete surface.
- The concrete mix used is 1:1:2 or 1:1:3. And aggregate used may be basalt, lime stone or quartz silt.

- The granolithic layer of concrete is laid before the base concrete is set to get a monolithic construction.
- The minimum thickness of finishing should be 12 mm.

Wooden floors (Fig 7)



- 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.
- These are also used in dancing halls, auditoriums, etc.
- 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

- The asphalt flooring can be carried out in a variety of colours and in different forms.
- 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.
- The asphalt terrazzo is formed by the combination of black or coloured asphalt with marble chips.
- This terrazzo is laid hot and the surface is made smooth by a trowel.
- The asphalt flooring is water-proof (no space), vermin proof, dustless and joint less.
- It is used for surface subjected to heavy wear as in case of dairies, breweries, hospitals, shops, restaurants, loading platforms, swimming pools, terrace etc.

Rubber floor

- It consists of sheets or tiles of rubber, in a variety of patterns and colours.
- The sheet or tile is manufactured by mixing pure rubber with fillers such as cotton fiber, granulated cork or asbestos fiber.

- 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.

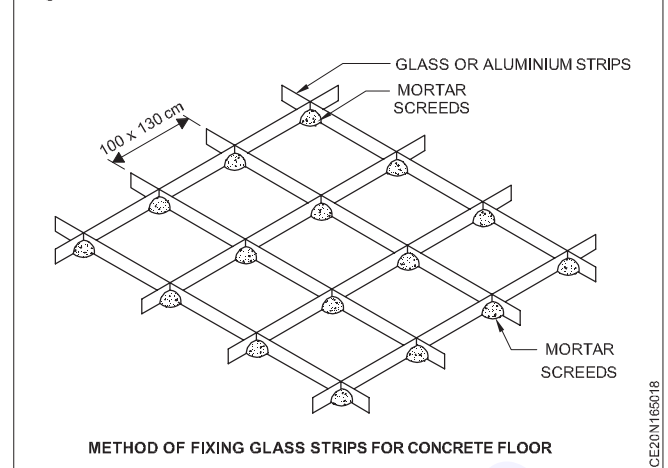
Cork floor

- 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.

Fig 8



- 2 Structural glass is available in the form of tiles or slabs, in thickness varying from 12 to 30 mm.
- 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 contact with burning objects.

Upper floors

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

- define the upper floor
- purpose
- 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.

Definition

The floors constructed above the ground floor are known as upper floors.

Purpose

To create more accommodation within 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.

Floors

Timber floors

- Single joint floor
- Double joint timber floor
- Framed or triple joist floor

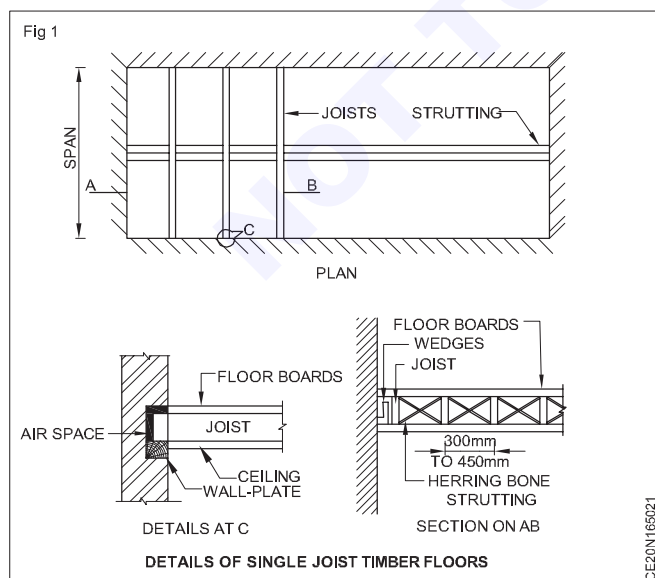
Composite floors

- Double flange stone floor
- Filler joist floor
- jack arch floor
- R.C.C floor
- Hollow block or rib floor
- Pre-cast concrete floor

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...

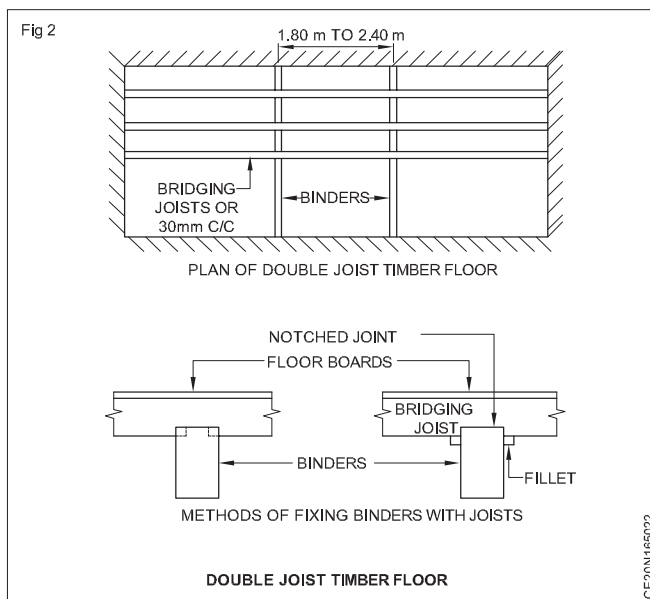
A Single joist timber floor (Fig 1)



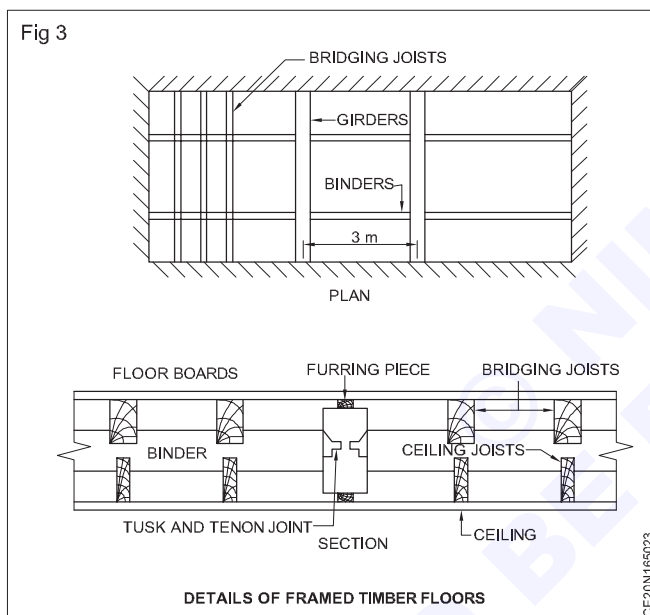
- It is adopted for maximum span of 3.6 m
- These floors consist of single joists which are placed below the floor boards.
- The joists are usually at a centre to centre distance of 300 mm to 450 mm.
- The joists are supported on wall – plates at their ends.
- When the span of joist exceeds about 2.4m, herring bone strutting is provided.
- Ends of these 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.



C Framed or triple joist timber floor (Fig 3)

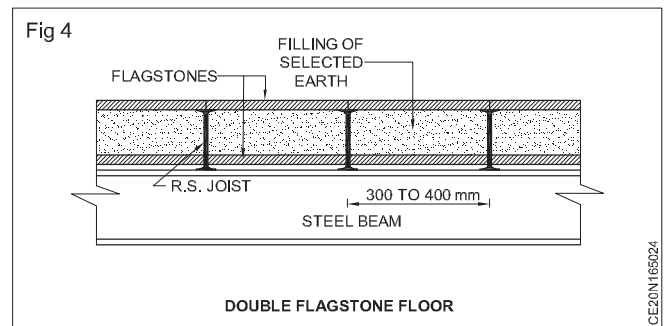


- 1 It is suitable for span greater than 7.5 m
- 2 In this type of floors, the intermediate support, known as the girders, are provided to support the binders.
- 3 The girders are placed at a centre to centre distance of 3 m.
- 4 The ends of binders are supported on iron stirrups which are fixed to the girders.
- 5 The ends of girders rest in walls on stone or concrete templates.

Composite floor

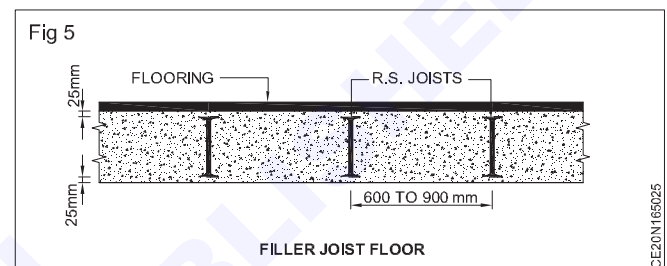
If floors are composed of more than one material, then they are known as composite floors. It is more fire resistant and sound proof than timber floor. It can be easily cleaned and possesses better hygienic property. It can be adopted for long spans.

A Double flagstone floor (Fig 4)



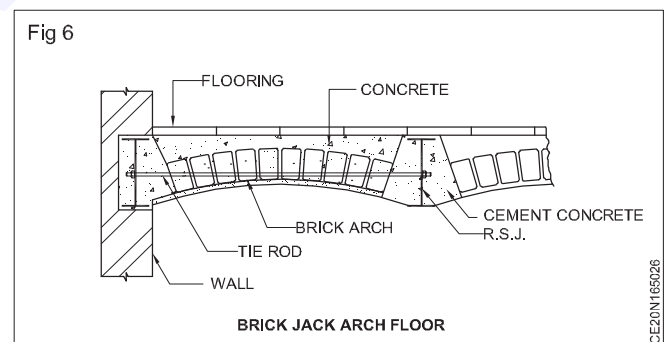
- 1 Flagstones of two layers are used.
- 2 If span is about 4 m only steel joists are provided.
- 3 Top layer of flag stone is finished.

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.

C Jack arch floor (Fig 6)



- 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.

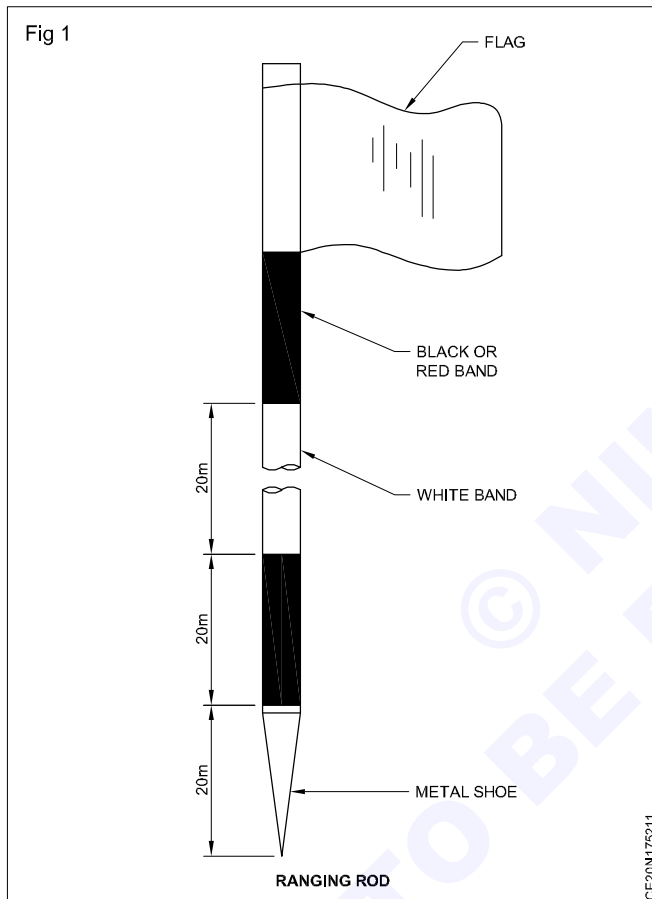
Introduction about chain survey instruments

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

- state the construction and uses of the following chain survey instruments.

- Ranging Rod
- Arrows
- Plumb bob
- Offset Rod
- Wooden Peg
- Measuring Tapes

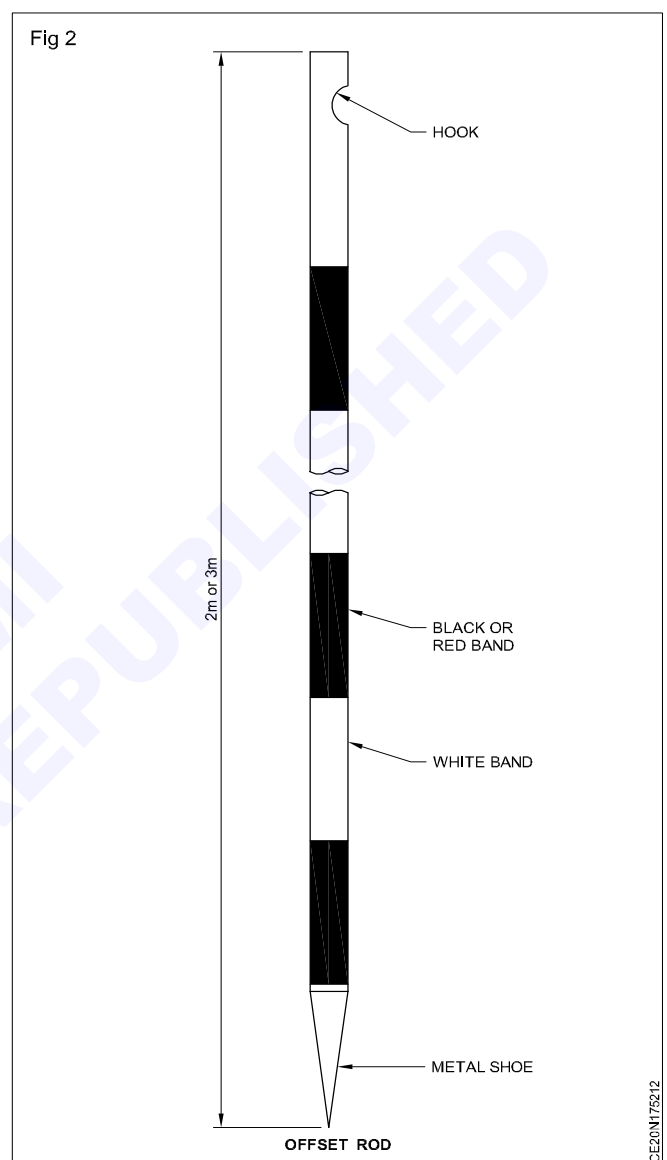
Ranging Rod (Fig 1)



- 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.
- It is also used for fixing intermediate points in ranging.

Offset rod (Fig 2)

- 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.

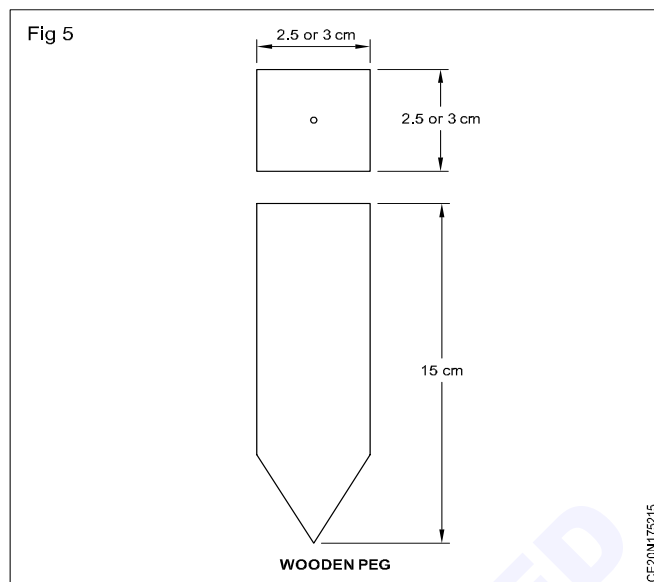
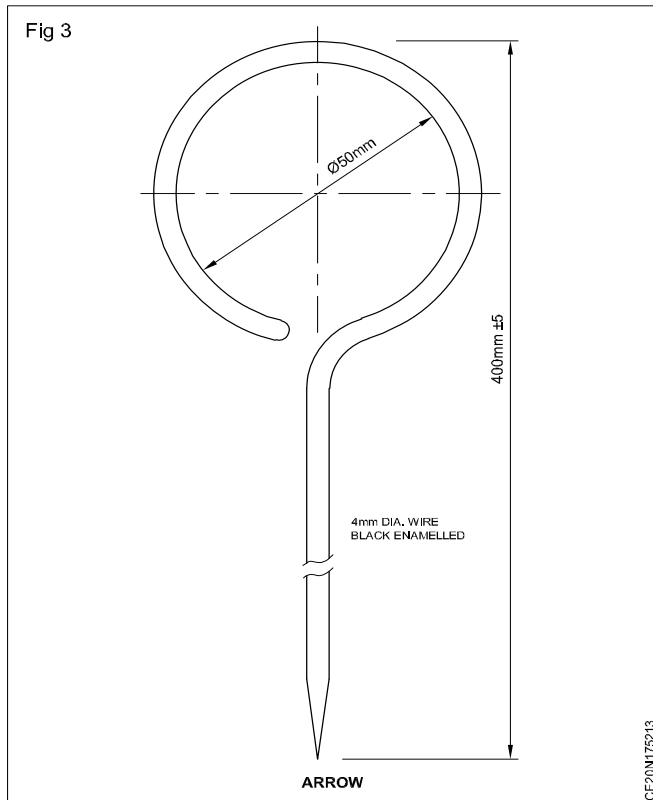


- It is also used for aligning offset line and measuring short offset.

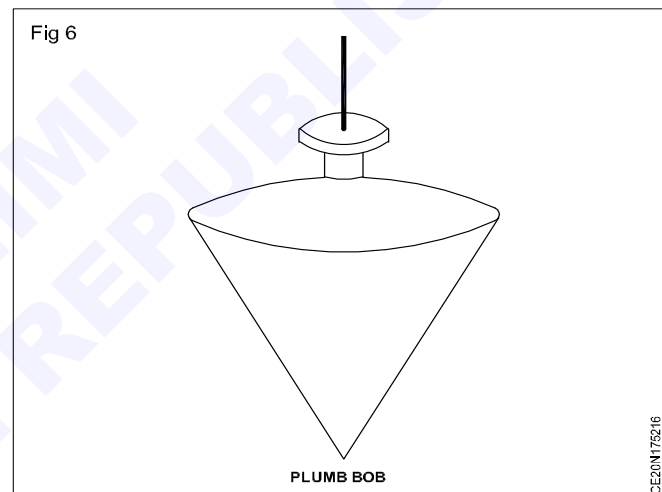
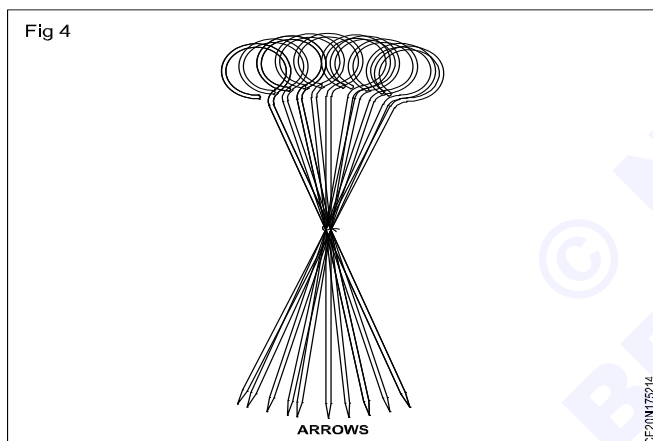
Arrows

- 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 have accompanied with 10 arrows as shown in Fig 4.
- It is used to mark the ends of each chain during the process of chaining.

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.



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.



Measuring tape : This is the instrument used for measuring distances.

They are made of

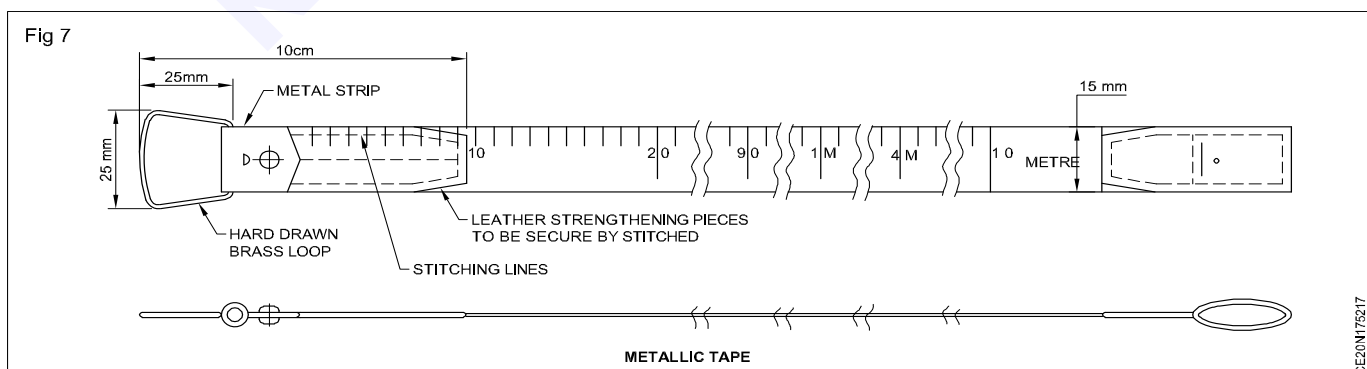
- 1 **Cloth or linen tape:** It is 12 to 15 mm wide and is made of linen cloth. It is available in length of 10m, 20 m and 30m. At the end of this tape provided with brass handle which is included in the total lengths of the tape.

It is easily affected by dampness.

It is used for taking measurement such as offsets.

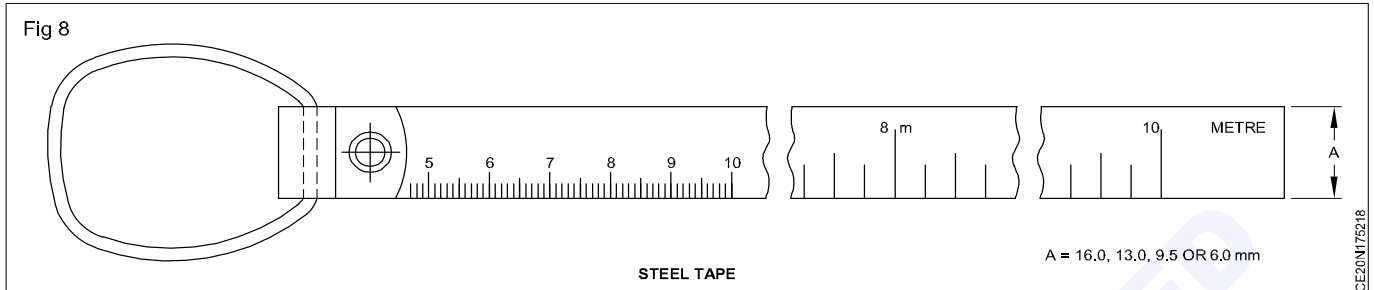
- 2 Metallic tape
- 3 Steel tape and Invar tape
- 4 Fiber or Plastic tape
- 5 Steel band

Metallic Tape (Fig 7)



- It is made up of linen and reinforced with fine brass or copper wire. It is covered in a leather case with winding device.
- It is available in 15m (50ft) and 30m (100ft).
- Each metre length is divided into 10 parts (decimetre) and each part is further subdivided into 10 parts (centimetre)
- The other side of the tape is graduated with feet and inches.
- It is commonly used for taking offsets in chain surveying.
- This cannot be used for taking very accurate measurement.

Steel Tape (Fig 8)



- It is made of steel ribbon varying in width 6mm to 16mm and available in 1m, 3m, 5m, 10m, 15m, 30m and 50m in length.
- Each meter is divided into 200 parts. (Each being 5mm) First 10 cm length of the tape is divided into millimeter.
- It is used for taking measurements and also used for testing chain lengths.

Steel Band

- 1 It is used for accurate work
- 2 It is lighter weight and easier to handle than the chain.
- 3 It is 20m or 30m long.
- 4 It is made from ribbon of steel 16mm wide.
- 5 The brass handles are provided at the ends of the chain with swivel joint.
- 6 It is wound on an open steel cross or a metal reel in a closed case.

- 7 The graduations are worked in two ways.
- 8 It is divided by brass studs at 0.2m and numbered at every 1m in the first portion and the last link is subdivided into cm and mm.
- 9 The graduations are etched as metres, decimeters and centimeters on one side and 0.2m links on the other side. Brass tallies are fixed at every 5 in length.

Invar Tape

- It is made of an alloy steel (64%) and nickel (36%) and available in 30m, 50m and 100m lengths.
- It is easily kinked and broken, so care should be taken while taking measurements.
- It has very low co-efficient of thermal expansion.
- It is only used for highest precision measurement like baseline in triangulation work.

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.

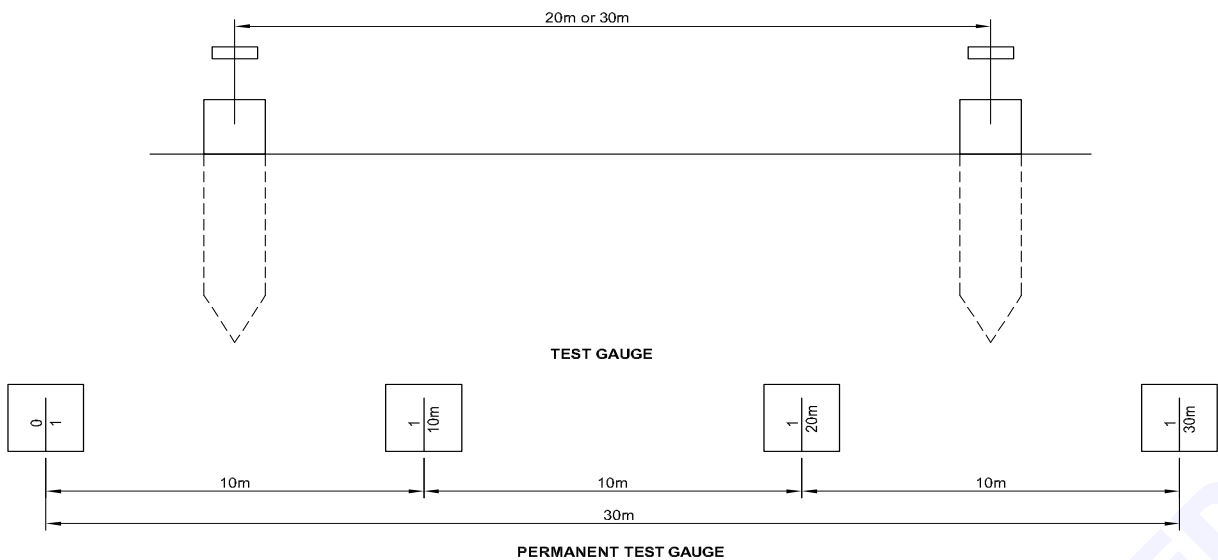
The length of chain decrease due to bending of the links and mud-sticking.

Therefore, it becomes necessary to check the chain before commencing the survey work. Before testing the chain, the bent up 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)
- 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.

Fig 1



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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 $\pm 2\text{mm}$ 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: $\pm 5\text{ mm}$

30m Chain: $\pm 8\text{mm}$

Adjusting the chain

- I** If the chain is found to be increased 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 be decreased 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 and chaining

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

- state chaining and chaining a line
- state unfolding the chain
- describe about 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

- 100 links in 20m chain
- 150 links in 30m chain

- 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 Figs 1-5.

Fig 1

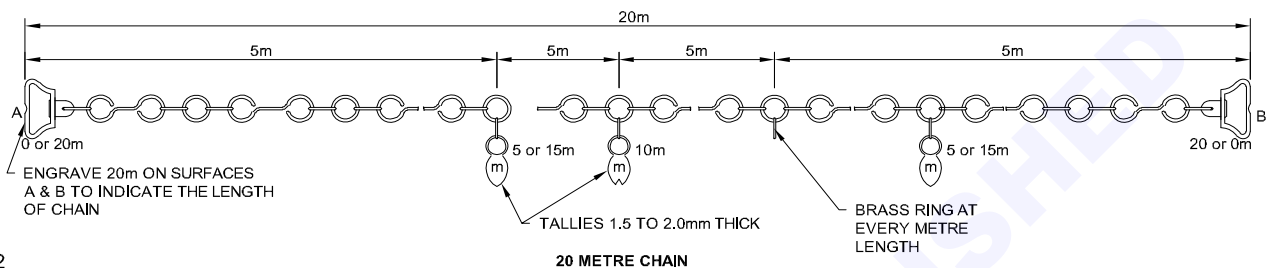


Fig 2

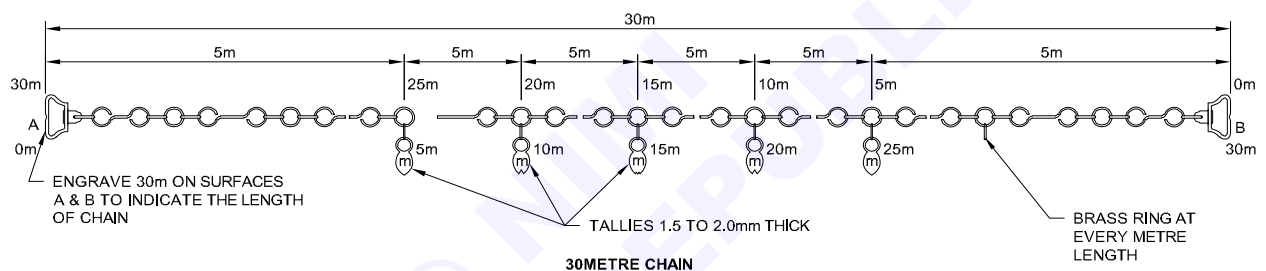


Fig 3

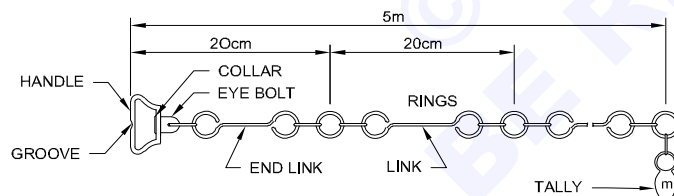


Fig 4

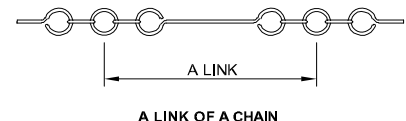
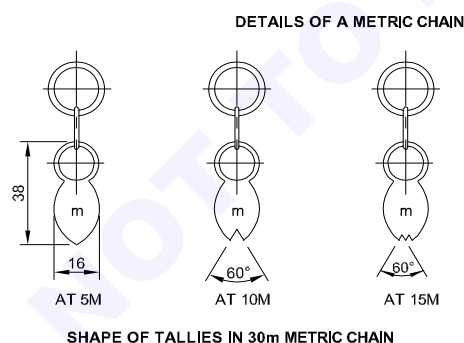


Fig 5



Chaining a line

For a chaining operation two chain men are required.

- The chainman 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

To drag the chain forward

To insert an arrow at the end of every chain

To obey the instructions of the follower

Follower

To direct the leader to be in line with the ranging rod at the end stations.

To carry the rear end of the chain ensuring that it is dragged above the ground.

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 one handle of the chain in his hand and moves forward 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 the number of full chain, if distance 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 tied up with a strip of leather.

Ranging

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

- state ranging
- state the necessity of ranging
- state the types of ranging
- interpret the signals by surveyor and the corresponding actions by his assistant.

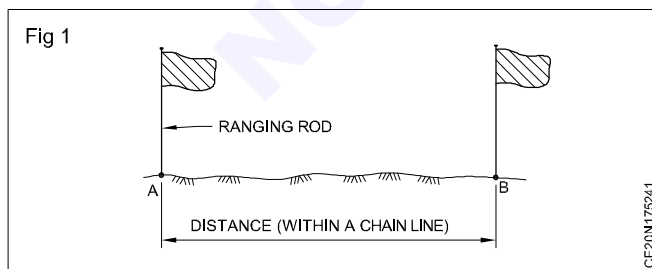
Ranging

The process of establishing intermediate points in line with the terminal points before chaining is known as ranging. This is necessary when the distance is longer than one chain length.

Necessity of ranging

To measure the length of a survey line also called a chain line, it is necessary that the chain should be laid out on the ground in a straight line between the end stations.

If the line AB is within a chain length or the end stations are clearly visible, it is easy to put the chain in a true alignment as shown in Fig 1.



But if the line AB is more than one chain length or the end stations A and B are not clearly visible, it is necessary to place intermediate ranging rods at M and N to maintain a straight line between the stations as shown in Fig 2.

Error in length due to incorrect chain

Correct or True distance =

(or)

In correct (or) measured distance ×

$\frac{\text{Incorrect length of chain or tape}}{\text{Correct length of chain or tape}}$

$$\text{True distance} = \text{Measured distance} \times \frac{L'}{L}$$

Where L = True length of chain or tape

L' = Incorrect length of chain or tape

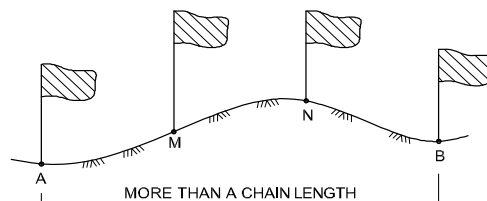
Error in area due to incorrect chain:

True area = Measured area × $(L' / L)^2$

Error in volume due to incorrect chain

True volume = Measured area × $(L' / L)^3$

Fig 2



Types of ranging

There are two types of ranging. They are

- Direct ranging
- Indirect ranging

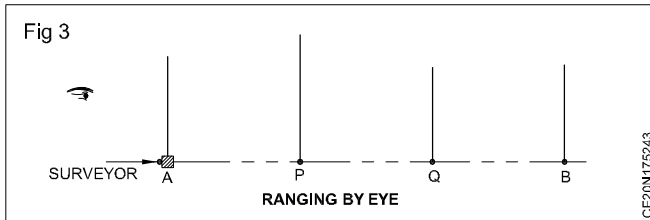
Direct ranging

When intermediate ranging rods are placed along the chain (in between the visible end) line by direct observation from either end station is known as direct ranging.

Direct ranging may be done either by eye judgement or by using line ranger but in important works theodolite is preferably used. Fig 3 shows A and B are the ends of a survey line and P and Q are the intermediate stations.

Indirect ranging (or) reciprocal ranging

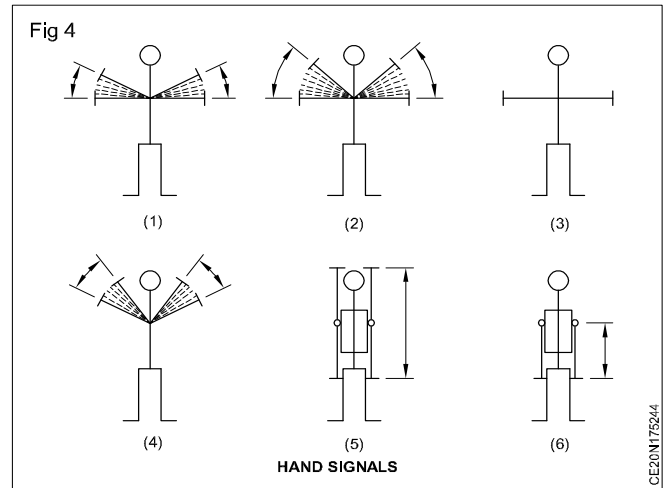
When the ends of the line are not interring visible due to high ground or a hill or a valley intervening, and also when the ends of a line are not distinctly visible from one another due to the distance being too great.



In this case, to fix the intermediate points indirect ranging is adopted.

Hand signals for ranging (Fig 4)

The following hand signals are used by a surveyor to direct the assistant to move to the desired position.



Sl. No.	Signal by the surveyor	Action by the assistant
1	Rapid sweep with right or left hand	Move considerably to the right or left.
2	Slow sweep with right or left hand	Move slowly to the right or left
3	Right or left arm extended	Move continuously to the right or left
4	Right or left arm up and moved to the right or left	Plumb the rod to the right or left
5	Both hands above head and then brought down	The position of the rod is correct
6	Both arms extended forward horizontally and then brought down.	Fix the rod

Offsets and offsetting

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

- state the meaning of offset and offsetting
- state the classification of offsets, its limits and its definition
- state the methods of taking offsets for various site conditions.

Offset

The lateral distance measured from the chain line to the object is called offset.

Offsetting

The process of measuring lateral distances from the chain line to the objects which are to be plotted is called as offsetting.

It is done to locate the objects with reference to the chainline.

These are measured on either side of a chain line.

Classification of offsets

Based on length of chain line

- Short offset
- Long offset

Based on direction of chain line

- Perpendicular offset
- Oblique offset

Limits of offsets

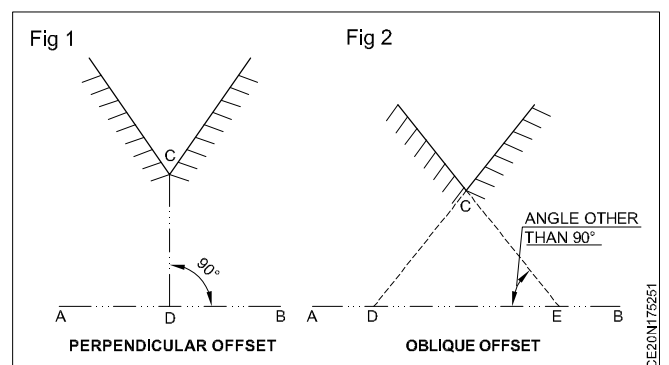
The length of offset depends upon the degree of accuracy required, scale used, method of setting out the perpendicular and nature of the ground. Hence the length of perpendicular offset should be within 15m

Short offset - Less than 15m

Long offset - More than 15m

Perpendicular offset

It is also known as rectangular offset or right offset. The distance measured at right angles to the chain line from the objects is known as perpendicular offset. (Fig 1)



Oblique offset

Offsets which are other than right angles to the chain line are known as oblique offset such as CD and CE in Fig 2.

This is taken when

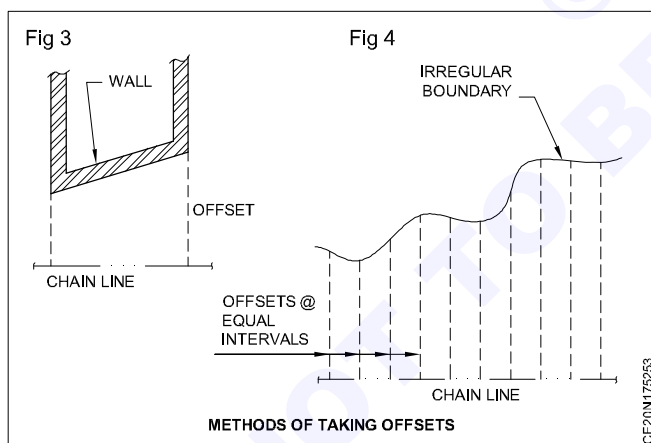
- The object is at a long distance
- accuracy is required.

Taking offsets

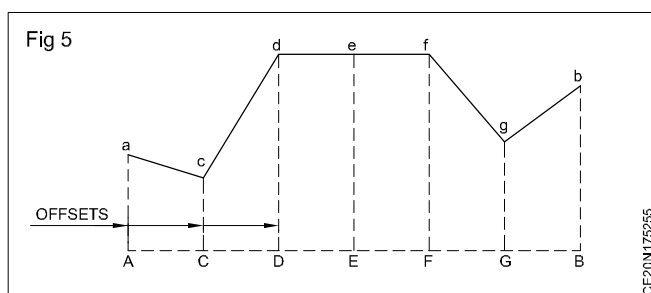
- The operation of taking and recording the distance on either side of a chain line is known as taking offsets.
- The measurement on the chain line is recorded as 'Chainage'
- Long offsets are measured with steel tape and short offsets are measured with metallic tape.
- When the offsets are short, perpendicular offset is laid by holding the zero end of the tape at the object and swing the tape over the chain to find the chainage.
- The minimum distance will be the perpendicular offset.
- When greater accuracy is required or the offsets are long, the right angles should be laid out with cross staff or optical square.

Methods of Taking offsets

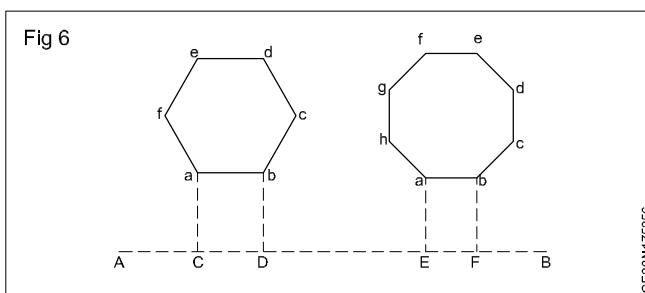
- An offset should be taken wherever the outline of an object changes.
- In case of straight wall or boundary, an offset should take at each end of the corner. (Fig 3)
- In case of an irregular boundary, sufficient number of offsets at suitable interval should be taken. (Fig 4)



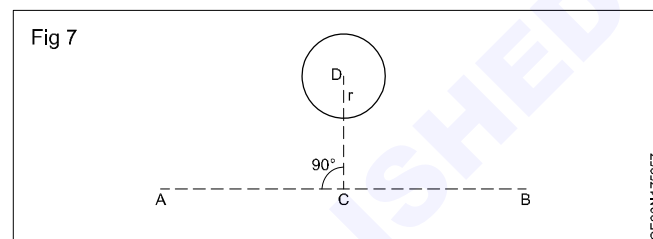
- Whenever the outline of the object changes its direction an offset, must be taken at each change of direction (Fig 5)



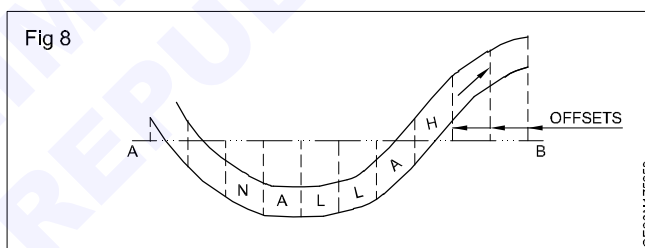
- In case of polygonal objects such as pentagon, Hexagon, Octagon etc., offsets should be taken at the ends of the side nearer to the chain line and the length of the sides (Fig 6)



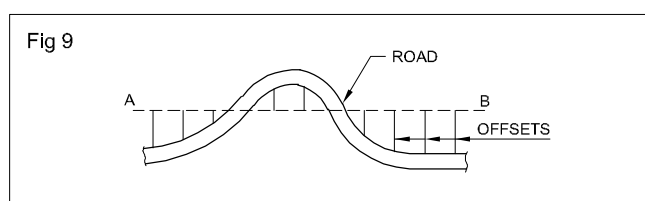
- In case of circular shapes, an offset should be taken to its centre and its radius should be measured. (Fig 7)



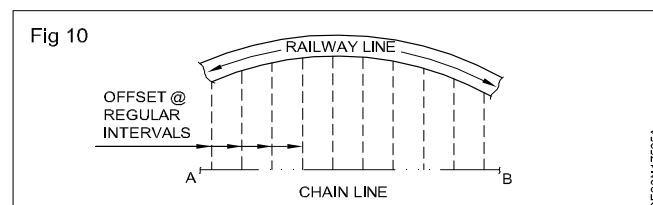
- In case if it is a stream offsets should be taken to both the sides of its width. (Fig 8)



- In case of roads or foot paths with constant width offsets should be taken at the beginning, middle and the end of the curve and a few points in between (Fig 9) width should also be measured.



- In case of fair curve such as railway line, offset should be taken at a regular interval and width should be measured. (Fig 10)



Field book

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

- name the two types of field book and explain.

Field book

The field measurements, sketches, notes are recorded for future reference in a notebook is called field book.

It is a rectangular notebook of size 20cm x 12cm and open length wise

There are two kinds of field book.

- Single line field book
- Double line field book

Single line field book

Single line field book is used for large scale survey and most detailed dimension work.

A red line is ruled down at the middle of each page.

This single line represents the survey line or chain line

The chainages are entered on the chain line.

Offsets are entered in the order they appear at the chain line.

Objects are sketched and offsetting distance are entered as shown in Fig 1.

Double line field book

Double line field book is used for all ordinary works.

Two blue lines or red lines are ruled down in the middle of each page.

The space between these two red or blue lines represents the chain line.

The chainages are entered in between these two lines.

Objects are sketched and offsetting distances are entered as shown in Fig 2

Booking Field notes

Following informations are recorded at the beginning of survey

- Date of commencement and completion of survey and names of surveyors.
- Symbol denoting the station point
- Details of survey lines.
- Location sketches of survey stations
- Name of the line (Say AB,BC)

Fig 1

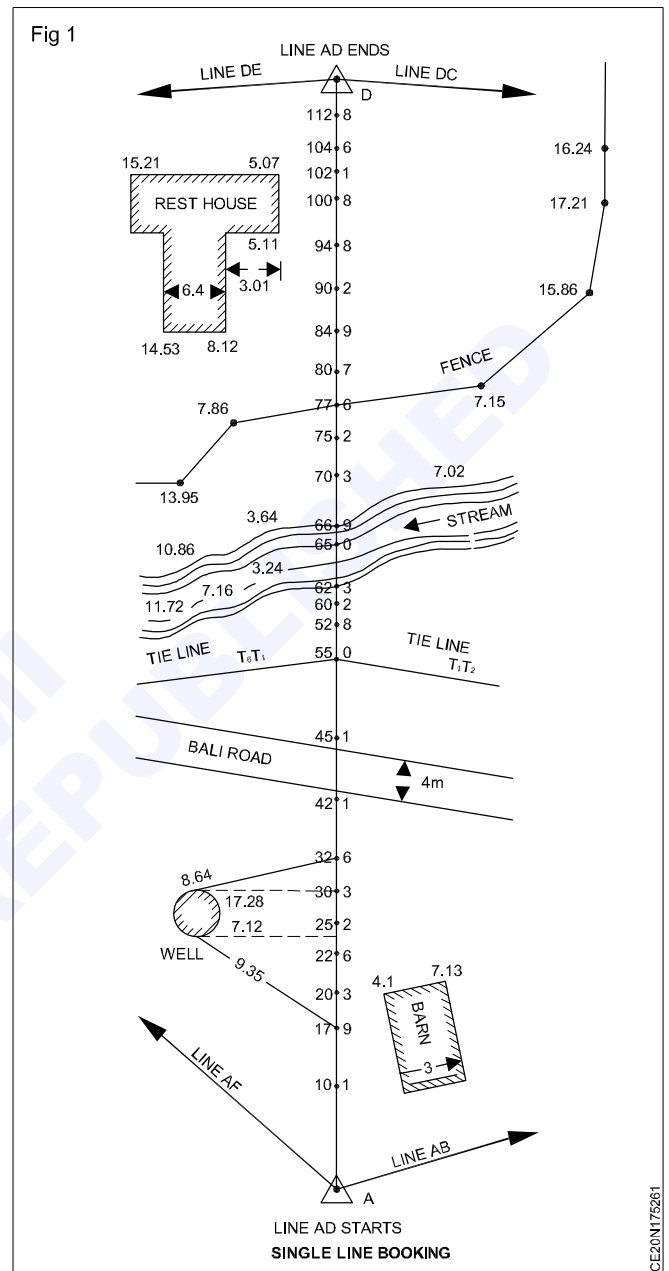
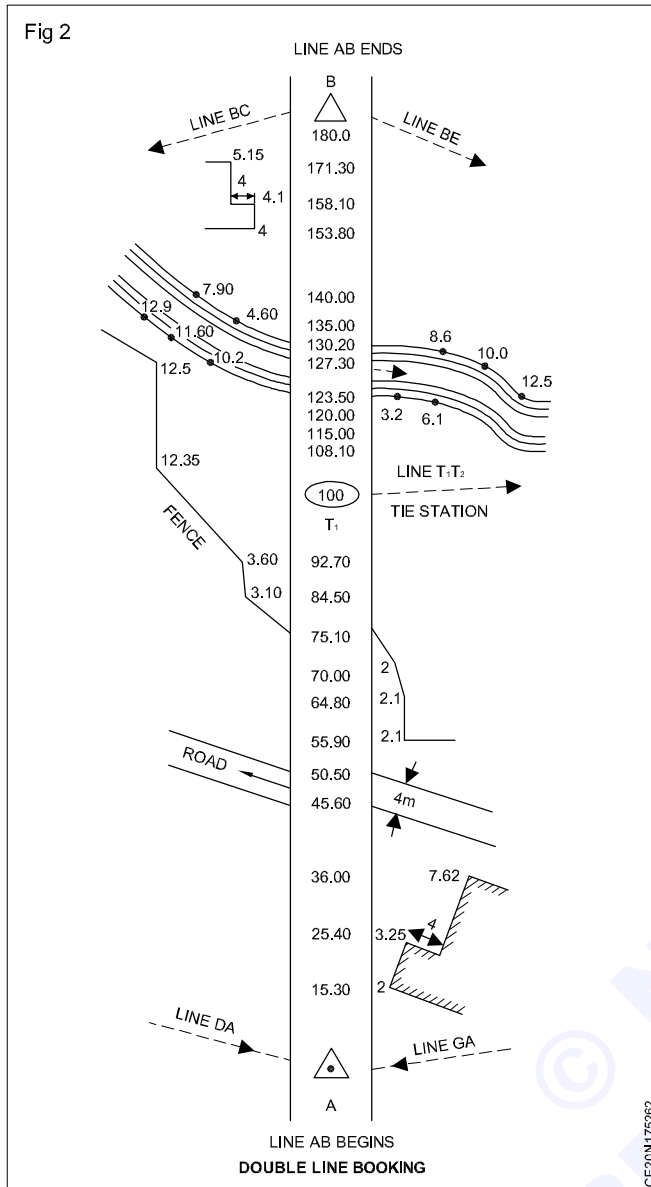


Fig 2



- Booking is commenced at the bottom of the page and worked upwards.
- Each chainline or tie line should be recorded in a separate page.
- The recorder should move in the forward direction of chaining.
- All measurements should be recorded immediately
- Wrong entries should be scored out and correct measurements should be written over the wrong measurements.
- If the entire page is discarded it should be crossed and marked as CANCELLED
- The offsetted objects are sketched with conventional signs (Fig 1 & 2) towards left or right of the central column.
- The sketches should be drawn proportionally
- Figures denoting the dimensions of the details of the objects should be included between the arrow heads.
- Numerals should be neatly and legibly written.

- Over writing should not be done.
- Offsets are written close to the points off setted and exactly opposite to and in line with the chainages.
- To avoid confusion sufficient space should be allowed between rows of booking.
- When objects such as fence, road, wall etc . crosses the chain line, the chain age of the point of intersection should also entered and direction should be noted.
- A symbol Δ is used to denote a main station.
- The zero chain age at the commencement and the closing chainage at the end of a line should written inside the Δ
- The name of the station should written close to the Δ .
- Tie or subsidiary stations should indicate by circles or ovals round the chain ages

Plotting of a chain survey

- Plotting work is started after the field work is over.
- The survey is plotted on the drawing sheet with a suitable scale.
- It should be plotted always north direction, so then the top of the drawing sheet represents north.
- The plotting should be always drawing on the centre of the sheet taking sufficient spaces for margin, title and scale.
- The base line is firstly drawn in its proper position.
- Intermediate stations are marked on the base line and complete the frame work of the triangles.
- The triangles are checked by check lines.
- For plotting offsets, mark the chainages of the points along the chain and from which the perpendicular offsets are marked by using an offset scale.
- The plotting of offsets should be continued according to the field book is maintained in the field book.
- The main stations and substations, objects, chain line are shown in accordance with the conventional signs.
- The heading should be written on the top of the drawing sheet.
- The map should not have any dimensions.

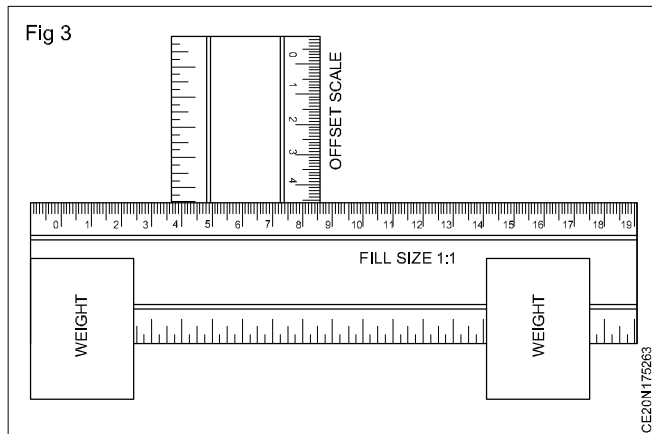
Offset scale (Fig 3): Using of offset scale for plotting perpendicular offset

- Put the long scale along the chain line, with its zero mark is exactly at the starting point of the line.
- The offset scale is placed at right angles to the long scale and moved to the required chainages. Then the offset lengths are marked with the help of the pricker.

Inking maps or plans

After completing and checking the plan, it is inked in. It is done to work from top of the plan downwards or from left or right. The inked in lines should be fair. Curved lines should

be inked first with the help of French curves after that straight lines should be inked.



Colouring

The following points should be considered in mind while colouring.

- Before commencing colouring clean the drawing thoroughly.
- Mix all colours in light and not too dark.
- Always mix more quantity of colour if one colour is required for the whole of the work.
- While colouring a drawing, the drawing board should be in a flat position to spread the colour evenly.

The following colours are used for the features shown

Features	Colours
Road metalled	Burnt Sienna
Road Unmetalled	Burnt amber
Compound wall	Indigo
Buildings	Crimson lake
Water	Prussian blue
Barren land	Burnt amber
Bench mark	Crimson lake
Truss	H green
Cultivated land	H green

North point

The north point must be shown on a plan in any convenient blank space on the paper preferably at the top pointing upwards

Scale

Scale should be drawn under the title or just inside the border at the bottom of the drawing.

Conventional signs & symbols

The earth surface contains varieties of natural and artificial features. If it is to be shown graphically, it will not be possible without its description. To overcome this difficulty standard symbols have been adopted for each type of details. The symbols which are drawn to natural or artificial details on a map is known as conventional signs.

Various signs used in Surveying.

Chaining on sloping ground

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

- explain the methods of chaining on sloping ground.

Methods of chaining on sloping ground

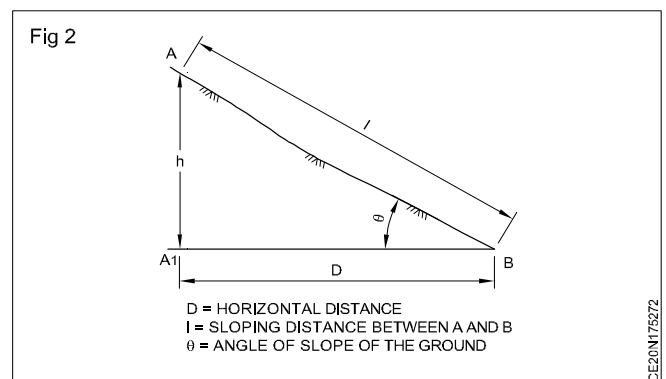
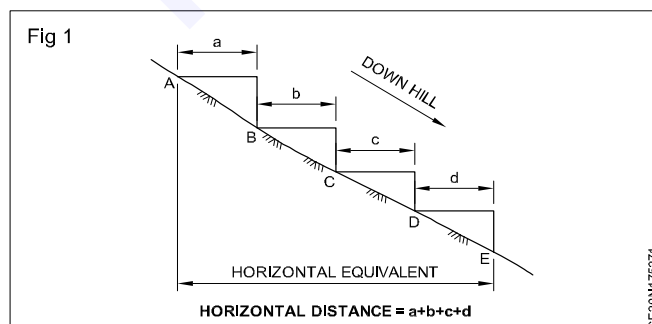
- Direct method
- Indirect method

Direct method

Stepping method (Fig 1): In this method the horizontal distance on sloping ground is directly measured.

Indirect method (Fig 2)

In this method the actual sloping ground is measured and the angle of slope is also measured by an angle measuring instrument.



Then the horizontal distance of the sloping ground is calculated by using the given formula.

Horizontal distance, $D = A_1B = I \cos \theta$.

Necessity of calculating horizontal distance:

Actually the distances measured on a sloping ground are inclined distance. This will be more than the horizontal distance for plotting purpose only horizontal distance (D) is taken into account.

Hence all the sloping distances are converted into a horizontalequivalent.

Calculating the area of site

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

- calculate the area of an irregular field
- apply geometrical formulae for calculating the area.

Calculation of the area of an irregular field

In this survey the area of plot may be determined by the direct use of field notes.

In this method of survey, a chain line known as base line to be laid through the centre of the area of the field.

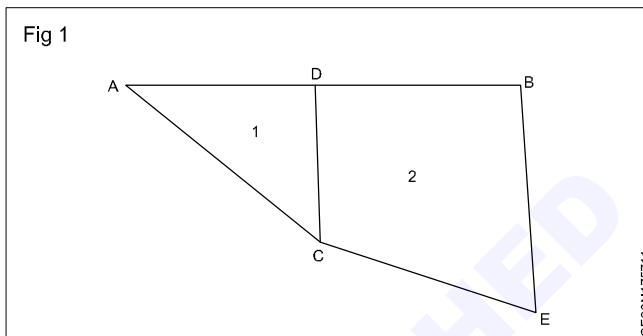
The offset is taken to the boundary points in the order of their chainages on both the sides of the base line.

The chainages and offsets are entered in the field book.

With reference to the field book the boundary points are plotted and the area to be divided into number of triangles and trapezium according to the shape.

Application of geometrical formulae for calculating the area

Now apply the geometrical formulae for calculating the area according to the shape of the figures. (Fig 1)



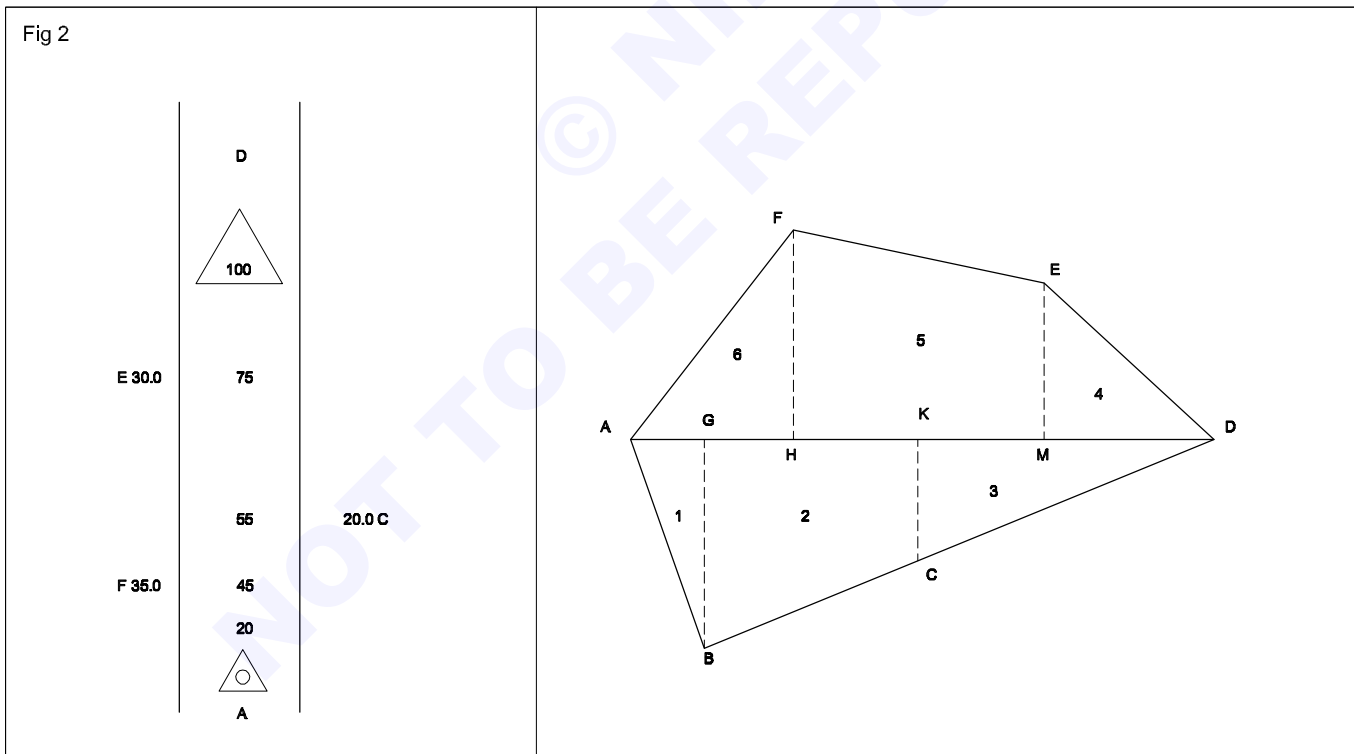
1 Area of triangle

$$\frac{1}{2} \times \text{base} \times \text{height}$$

2 Area of trapezium

$$\text{base } (a+b) / 2 \times \text{height}$$

Plot the following details of a field and calculate its area. All measurements are in metres (Fig 2)



Serial No. 1 In $\triangle ABG$

Chainage in metres 0 and 20m.

Offsets in metres 0 and 36m.

In $\triangle ABG$

Area = $\frac{1}{2} \times \text{base} \times \text{height}$

$$= \frac{1}{2} \times 20 \times 36$$

$$= 360 \text{ sq.m}$$

Area of trapezium GBCK

Chain age in metres = 2m and 55m = 35m

Offsets in metres 36m and 20m = 28m

$$= 35 \times 28 = 980 \text{ sq.m}$$

Sl. No. 3

Area of triangle KCD
 $= 45\text{m} \times 10\text{m} = 450 \text{ Sq.m}$

Sl. No. 4

Area of triangle DME $= 25 \times 15 = 375 \text{ sq.m}$

Sl. No. 5

Area of Trapezium $= 30 \times 32.50\text{m} = 975.00 \text{ sq.m}$

Sl. No. 6

Area of triangle AHF $= 45 \times 17.50 = 787.50 \text{ sq.m}$

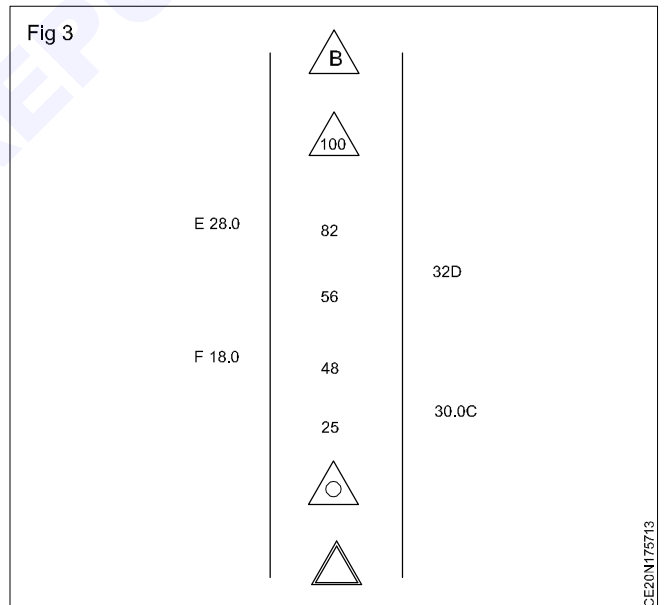
S. No.	Figure	Chainage in metres	Base in Metres	Offsets in metres	Mean offsets in metres	Area in square Metres		Remarks
						+ve	-ve	
1	2	3	4	5	6	7	8	9
1	$\triangle ABG$	0 and 20	20	0 and 36	18	360.00	—	
2	Trapezium GBCK	20 and 55	35	36 and 20	28	980.00	—	
3	$\triangle KCD$	55 and 100	45	0 and 20	10	450.00	—	
4	$\triangle DME$	100 and 75	25	0 and 30	15	375.00	—	
5	Trapezium	75 and 45	30	30 and 35	32.50	975.00	—	
6	$\triangle AHF$	45 and 0	45	35 and 0	17.50	787.50	—	
Total						3927.50		

Exercise

The same exercise may be used by planimeter and find the area.

Exercise 1, (2)

The following readings were taken in the field. Plot and calculate its area. All measurements in metres. (Fig 3)



Preparing site plan and Knowledge of mouza map

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

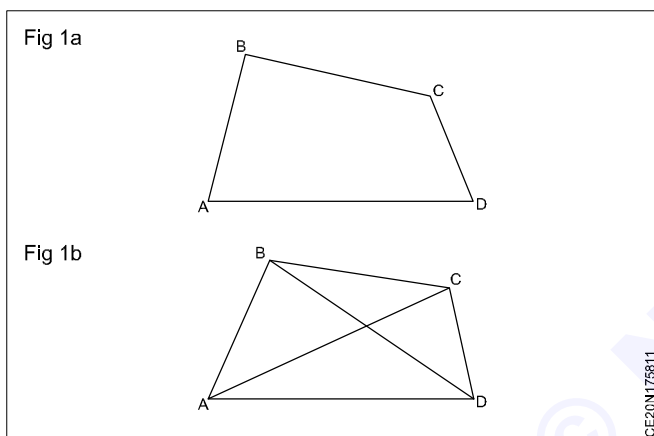
- define the triangulation and traverse in survey
- state closed and open traversed survey
- state the three types of survey lines in triangulation
- explain about field work
- knowledge of mouza map.

General Information

As a surveyor, you will not able to plot the Fig 1a without anyone of the angular measurements.

You can able to plot the same figure without any angular measurements, if the length AC and BD is given. (Fig 1b)

Fig 1a is converted into number of triangles as in Fig 1b.



A triangle is the simplest plane figure, which can be drawn without any angular measurements.

Hence the area to be surveyed is divided into a network of triangles.

Triangulation

The method of dividing the whole area to be surveyed into network of triangles and the sides of all the triangles are measured directly in the field and no angular measurements are taken is known as Triangulation survey.

Traverse

A series of connected survey lines of known lengths and directions is called as traverse. The survey lines are measured with chain or tape and directions are determined with angular instruments. It is of two types. They are closed traverse and open traverse.

Frame work

The lines or the triangles covering the whole area to be surveyed is called frame of work such as ABCD in Fig (1a,b)

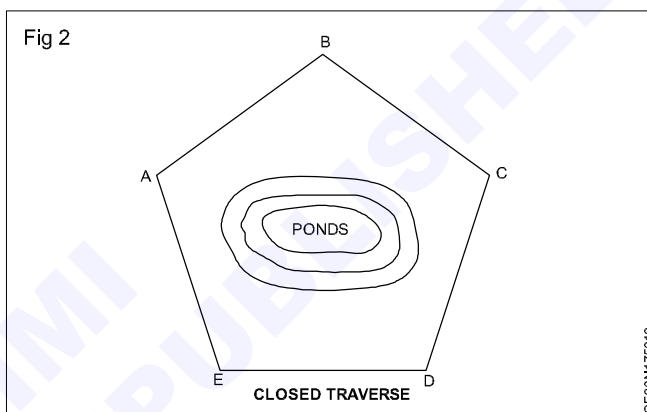
According to the nature and shape of the area of the triangles are to be arranged.

When forming triangles in a chain survey, the angle between the triangles should be selected more than 30° and less than 120° . This process of forming triangles are called as well conditioned triangle.

The angles formed in a chain survey should be an equilateral one which is best suited for plotted work.

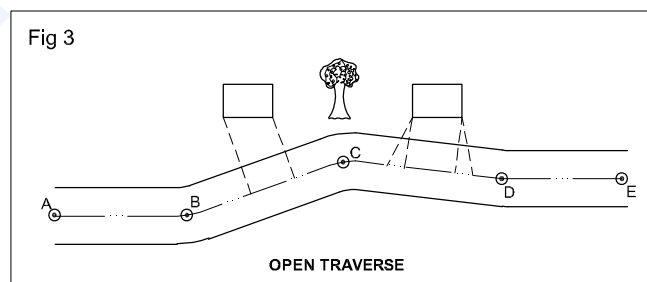
Closed traverse (Fig 2) : When the finishing points of the survey coincides with the starting point of the survey is known as a closed traverse.

It is suitable for the survey of boundaries of forests, ponds, estate, lakes etc.



Open traverse (Fig 3): It consists of series of survey lines extending in the same direction and not returning to the starting point.

It is suitable for the survey of road, railway, river, coast line etc.



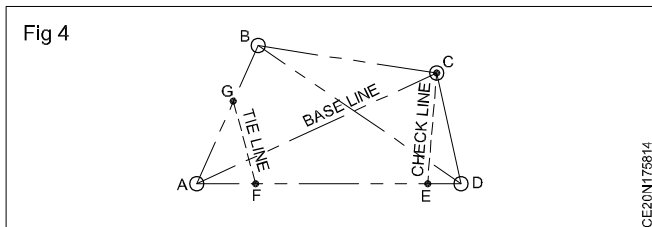
State the three types of survey lines in triangulation

To conduct a Triangulation survey stations are to be established.

- The beginning and end points of a chain line is called as survey stations. Stations are denoting as .
- Stations are divided into main stations and Tie station or subsidiary station.
- The stations connecting boundaries of the area are called as main stations (in Fig 4, A,B,C,D)
- The stations other than main stations are called as Tie stations.

Baseline

The longer line of the chain line is considered as baseline is AC (in Fig 4) From this line the chainages and offsets are taken.



The accuracy of the whole survey is mainly based on the accuracy of this line.

Baseline should be decided in such a way that it should divide the whole area approximately equal on both sides of chain line.

Check line/Proof line

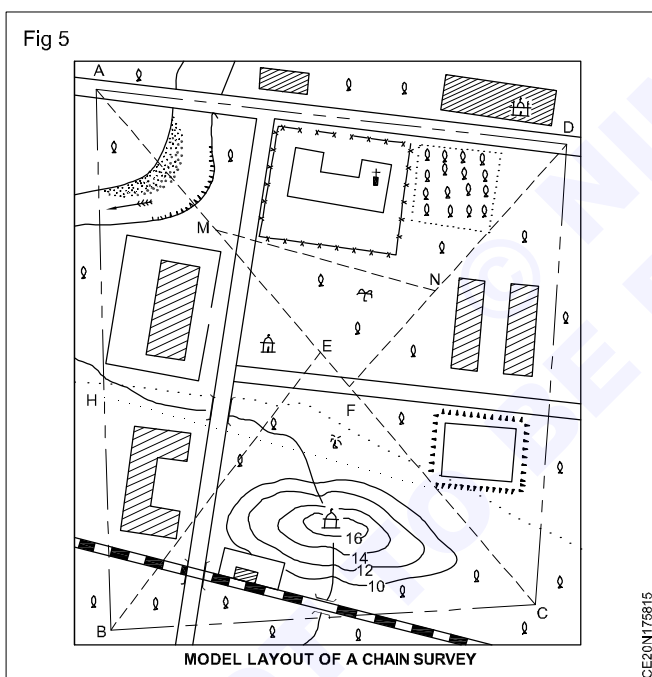
A line joining the apex of a triangle 'C' and a fixed point on the opposite side 'E' (In Fig 4) CE is the check line.

It is used to check the accuracy of the frame work

Tie line: A line joining some fixed points on any two lines in a main survey line is known as tie line. (FG in Fig 4)

It is used to check the accuracy of framework to locate the interior details which are far away from main lines.

Fig 5 shows a model layout of chain survey.



Field work

It consists of

- 1 Reconnaissance
- 2 Marking and fixing stations
- 3 Reference sketches
- 4 Running survey lines

Reconnaissance

The preliminary inspection of the whole area of the site to be surveyed is known as reconnaissance.

It is always essential to fix survey stations for running survey lines and taking details.

Hence the surveyor should walk over the whole area to examine the ground and decide about for laying survey lines.

A key plan also being prepared.

Marking and fixing stations

After preparing a key plan the survey stations are fixed by driving a wooden pegs or nails.

Wooden pegs are used in soft ground and for roads or hard surface nails may be used for fixing on the ground.

Reference sketches

Each and every survey stations are referred with some permanent points.

These permanent points to the survey stations are located by measurement and made with reference sketches.

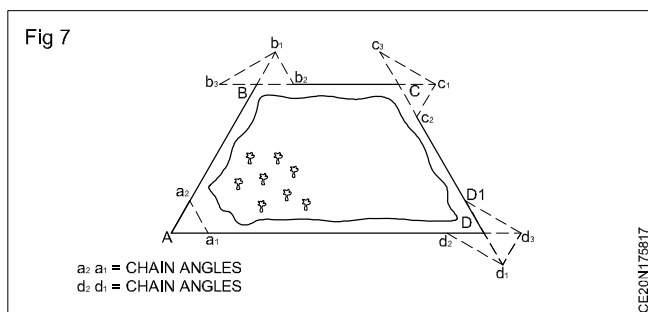
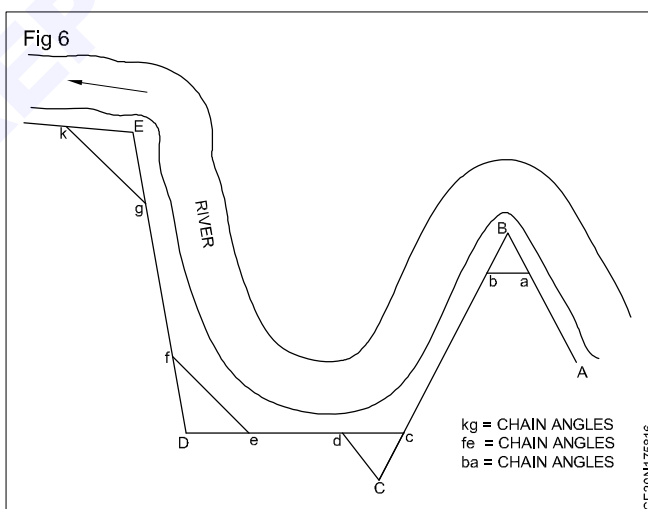
These are very useful to refix a survey station when it is displaced or lost.

Running survey lines

Survey lines are then laid in between the survey stations and details should be taken by offsetting method.

Chain angles

In a chain traversing the entire work is done only by a chain or tape without having angular instrument is known as chain angle method. It is to be done when the area cannot be divided into triangles such as river, nalla, standing crop etc. (Fig 6 and 7)



Knowledge of mouza map

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

- describe about mouza.

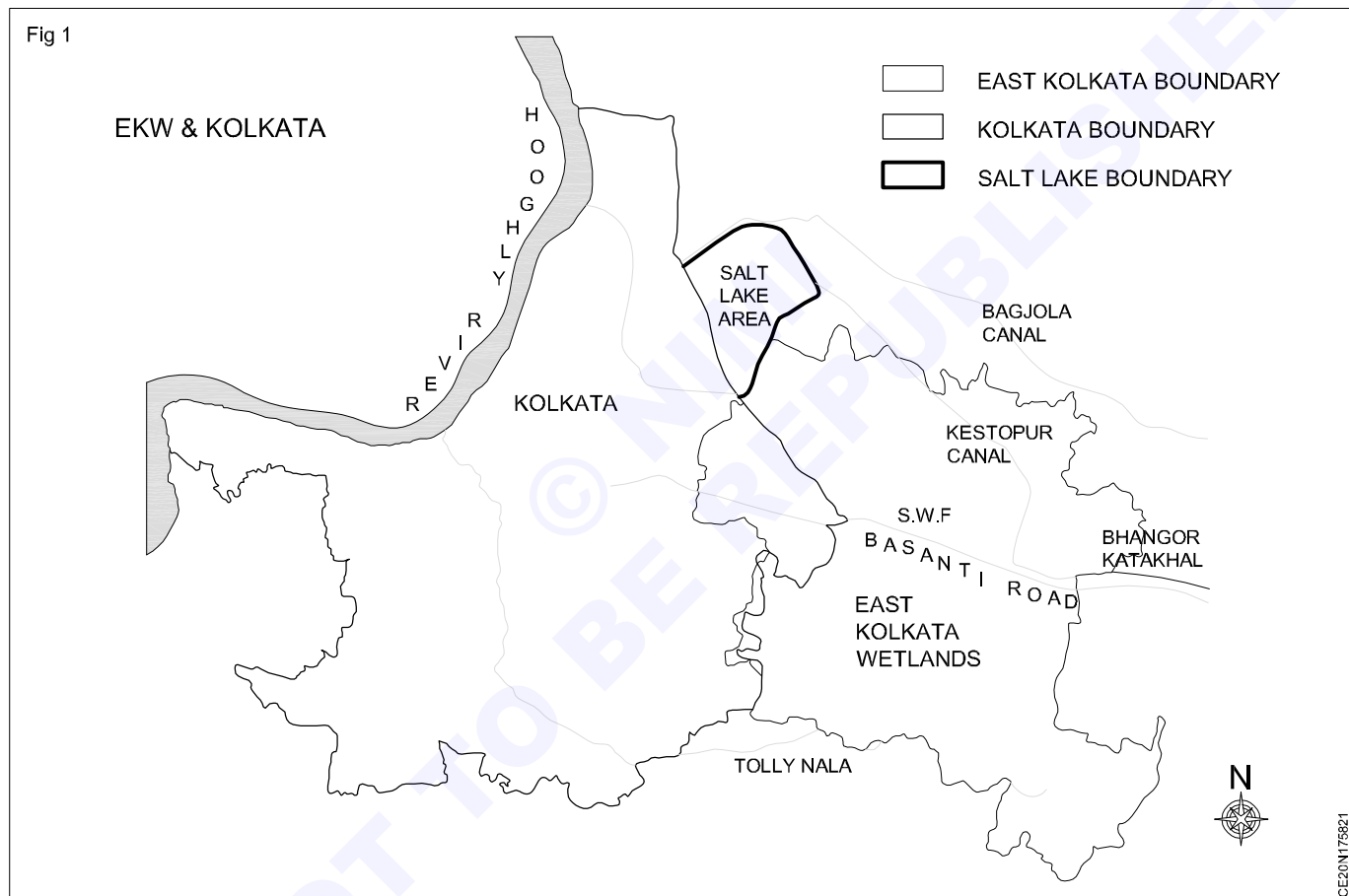
Mouza

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 term 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)



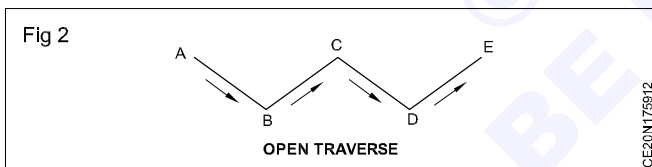
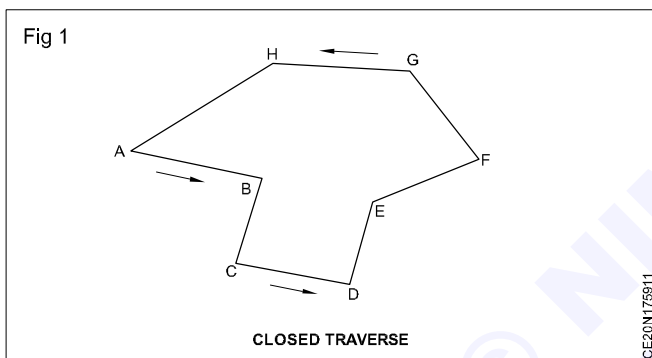
Identification and parts of instruments in compass survey

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 surveyors 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)



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.

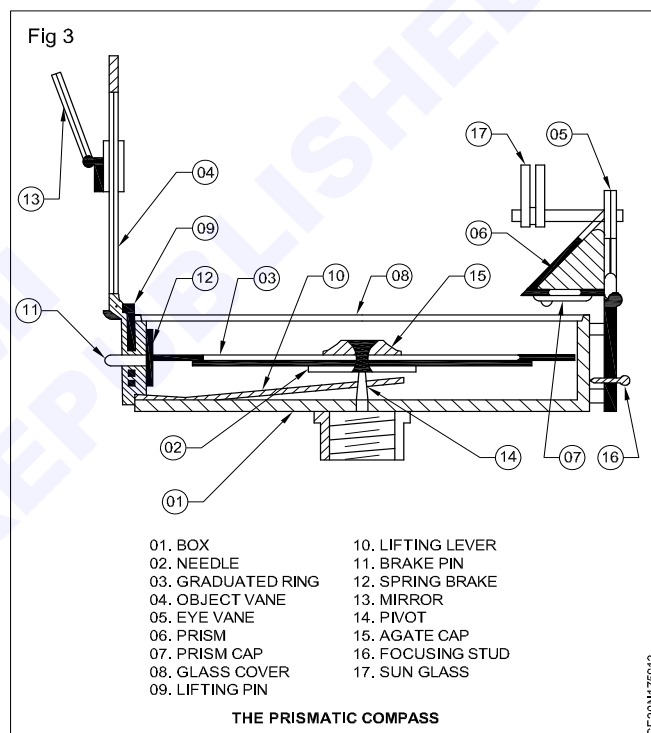
The compass cannot measure the angle directly. If it is desired to find out the angle between the two lines, firstly their angles with the magnetic meridian are determined separately and the difference of the two values is found which is equal to the angle between the lines.

Types of Compass: The two forms of the compass commonly used are:

- 1 The prismatic compass
- 2 The surveyors compass

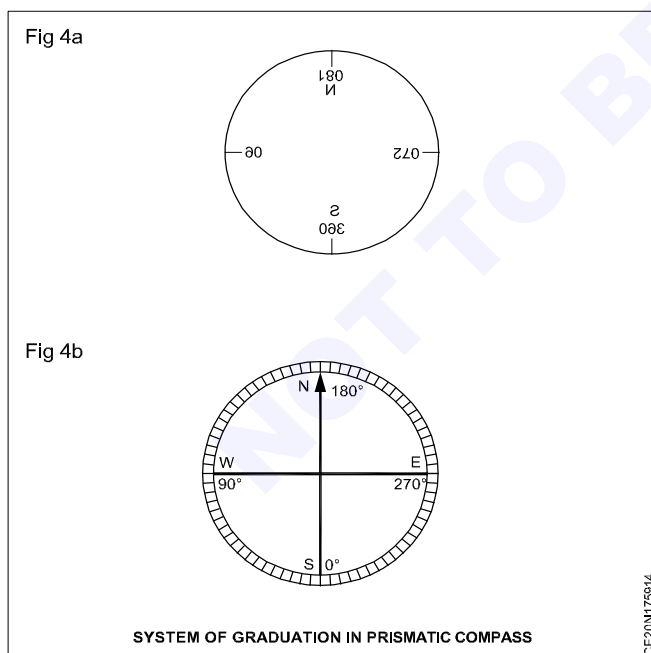
The prismatic compass: It is the most convenient portable magnetic compass, which can either be used as a hand instrument or can be fitted on a tripod. The main parts of prismatic compass are shown in Fig 3.

Construction (Fig 3)



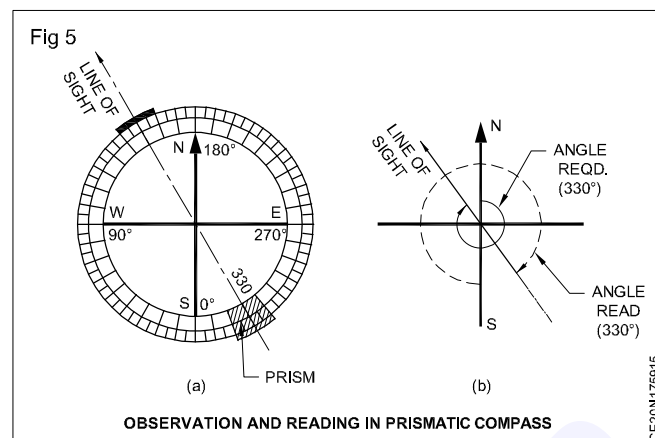
- The prismatic compass consists of cylindrical metal box (1) of 8cm to 12 cm diameter in the centre of which is a pivot (2) carrying a magnetic needle. (3) which is already attached to the graduated aluminum ring (4) with the help of an agate cap (5)
- The ring is graduated to half a degree and is ready 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 figs are written upside down as in Fig (4b)

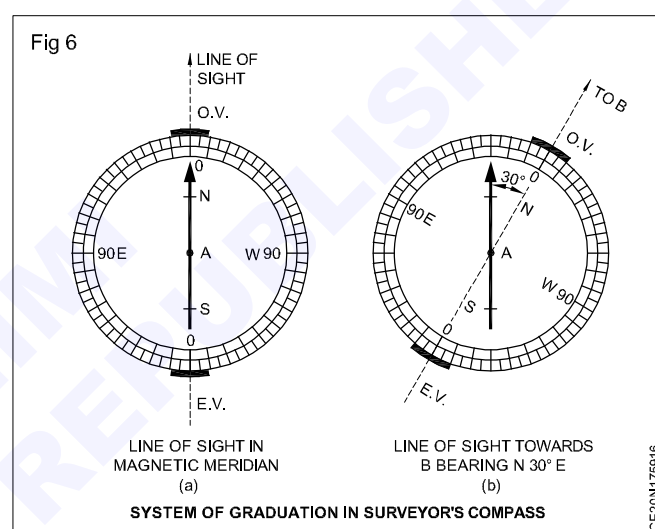


- The greatest advantages of prismatic compass is that both sighting the object as well as reading circle can be done simultaneously without changing the position of the eyes.

The bearing shows 330° at the observer's end under the prism (i.e. at the south end) (Fig 5)



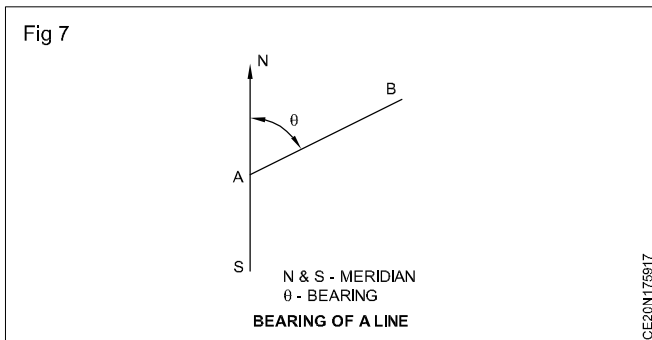
Surveyors compass: It is similar to prismatic compass except with a following few modification (Fig 6)



- The graduated ring is directly attached to the circular box and not with the magnetic needle.
- 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 quadrantal system of having 0° at north and south ends, 90 at East and west ends. Fig 6a shows when the line of sight towards 'B' and the bearing is N 30° E shows Fig 6b.

Bearing of a line: It is the horizontal angle which a line makes with some reference direction also known as meridian. The reference direction may be any of the following (Fig 7)

- True meridian
- Magnetic meridian
- An assumed meridian



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 arbitrary meridian: Arbitrary 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.

Arbitrary bearings: Arbitrary 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.

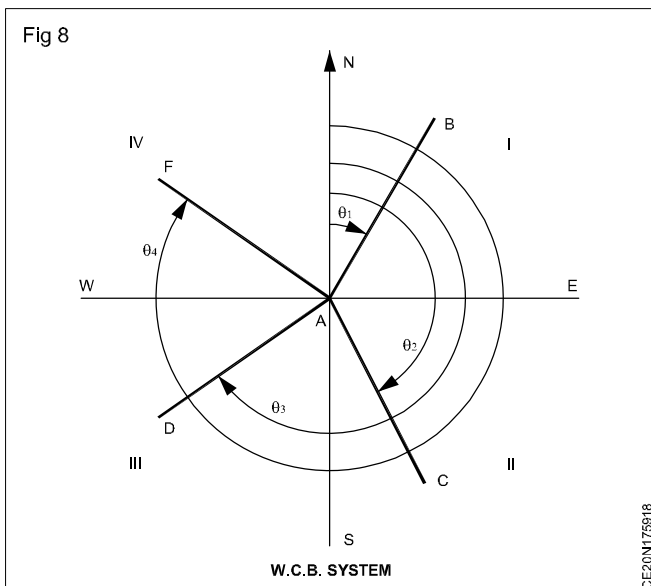
- Whole circle bearings.
- Quadrantal bearings.

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 θ_1 ; of AC is θ_1 and AC is θ_2 ; AD is θ_3 and of AF is θ_4 .

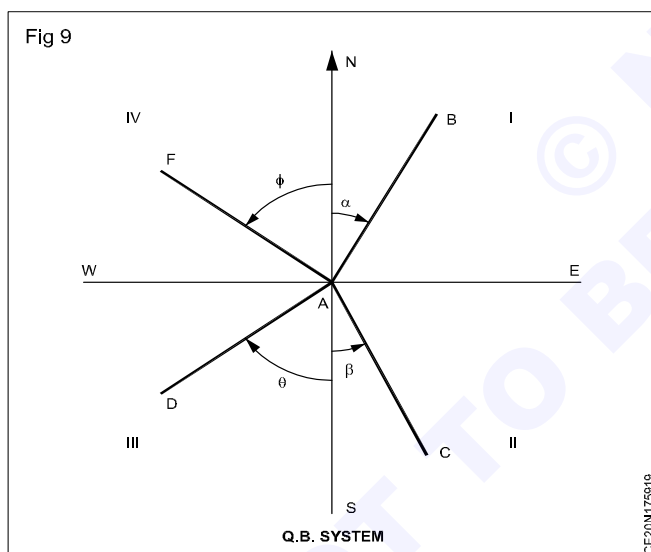
Comparison between prismatic compass and surveyors compass

No	Item	Prismatic compass	Surveyor'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 and South, 90° at East and West. East and west are interchanged. The graduations engraved are erect.
3	Sighting vane	The object vane consists of metal vane with a vertical hair.	The object vane consists of a metal vane with a vertical hair.
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 reading is taken by directly seeing through the top of the glass. Sighting and reading cannot be done simultaneously from one position of the observer.
5	Tripod	It is used with or without Tripod.	It cannot be used without a Tripod



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 ∞ and it is written as $N \infty E$



The bearing of Line AC is β and it is written as $S \beta E$.

Similarly, the bearing of line AD and AF are written as $S \theta W$ and $N \phi W$

Conversion of bearings from one system to other system

Reduced bearing

When the whole circle bearings exceed 90° , 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.

Table 1

Line	W.C.B between	Rule for R.B	Quadrant
AB	0° and 90°	$R.B = W.C.B$	NE
AC	90° and 180°	$R.B = 180^\circ - W.C.B$	SE
AD	180° and 270°	$R.B = W.C.B - 180^\circ$	SW
AF	270° and 360°	$R.B = 360^\circ - W.C.B$	NW

- ii Referring Fig 9 the conversion of R.B into W.C.B can be expressed in the following table.

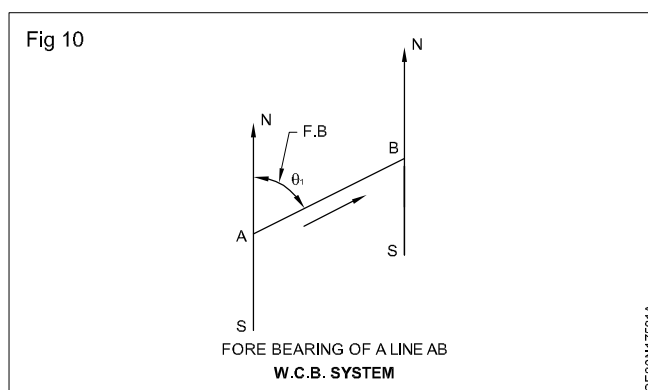
Table 2

Line	R.B	Rule for W.C.B	W.C.B between
AB	$N \alpha E$	$W.C.B = R.B$	0° AND 90°
AC	$S \beta E$	$W.C.B = 180 - R.B$	90° AND 180°
AD	$S \theta W$	$W.C.B = 180 + R.B$	180° AND 270°
AF	$N \phi W$	$W.C.B = 360 - R.B$	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.



The bearing of line AB when recorded in the opposite direction from B to A is B.B (or) F.B of BA (Fig 11)

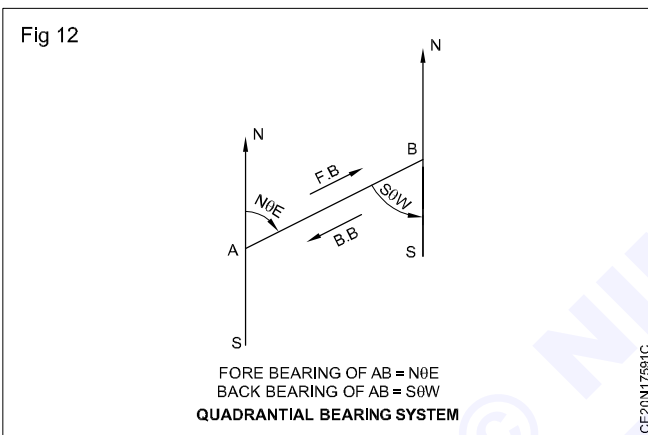
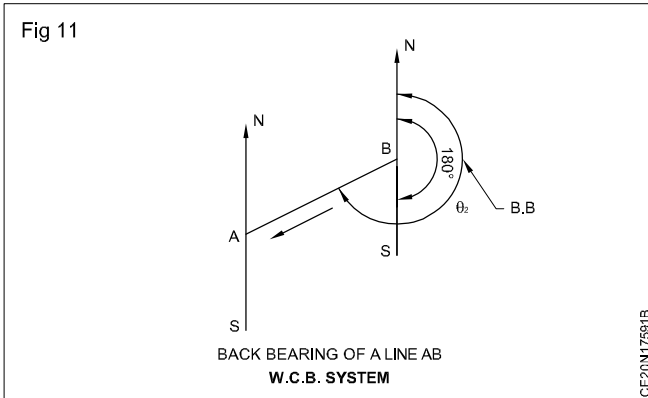
In the whole circle system, the fore and back bearings of a line differ exactly by 180°

$$\therefore B.B \text{ of a line} = F.B \pm 180^\circ \text{ [Equation 1]}$$

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 a line 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 $n^{\circ} 30' E$ then its B.B is equal to $S 30^{\circ} W$

Example

Problems on conversion of bearing

a Convert the following W.C.B to quadrantal bearings.

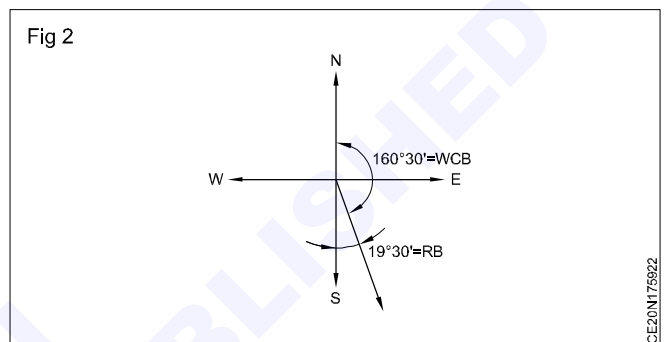
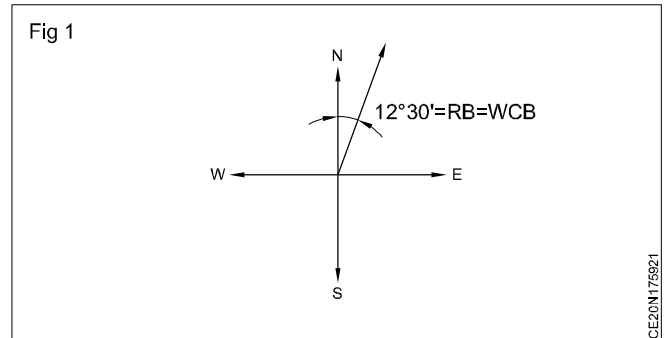
- $12^{\circ} 30'$
- $160^{\circ} 30'$
- $210^{\circ} 30'$
- $285^{\circ} 30'$

Solution

Applying the rules given in the table 1

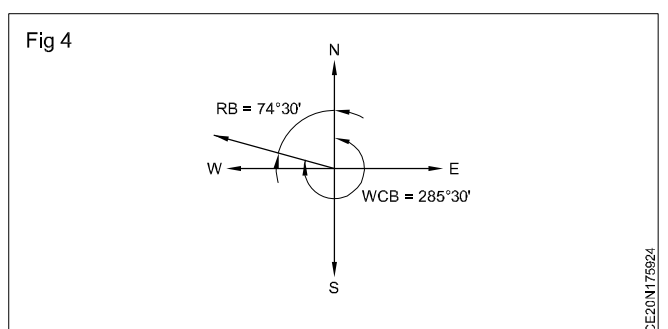
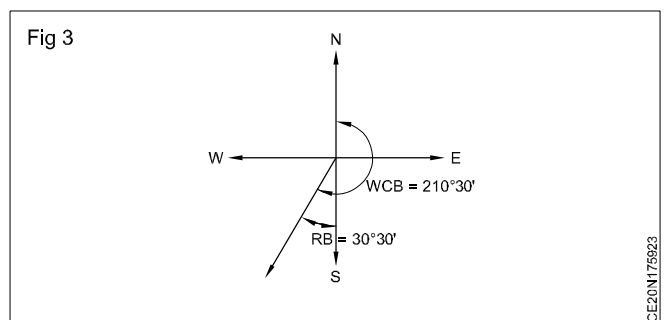
- W.C.B = $12^{\circ} 30'$
W.C.B = $12^{\circ} 30'$ which is less than 90°
 $\therefore$ R.B = $N 12^{\circ} 30' E$ (Fig 1)
- W.C.B = $160^{\circ} 30'$
The W.C.B is within 90° to 180°

$$\begin{aligned}\therefore \text{R.B} &= 180^{\circ} - \text{W.C.B} \\ &= 180^{\circ} - 160^{\circ} 30' \\ &= S 19^{\circ} 30' E \text{ (Fig 2)}\end{aligned}$$



$$\begin{aligned}\text{iii W.C.B} &= 210^{\circ} 30' \\ \text{The W.C.B is within } 180^{\circ} \text{ to } 270^{\circ} \\ \therefore \text{R.B} &= \text{W.C.B} - 180^{\circ} \\ &= 210^{\circ} 30' - 180^{\circ} \\ &= S 30^{\circ} 30' W \text{ (Fig 3)}\end{aligned}$$

$$\begin{aligned}\text{iv W.C.B} &= 285^{\circ} 30' \\ \text{The W.C.B is within } 270^{\circ} \text{ to } 360^{\circ} \\ \therefore \text{R.B} &= 360^{\circ} - \text{W.C.B} \\ &= N 74^{\circ} 30' W \text{ (Fig 4)}\end{aligned}$$



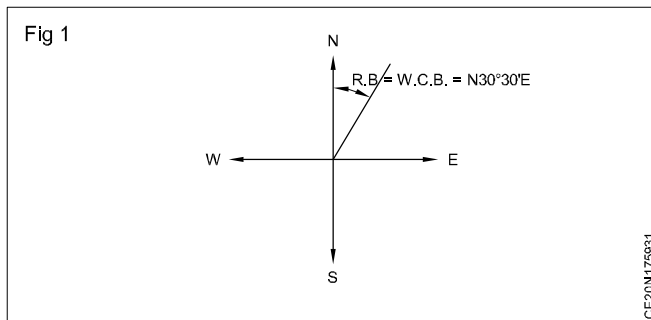
b Convert the following quadrantal bearings to whole circle bearings.

- i N 30° 30' E
- ii S 70° 30'
- iii S 36° 30' W
- iv N 85° 30' W

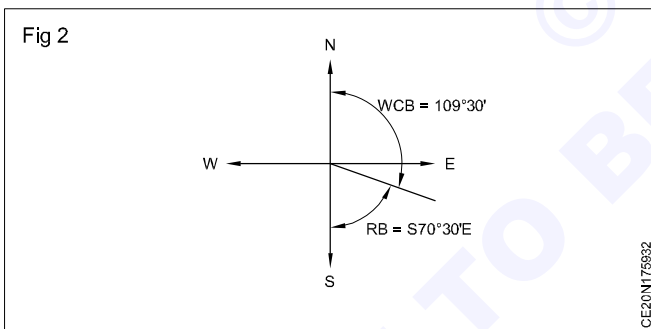
Solution

Applying the rules given in Table 2

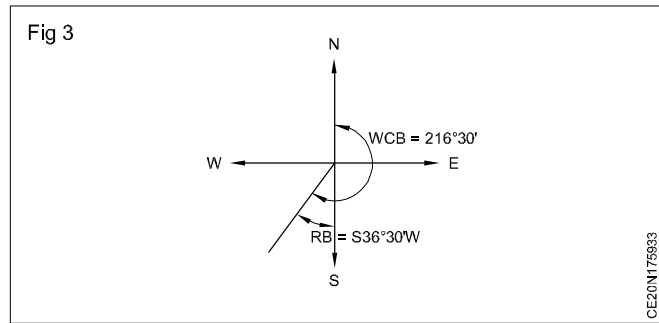
- i Q.B = N 30° 30' E
W.C.B = RB = 30° 30' (Fig 1)



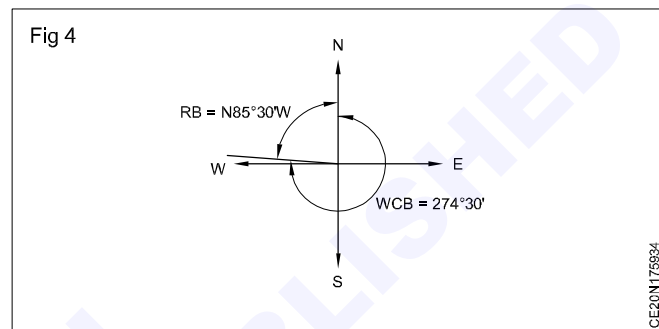
- ii Q.B = S 70° 30' E
W.C.B = 180° - R.B.
= 180° - 70° 30'
= 109° 30' (Fig 2)



- iii Q.B = S 36° 30' W
W.C.B = 180° + Q.B
= 180° + 36° 30'
= 216° 30' (Fig 3)



- iv Q.B = N 85° 30' W
W.C.B = 360° - 85° 30'
= 274° 30' (Fig 4)



Exercise

1 Convert the following W.C.B to R.B

- a 87° 30'
- b 120° 30'
- c 210° 00'
- d 266° 30'
- e 310° 30'
- f 359° 30'

2 Convert the following R.B to W.C.B

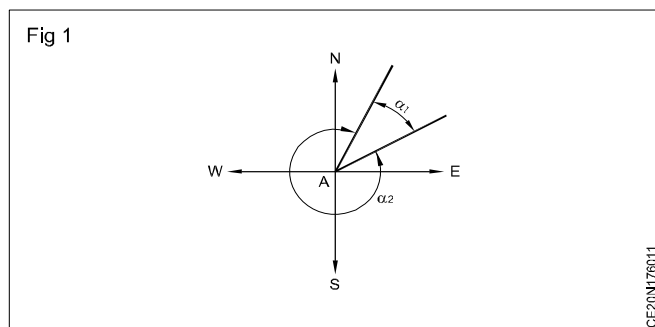
- a N 46° 30' E
- b S 20° 30' E
- c S 10° 30' W
- d N 50° 30' W

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 360° (see Fig 1 $\alpha_1 + \alpha_2 = 360^\circ$)



The following rules may be adopted to find the included angle between two lines whose bearings are given.

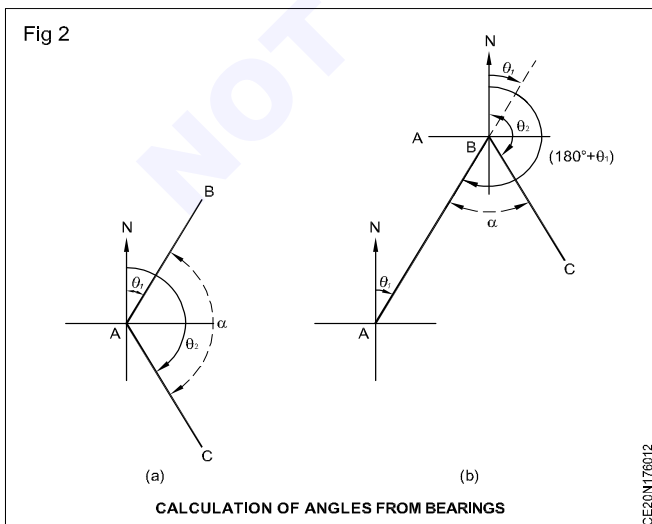
Case 1: Given the bearings in whole circle bearing system

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.

$$\begin{aligned} \text{LA} &= \alpha = \text{Bearing of AC} - \text{Bearing of AB} \\ \text{AB} & \\ &= \theta_2 - \theta_1 \end{aligned}$$



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.

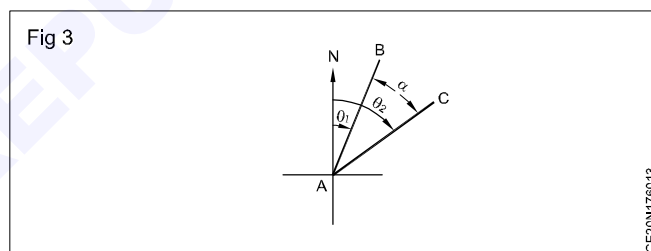
From Fig 2b, the included angle ' α ' between BC and BA

$$\begin{aligned} \angle B &= \text{B.B of AB} - \text{F.B of BC} \\ &= (180^\circ + \theta_1) - \theta_2 \end{aligned}$$

Note: If the difference is less than 180° , then it is an interior angle and if it exceeds 180° , it is an exterior angle.

Case II: Given the bearings in quadrantal system

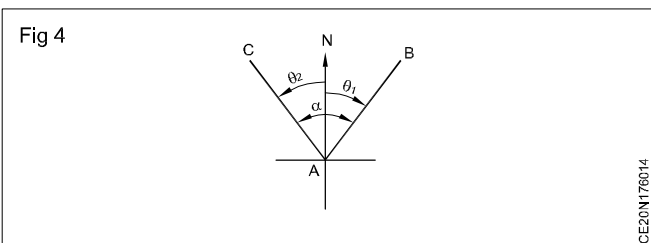
- Referring to Fig 3, in which both the bearings have been measured to the same side of same meridian.



Rule: Included angle = difference between the two bearings AC and AB

$$\begin{aligned} \text{The included angle is } \alpha &= \theta_2 - \theta_1 \\ &= \text{F.B of Line AC} - \text{F.B of line AB} \end{aligned}$$

- Referring to Fig 4 both the bearings have been measured to the adjacent sides of the same meridian.

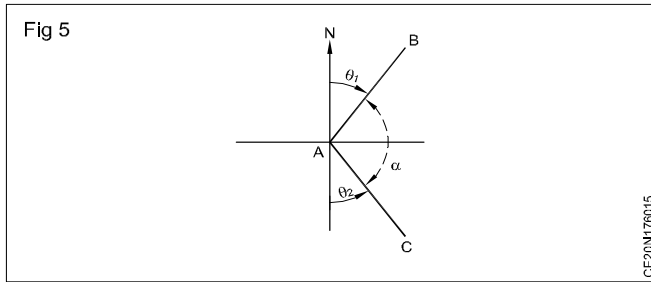


Rule: Included angle = sum of the two bearings AB and AC

$$\text{The Included angle } \alpha = \theta_1 + \theta_2$$

$$= \text{F.B of Line AB} + \text{F.B of line AC}$$

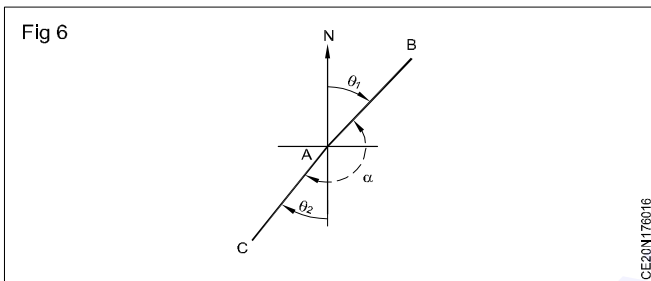
iii Referring to Fig 5 both the bearings have been measured to the same side of different meridians.



Rule: Included angle = $180^\circ - \text{sum of the bearings AB and AC}$

$$\angle A, \text{ Included angle, } \alpha = 180^\circ - (\theta_2 - \theta_1)$$

iv Referring to Fig 6 both the bearings have been measured to the opposite side of different meridians.



Rule: Included angle = $180^\circ - \text{difference of the bearings AB and AC}$

$$\angle A, \text{ Included angle, } \alpha = 180^\circ (\theta_1 + \theta_2)$$

Problems on calculation of angles from bearing

Example 1

Find the angle between the lines OA and OB, if their respective bearings are

a $32^\circ 30'$ and $148^\circ 00'$

b $16^\circ 00'$ and $332^\circ 30'$

c $126^\circ 30'$ and $300^\circ 30'$

Solution

a $32^\circ 30'$ and $148^\circ 00'$ (Fig 1)

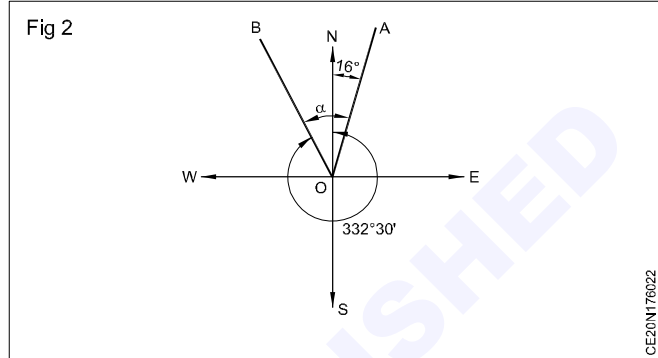
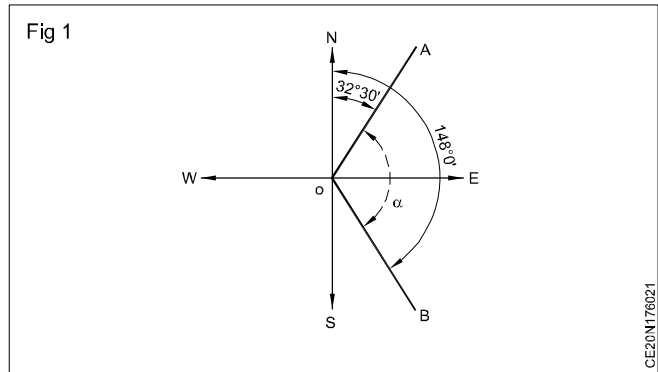
$$\text{F.B of line OA} = 32^\circ 30'$$

$$\text{F.B of line OB} = 148^\circ 00'$$

$$\begin{aligned} \therefore \text{angle LAOB or } &= \text{F.B of line OB} - \text{F.B of line OA} \\ &= 148^\circ 00' - 32^\circ 30' \end{aligned}$$

$$\alpha = 115^\circ 30'$$

b $16^\circ 00'$ and $332^\circ 30'$ (Fig 2)

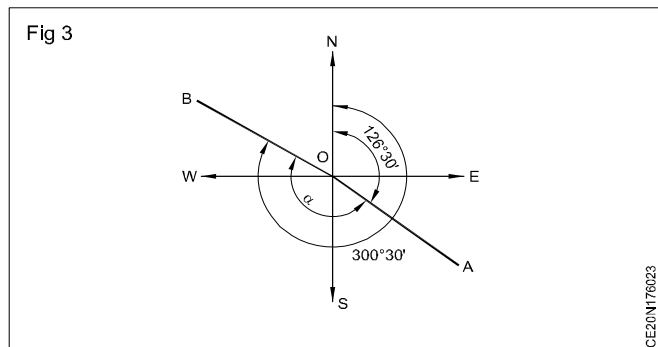


$$\text{F.B of OA} = 16^\circ 00'$$

$$\text{F.B of OB} = 332^\circ 30'$$

$$\begin{aligned} \therefore \text{angle LAOB or } \alpha &= (360^\circ - \text{F.B of line OB}) \\ &+ \text{F.B of line OA} \\ &= (360^\circ 00' - 332^\circ 30') \\ &+ 16^\circ 00' \\ &= 27^\circ 30' + 16^\circ 00' \\ &= 43^\circ 30' \end{aligned}$$

c $126^\circ 30'$ and $300^\circ 30'$ (Fig 3)



$$\text{F.B of OA} = 126^\circ 30'$$

$$\text{F.B of OB} = 300^\circ 30'$$

$$\begin{aligned} \therefore \text{angle LAOB or } \alpha &= \text{F.B of line OB} - \text{F.B of line OA} \\ &= 300^\circ 30' - 126^\circ 30' \\ \alpha &= 174^\circ 00' \end{aligned}$$

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

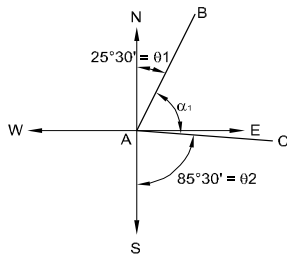
Line AC

N 25° 30' E

S 85° 30' E

In Fig 1 α_1 is the included angle at A or LBAC Ref. Case II (iii) both the bearings have been measured to the same side of different meridians.

Fig 1



$$\begin{aligned}\alpha_1 &= 180^\circ - (\theta_1 - \theta_2) \\ &= 180^\circ - (25^\circ 30' + 85^\circ 30') \\ &= 180^\circ - 111^\circ 0'\end{aligned}$$

$$\angle BAC = 69^\circ 0'$$

ii Line AB

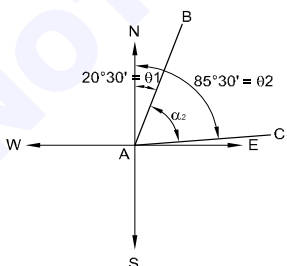
Line AC

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

$$\angle BAC = \text{FB of AC} - \text{FB of AB}$$

$$\alpha_2 = (\theta_2 - \theta_1)$$

$$= 85^\circ 30' - 20^\circ 30'$$

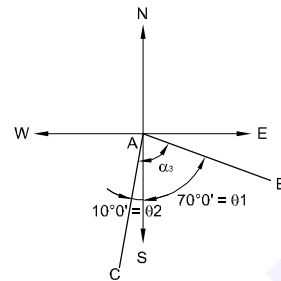
$$\angle BAC = 65^\circ 0'$$

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.

Fig 3



$$\begin{aligned}\text{Included angle } \alpha_3 &= (\theta_1 - \theta_2) \\ &= 70^\circ 0' + 10^\circ 0'\end{aligned}$$

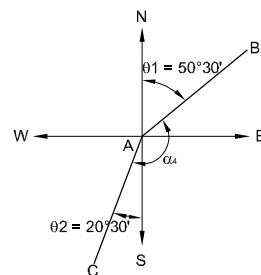
$$\angle BAC = 80^\circ 0'$$

v N 50° 30' E

S 20° 30' W

In Fig 4 From Ref. case II (iv) both the bearings have been measured to the opposite side of different meridians.

Fig 4



$$\begin{aligned}\alpha_4 &= \angle BAC = 180^\circ - (\theta_1 - \theta_2) \\ &= 180^\circ - (50^\circ 30' - 20^\circ 30') \\ &= 180^\circ - 30^\circ 00'\end{aligned}$$

$$\angle BAC = 150^\circ 00'$$

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

$$\begin{aligned}\angle BAC &= \theta_5 = \theta_1 \theta_2 \\ &= 40^\circ 30' + 46^\circ 00' \\ &= 86^\circ - 30'\end{aligned}$$

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.

$$\begin{aligned}\text{Included angle } \alpha_6 &= \angle BAC = 180^\circ - (\theta_1 \theta_2) \\ &= 180^\circ - (45^\circ 30' + 60^\circ 0')\end{aligned}$$

$$\begin{aligned} &= 180^\circ - 105^\circ 30' \\ \angle BAC = \alpha &= 74^\circ 30' \end{aligned}$$

Fig 5

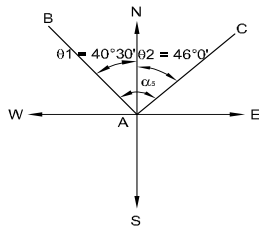
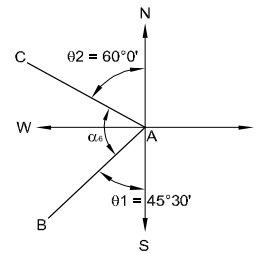


Fig 6

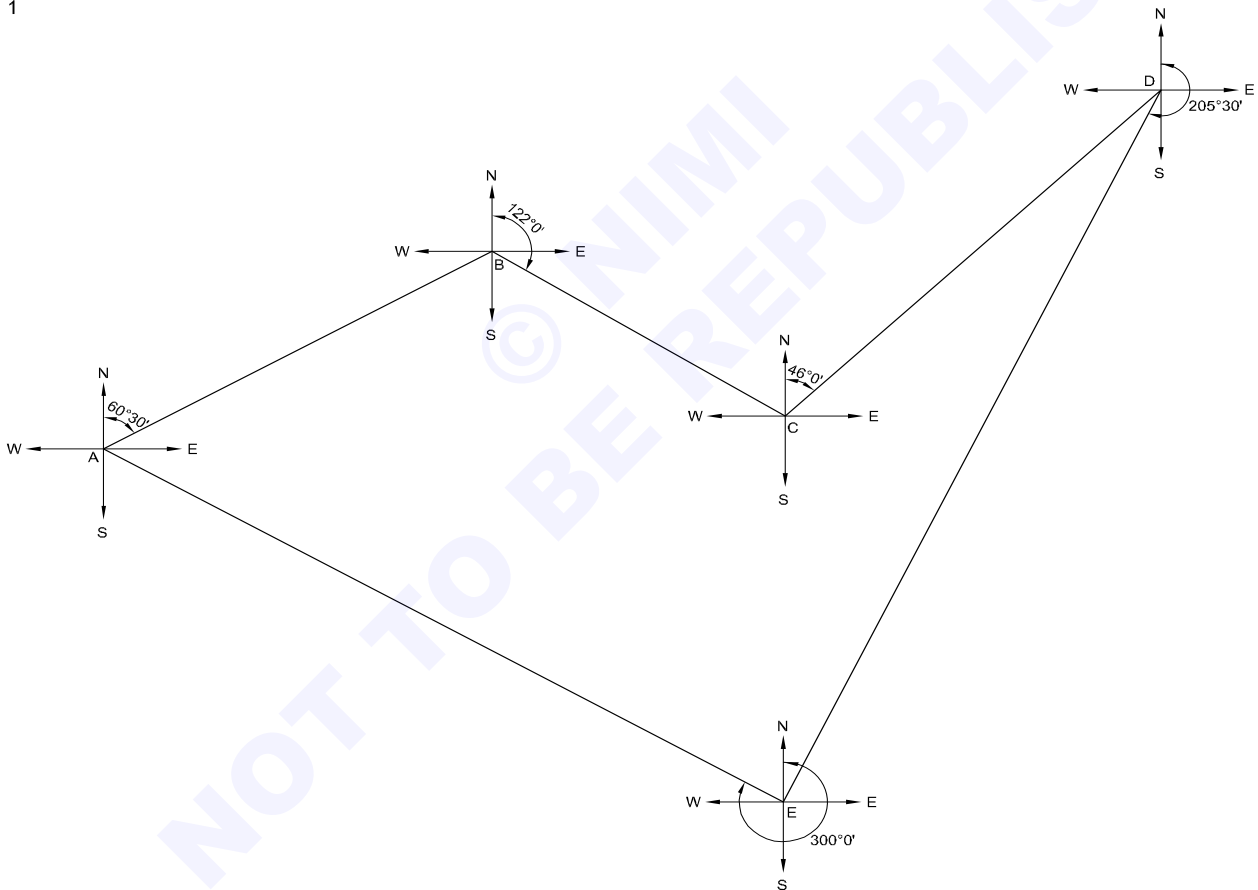


Determining the bearings of a given pentagonal plot of ABCDE and calculating included angles

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

- calculate the angles from bearings for a closed traverse
- calculate the bearings of a pentagon.

Fig 1



Example 1

The following bearings were observed with a compass. Calculate the interior angles. (Fig 1)

Line	Fore Bearings
AB	60° 30'
BC	122° 00'
CD	46° 00'

DE	205° 30'
EA	300° 00'

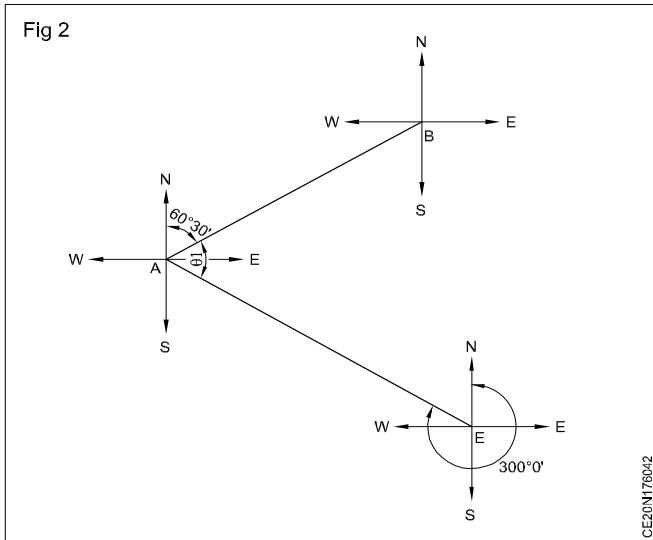
Solution:

Fig 1 shows the plotted traverse by using the above given fore bearings.

Consider station A (Fig 2)

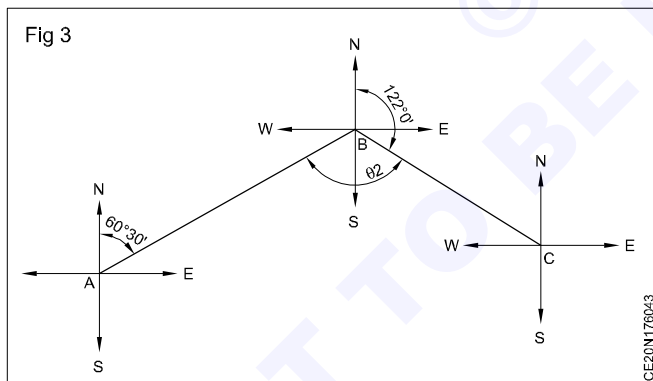
$$\text{Included angle} = \text{Bearing of previous line} - \text{Bearing of Next Line}$$

$$\begin{aligned}\theta_1 = \angle A &= \text{Bearing of AE} - \text{Bearing of AB} \\ &= (300^\circ - 180^\circ) - 60^\circ 30' \\ \theta_1 &= 59^\circ 30'\end{aligned}$$



Consider station B (Fig 3)

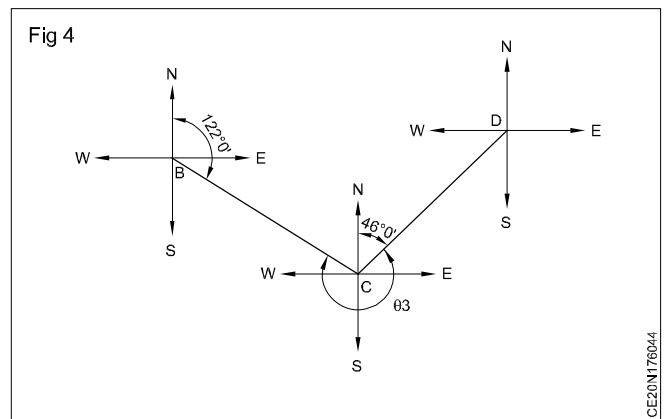
$$\begin{aligned}\theta_2 = \angle B &= \text{Bearing of BA} - \text{Bearing of BC} \\ &= (180^\circ + \text{FB of AB}) - 122^\circ 0' \\ &= (180^\circ + 60^\circ 30') - 122^\circ 0' \\ &= 240^\circ 30' - 122^\circ 0' \\ \theta_2 = \angle B &= 118^\circ 30'\end{aligned}$$



Consider station C (Fig 4)

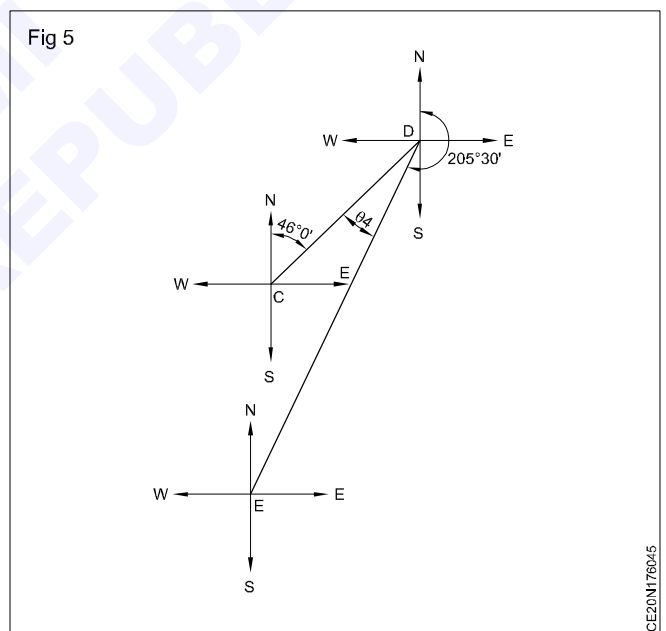
$$\begin{aligned}\theta_3 = \angle C &= \text{Bearing of CB} - \text{Bearing of CD} \\ &= (180^\circ + \text{FB of BC}) - 46^\circ 0' \\ &= (180^\circ + 122^\circ 0') - 46^\circ 0' \\ &= 302^\circ 0' - 46^\circ 0' \\ \theta_3 = \angle C &= 256^\circ 00'\end{aligned}$$

In some of the cases in a closed traverse the calculated included angle exceeds 180° and that angle is known as interior angle according to the traverse as here at station 'C'.



Consider station C (Fig 5)

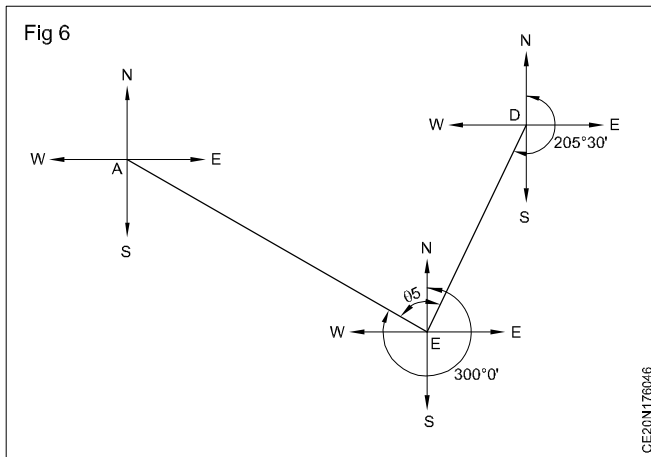
$$\begin{aligned}\theta_4 = \angle D &= \text{Bearing of DC} - \text{Bearing of DE} \\ &= (180^\circ + \text{FB of CD}) - 205^\circ 30' \\ &= (180^\circ + 46^\circ) - 205^\circ 30' \\ &= 226^\circ 00' - 205^\circ 30' \\ \theta_4 = \angle D &= 20^\circ 30'\end{aligned}$$



Consider station E (Fig 6)

$$\begin{aligned}\theta_5 = \angle E &= \text{Bearing of previous line} - \text{Bearing of next line} \\ &= (\text{F.B of DE} - 180^\circ) - 300^\circ + 360^\circ \\ &= (205^\circ 30' - 180^\circ) - 300^\circ + 360^\circ \\ &= 25^\circ 30' - 300^\circ + 360^\circ \\ \theta_5 = \angle E &= 85^\circ 30'\end{aligned}$$

$$\therefore \begin{aligned} \angle A &= 59^\circ 30' \\ \angle B &= 118^\circ 30' \end{aligned}$$



$$\begin{aligned}
 \angle C &= 256^{\circ} 00' \\
 \angle D &= 20^{\circ} 30' \\
 \angle E &= 85^{\circ} 30' \\
 \text{sum} &= 540^{\circ} 00'
 \end{aligned}$$

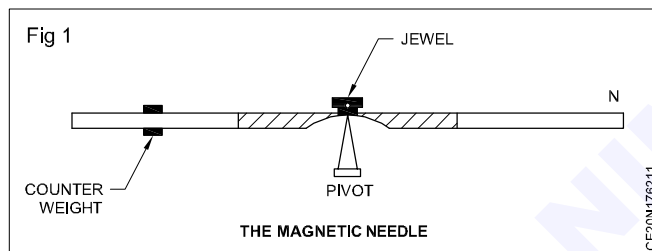
The sum of interior angle of a pentagon
 $= (2n-4) \times 90^{\circ}$
 $= (10 - 4) 90^{\circ} = 540^{\circ}$
 Where n = No. of sides.

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
- calculation of true bearings
- state local attraction and its elimination
- explain about errors and its limits
- state the testing of 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)

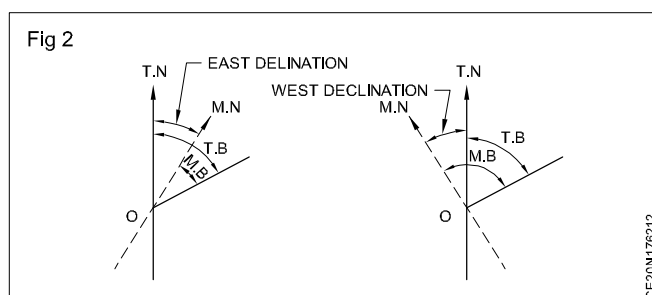


The amount of the dip is not uniform, but it varies in different parts of the earth. It varies from 0° to 90° (zero at equator and 90° at the poles)

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.

Calculation of true bearings

Rule 1

True bearing of a line = Magnetic bearing of the line $\pm$ 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 $\pm$ 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 therefore it is known as annual variations. The amount of variation is in difficult places 0 to ± 12 minutes, but it will 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.

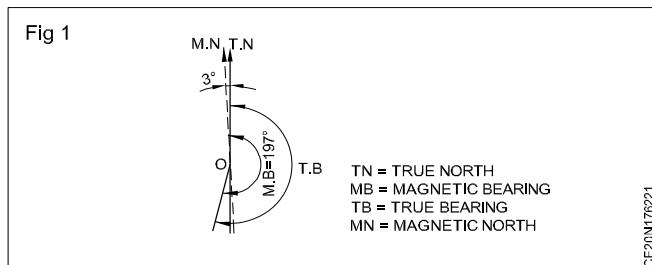
2 Irregular variations: These are occurred by magnetic storms such as earth quakes or volcanic eruptions and their amount may be even 1° or 2° at a time. It may occur at any time. It cannot be predicted.

Calculate true bearing problems on magnetic declination

Example 1

The magnetic bearing of line is 197° . Find its true bearing, if the magnetic declination is 3° W

Solution (Fig 1)



Using Rule 1

True bearing of the line = Magnetic bearing of the line $\pm$ declination.

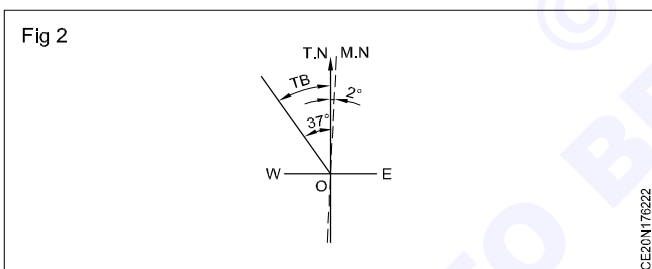
Use - sign because the declination is west.

$$\begin{aligned}\text{True bearing of the line} &= \text{Magnetic bearing of the line} - \text{declination.} \\ &= 197^{\circ} - 3^{\circ} \\ &= 194^{\circ}\end{aligned}$$

Example 2

If the magnetic bearing of the line is $N 37^{\circ} W$ and the magnetic declination is $2^{\circ} E$ Find the true bearing.

Solution (Fig 2)



From Rule I

$$\begin{aligned}\text{True bearing of a line} &= \text{Magnetic bearing of line} \pm \text{declination} \\ &= N(37^{\circ} - 2^{\circ}) W \\ &= N 35^{\circ} W\end{aligned}$$

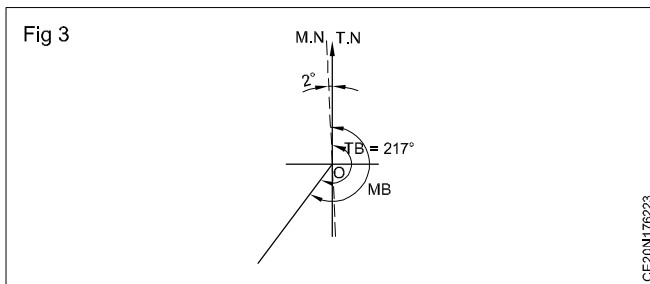
Example 3

True bearing of a line is 217° and magnetic declination is 2° W. Find the magnetic bearing.

In Fig 3 Magnetic bearing of the line

$$\begin{aligned}&= \text{True bearing of line} + \text{declination.} \\ &= 217^{\circ} + 2^{\circ} \\ &= 219^{\circ}\end{aligned}$$

Use + sign declination in west.



Example 4

The magnetic and true bearing of a line are $327^{\circ} 14'$ and $324^{\circ} 37'$ 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

$$\begin{aligned}\text{Magnetic bearing of the line} &= 327^{\circ} 14' \\ \text{True bearing of the line} &= 324^{\circ} 37' \\ \therefore \text{Declination} &= 327^{\circ} 14' - 324^{\circ} 37' \\ &= 2^{\circ} 37'\end{aligned}$$

From Fig 4,

declination is west, ie $2^{\circ} 37'$

Annual variation = $3'$ west

Variation in 4 years = $4 \times 3' = 12' W$

Total declination after 4 years

$$\begin{aligned}&= 2^{\circ} 37' + 12' \\ &= 2^{\circ} 49' W\end{aligned}$$

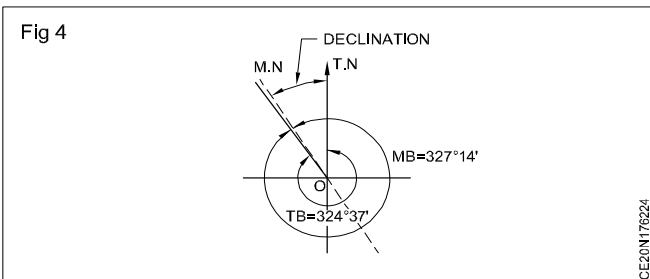
True bearing of a line after 4 years

$$= 324^{\circ} 37'$$

(Same as above)

magnetic bearing after 4 years

$$\begin{aligned}&= 324^{\circ} 37' + 2^{\circ} 49' \\ &= 327^{\circ} 26'\end{aligned}$$

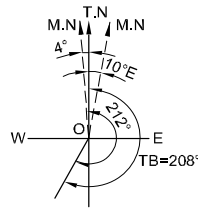


Example 5

A line was drawn as its magnetic bearing 212° on an old map when the magnetic declination was $4^{\circ} W$. To what bearing should be set now if the present declination is $10^{\circ} E$.

Solution (Fig 5)

Fig 5



When the declination was 4°W.

$$\begin{aligned}\text{True bearing of the line} &= \text{Magnetic bearing of the line} - \text{declination} \\ &= 212^\circ - 4^\circ \\ &= 208^\circ\end{aligned}$$

When declination is 10° East,

$$\begin{aligned}\text{Magnetic bearing of the line} &= \text{True bearing of the line} - \text{declination.} \\ &= 208^\circ - 10^\circ \\ &= 198^\circ\end{aligned}$$

∴ To set the line now to the bearing of 198°

Exercise

- The magnetic bearing of a line AB is 125°. Find its true bearing if the magnetic declination at A is
 - 9° 0' W
 - 5° 30' E
- The true bearing of a line CD is 138° 30'. Find its magnetic bearing if the magnetic declination at C is
 - 5° 30' W
 - 3° 15' E
- A line has a true bearing of 255°. The declination is 3° 30' E. Calculate the magnetic bearing on whole circle and reduced bearing systems.
- Find the magnetic declination if magnetic bearings of the sun at noon, are,
 - 182° 00'
 - 178° 30'
 - 359° 0'
- The true bearing of a line is N 30° 30' E compute the magnetic bearing of the line if the magnetic declination is
 - 4° 15' E and
 - 5° 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° there is no local attraction at both stations, provided instrumental and observational errors are eliminated. But if the difference is not equal to 180° 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 anticlockwise 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 traverse

Line	FB	BB
AB	75° 00'	254° 30'
BC	115° 30'	296° 30'
CD	165° 30'	345° 30'
DE	225° 00'	44° 00'
EA	304° 30'	125° 00'

Find the error due to local attraction. Determine the correct bearings.

Solution

Line	FB	BB	Error
AB	75° 00'	254° 30'	0° 30'
BC	115° 30'	296° 30'	1° 00'
CD	165° 30'	345° 30'	NIL
DE	225° 00'	44° 00'	1° 00'
EA	304° 30'	125° 00'	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 = $225^{\circ} 00'$
Deduct = $180^{\circ} 00'$

Corrected B.B of DE = $45^{\circ} 00'$
Observed B.B of DE = $44^{\circ} 00'$

Error at station E (-) $1^{\circ} 00'$
Observed FB of EA = $304^{\circ} 30'$
Correction at station E
= (+) $1^{\circ} 00'$

Corrected FB of EA = $305^{\circ} 30'$
Deduct = $180^{\circ} 00'$

Correct B.B of EA = $125^{\circ} 30'$
Observed B.B of EA = $125^{\circ} 00'$

Error at station A (-) $0^{\circ} 30'$

Observed F.B of AB = $75^{\circ} 00'$
Correction at station A (+) $0^{\circ} 30'$

Corrected FB of AB = $75^{\circ} 30'$
Add = $180^{\circ} 00'$

Corrected BB of AB = $255^{\circ} 30'$
Observed BB of AB = $254^{\circ} 30'$

Error at station 'B' (-) $1^{\circ} 00'$

Observed F.B of BC = $115^{\circ} 30'$
Correction at station 'B'
= (+) $1^{\circ} 00'$

Corrected FB of BC = $116^{\circ} 30'$
Add = $180^{\circ} 00'$

Corrected B.B of BC = $296^{\circ} 30'$

Observed B.B of BC = 296.30

Corrected					
Line	F.B	B.B	Correction	FB	BB
AB	$75^{\circ} 00'$	$254^{\circ} 30'$	(+) $0^{\circ} 30'$ at 'A'	$75^{\circ} 30'$	$255^{\circ} 30'$
BC	$115^{\circ} 30'$	$296^{\circ} 30'$	(+) $1^{\circ} 00'$ at 'B'	$116^{\circ} 30'$	$296^{\circ} 30'$
CD	$165^{\circ} 30'$	$345^{\circ} 30'$	Nil at 'C'	$165^{\circ} 30'$	$345^{\circ} 30'$
DE	$225^{\circ} 00'$	$44^{\circ} 00'$	Nil at 'D'	$225^{\circ} 00'$	$45^{\circ} 00'$
EA	$304^{\circ} 30'$	$125^{\circ} 00'$	(+) $1^{\circ} 00'$ at 'E'	$305^{\circ} 30'$	$125^{\circ} 30'$

Plotting of a compass traverse

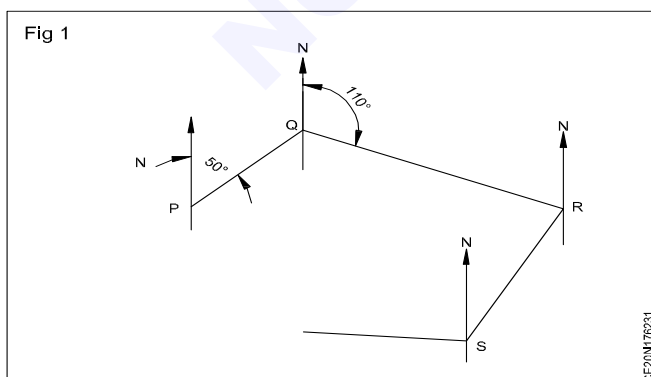
Before plotting traverse on the drawing sheet, first to draw a rough sketch on the paper.

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)



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.

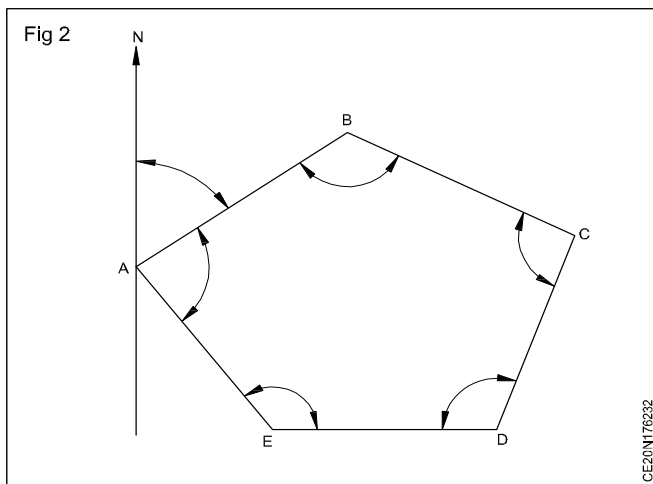
If the traverse is a closed one the last line must coincide with the starting station P.

If not the error is called as closing error.

By included angle method (Fig 2)

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'

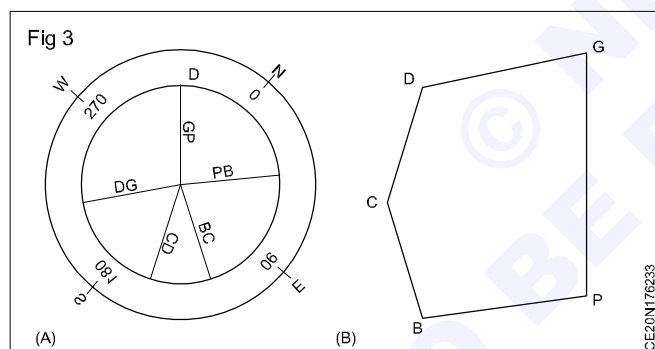
From B draw the included angle ABC.

The same process may be repeated at each successive stations.

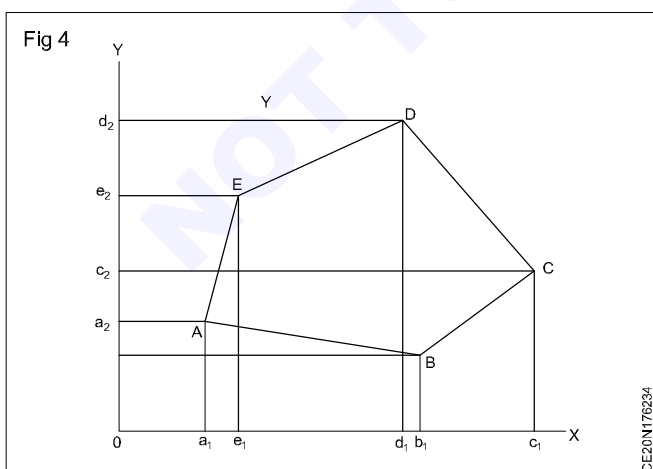
By paper protractor (Fig 3)

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 protractor 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)



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 axis.

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.

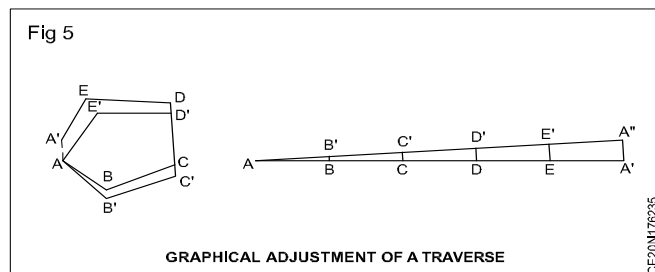
When the angular and linear measurements are of equal precision graphical adjustment of the traverse may be used. This method is based on the Bowditch's rule.

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 as plotted. Hence, A' is the closing error.



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 plan 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 a graphical method of surveying in which field observations and plotting are done simultaneously on a plane table.

It is most suitable for filling in 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.

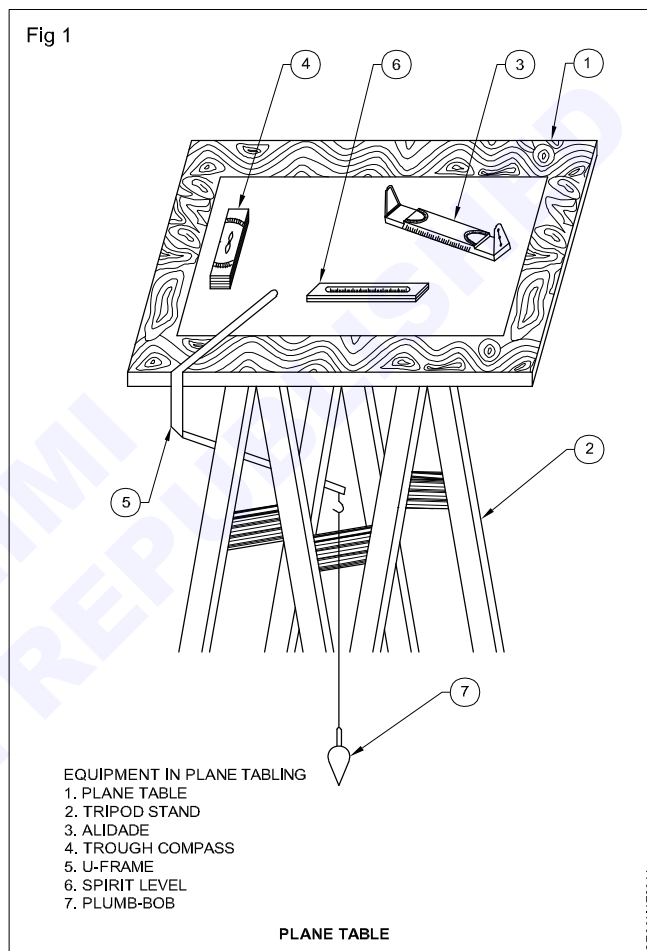
- Small: 50cm x 40cm x 1.5cm
- Medium: 50cm x 50cm x 1.5cm
- Large: 75cm x 60cm x 1.5cm

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.



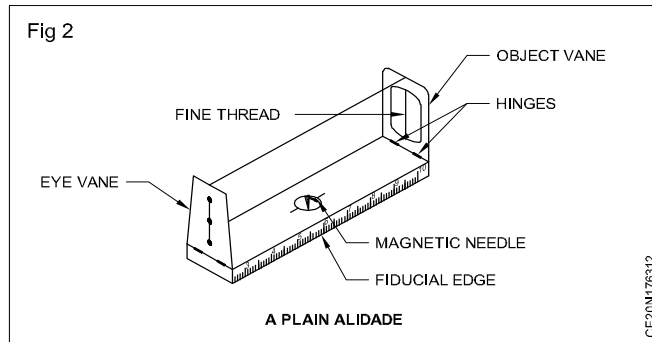
- Plain Alidade
- Telescopic alidade

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.

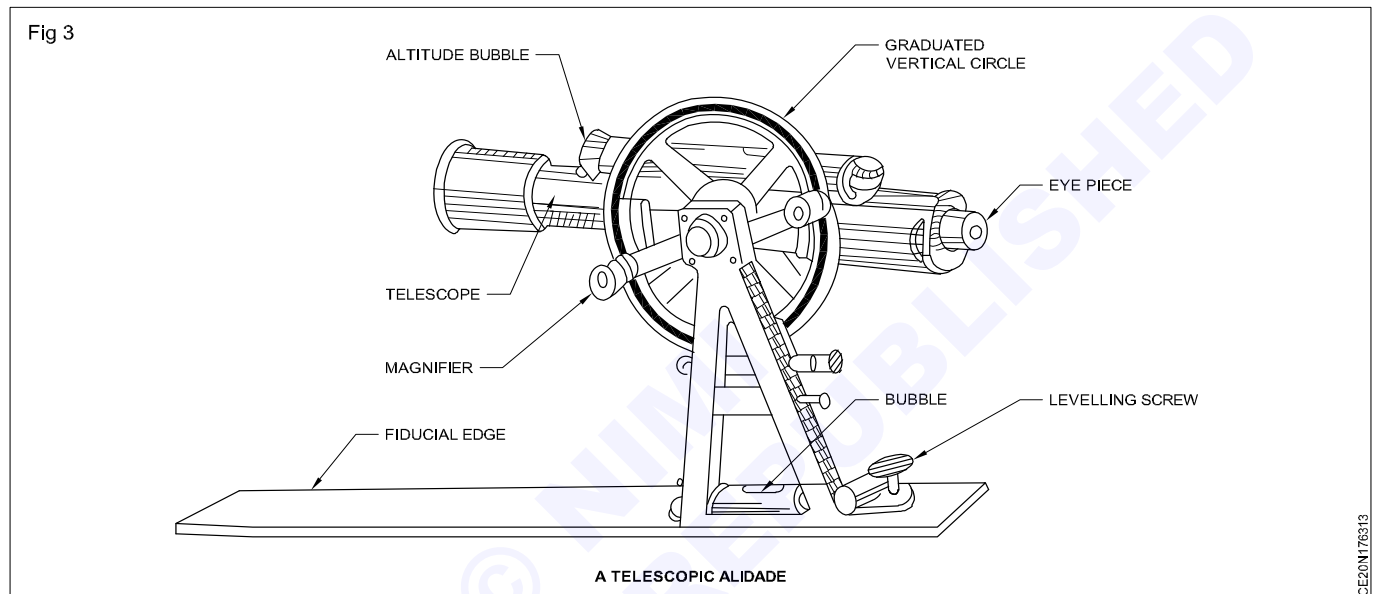
The other vane which is known as object vane is open and carries a hair stretched between the top and bottom of the slit. With the help of the slit, a definite line of sight may be established parallel to the ruling edge of the alidade. The alidade can be rotated about the point which represents the 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.

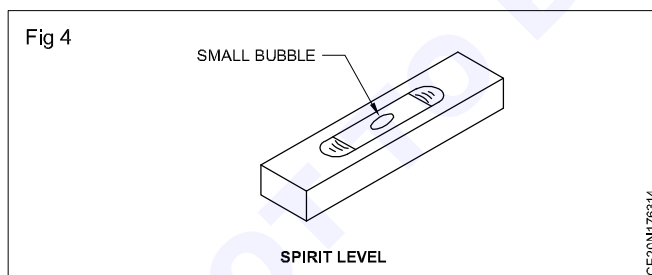


The plain alidade can be used when the elevations or depressions of the objects are low.

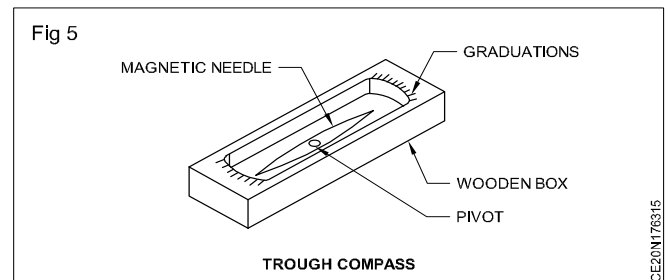
Telescopic Alidade: It is generally used when it is required to take inclined sights. The telescope increases the range and accuracy of the sights. It consists of a small telescope with a level tube. A graduated scale is mounted on a horizontal axis. The horizontal axis rest on a A-frame which is supported 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).



Spirit 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)



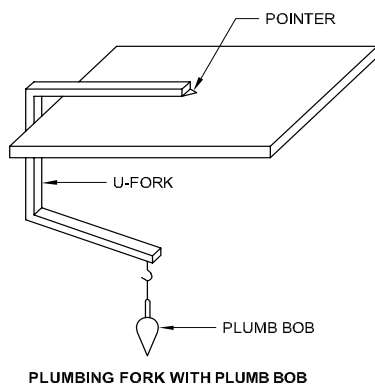
Trough compass or magnetic compass: A box compass consists of a magnetic needle pivoted at its centre freely. It is used for making the direction of the magnetic meridian on the sheet. So it is also used for orienting the plane table to magnetic north. Both the edges of a compass are straight, and bottom 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 placed with the upper arm lying on 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 6



CE20N176316

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.

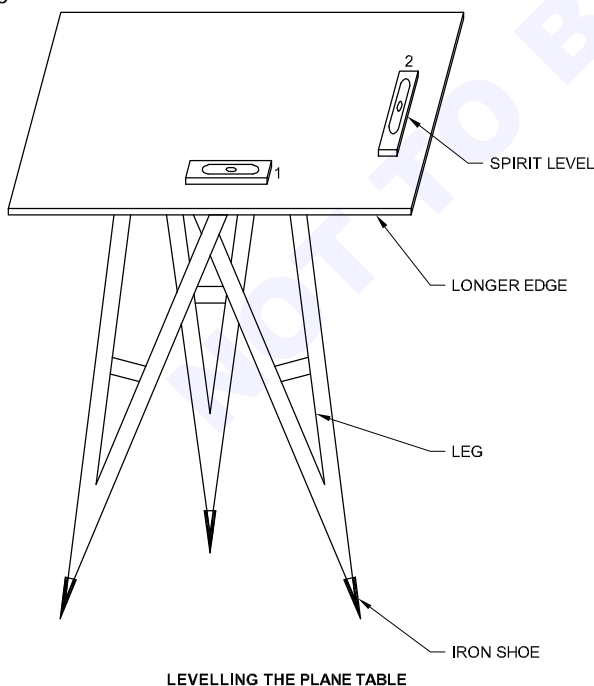
Setting up the plane Table

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).

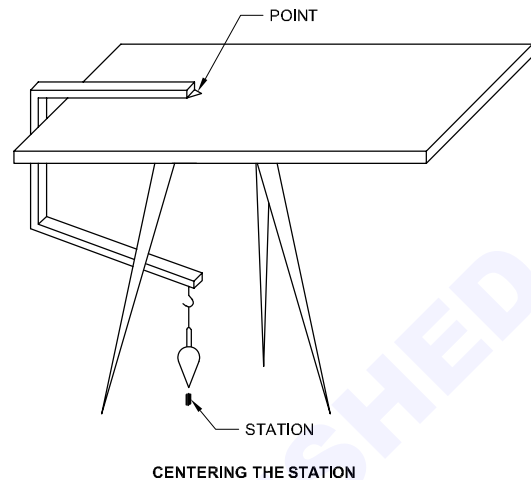
Fig 7



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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)

Fig 8

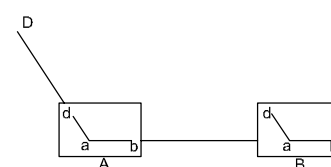


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Orienting the plane table: It is the process of putting the plane table in to some fixed direction so that the line representing a particular direction on the plan is parallel to the direction on the ground. Orientation is necessary when more than 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.

Orientation by back sighting (Fig 9)

Fig 9



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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 slid on ba, turn the table till the station 'A' is bisected. Then clamp the load in this position.

Orientation by magnetic needle

For orientation 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

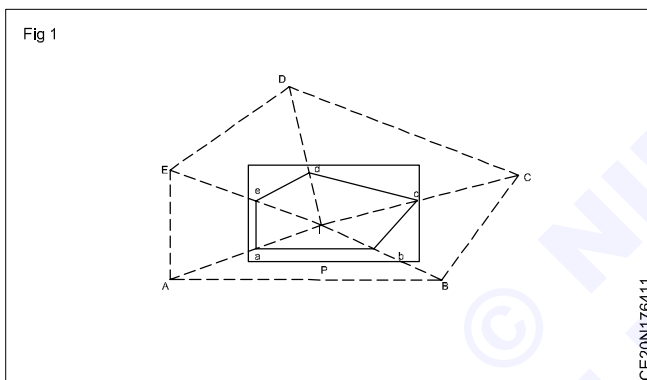
- methods of plane table survey
- radiation method of plane table survey
- intersection method of plane table survey.

The following are the 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)



- 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.

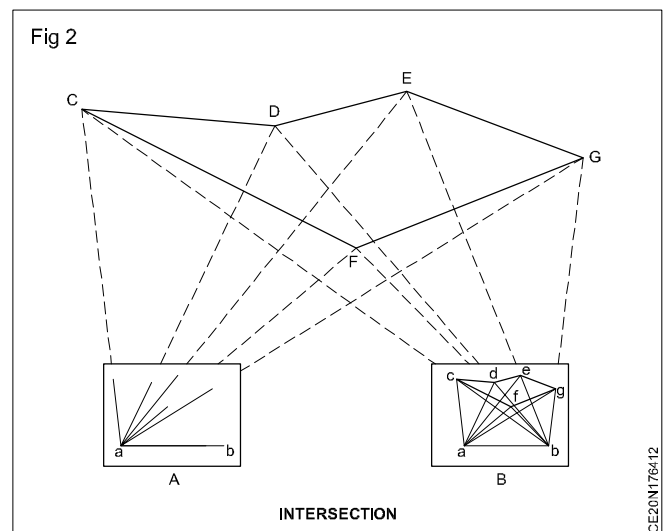
It is also useful in combination with other methods for surveying details within a tape length from the station.

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)

- 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 the ground.

- Orient the table by placing the alidade along 'ba' turning the table till the line of sight strikes 'A' and clamp it.
- With the alidade pivoted on 'b' draw rays sighting towards the same objects (i.e.) 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

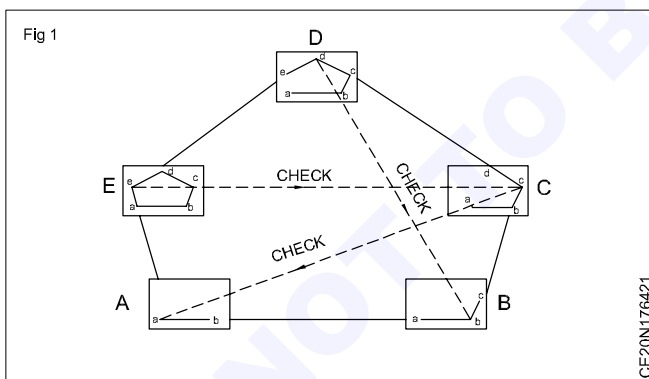
- state traverse method of plane table survey
- conduct traverse method of plane table survey.

Traversing

- This is a 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.
- 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. (Fig 1)



- 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 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

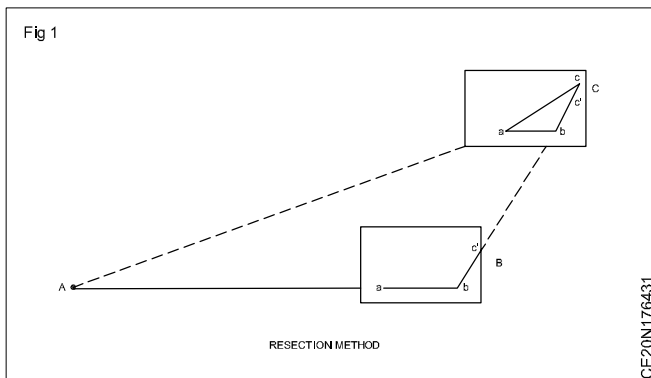
- state the resection method of plane table survey
- errors in plane tabling.

Resection method

- 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.
- 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 is necessary to locate the other station in the above manner. It is also known as back ray method.

Errors in plane tabling

The common sources of error in plane tabling are,

- 1 Instrumental Error
- 2 Errors of 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.

Principle of levelling - auto level - dumpy level- tilting level

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

- describe the principle and types of levelling
- List the required instruments for levelling
- describe the functions of parts.

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 hollow 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 focusing telescope: In this type of telescope, out of two tubes one 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.

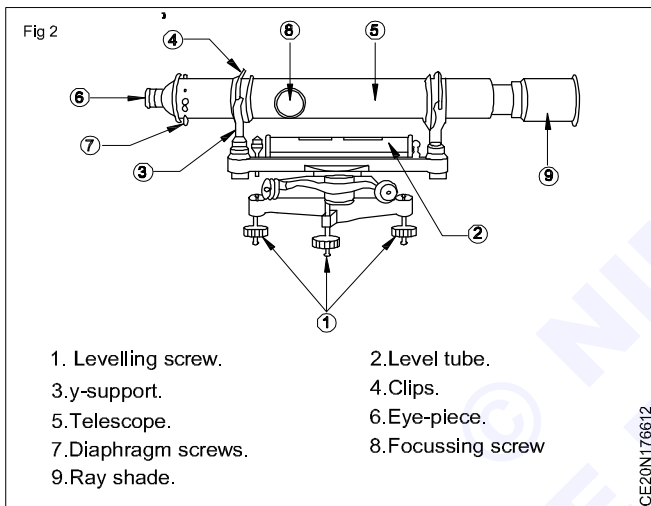
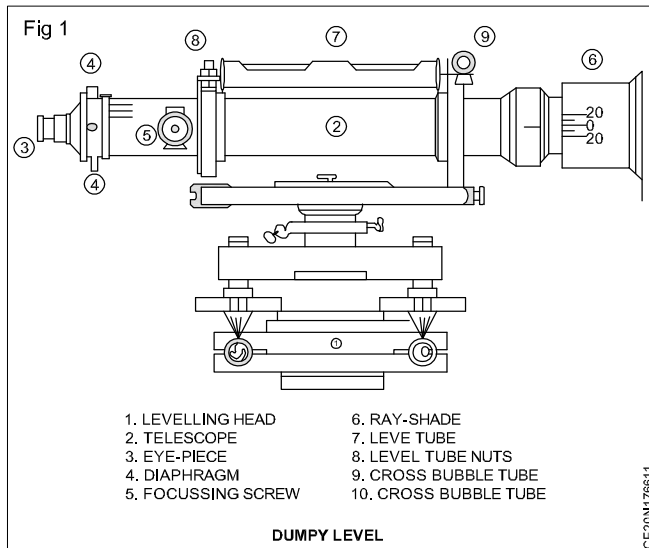
5 The dumpy level (Fig 1)

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.

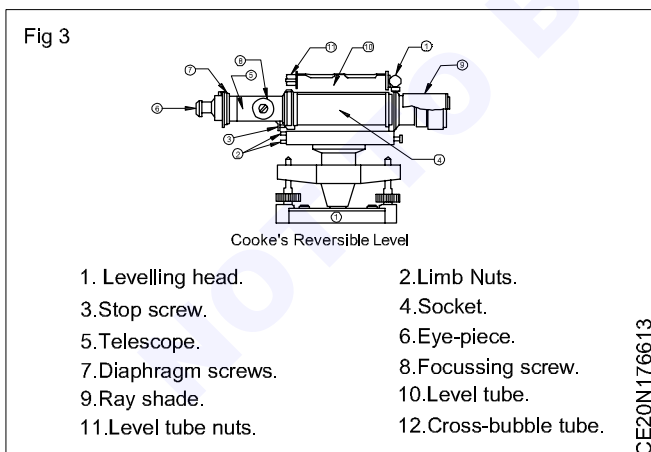
6 The wye or Y level (Fig 2)

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.



7 The cooke's reversible level (Fig 3)



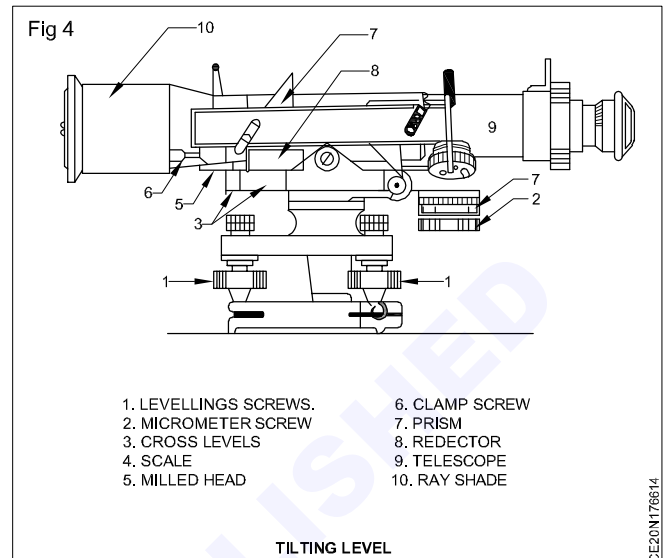
The cooke's level combines good features of both the dumpy and Y levels. By slackening the stop screw the telescope can be rotated about its longitudinal axis in its sockets and can also be withdrawn from its sockets and replaced and for end.

8 The crushing'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 is 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.

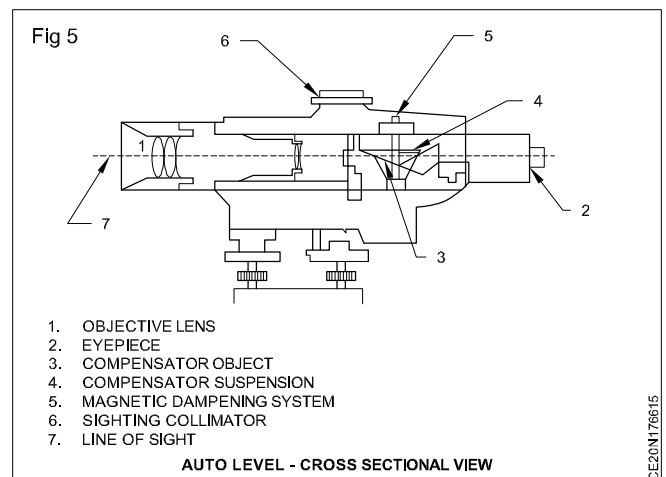
9 The modern (Tilting) Level (Fig 4)



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.

10 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)



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 ± 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 - It's 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 correspond 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 is 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.

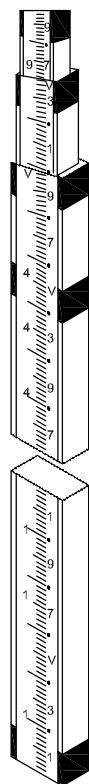
The foot of the staff is provided with a brass cap to avoid wear and tear due to usage.

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 1.25 m, which slides into the central box of 1.25 m length, which in turn slides into the lower box of length 1.5 m. Brass spring catches are provided to hold the extensions in position.

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.

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 man. This target staff is provided with a movable target. The target is provided with vernier, 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

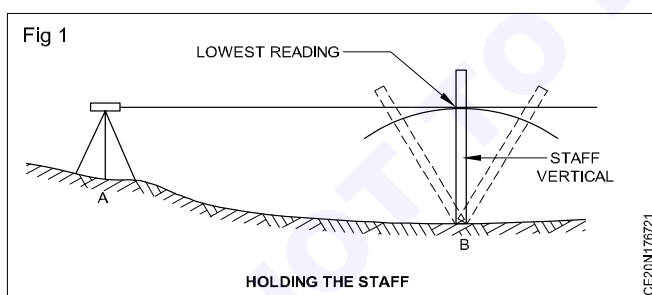
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Holding of levelling staff - temporary adjustments

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 staff, 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:

- Having set up and levelled the instrument carefully, direct the telescope towards the staff held vertically on the staff station and focus it.
- 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.
- 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 Focusing

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.

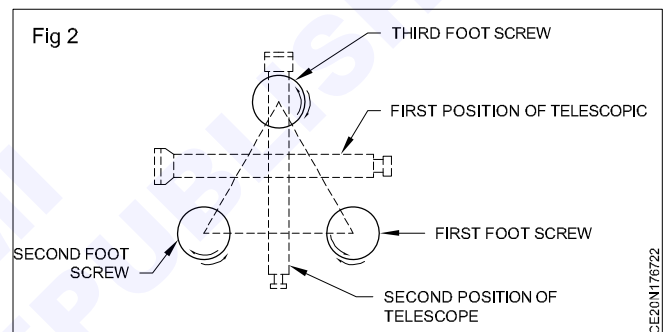
Levelling by foot-screws: Place the telescope parallel to any pair of the foot-screws and bring the long bubble to the centre of its run by turning these screws equally either both inwards or both outwards. To move the bubble to the right, turn the screws inwards and to move it to the left turn the screws outwards (right in and left out).

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 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.

Focusing

This is done in two steps viz. (Fig 2)



- i Focusing the eye-piece for distinct vision of the cross-hairs at diaphragm, and
- ii Focusing the object-glass for bringing the image of the object into the plane of the diaphragm.

Focusing 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.

Focusing 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 focusing 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 aluminum 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)

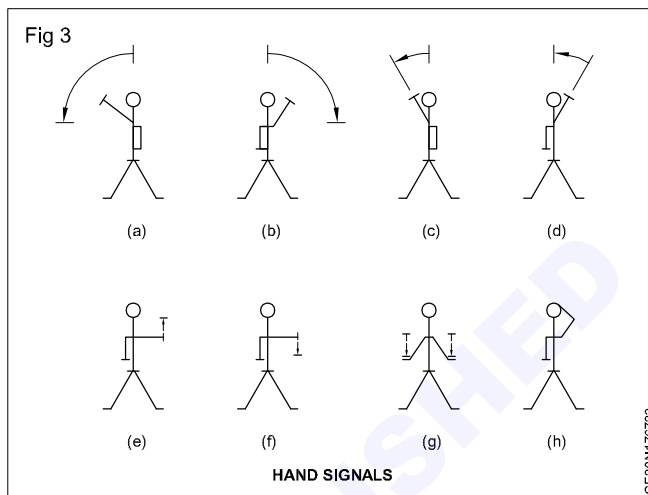


Table 1

	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

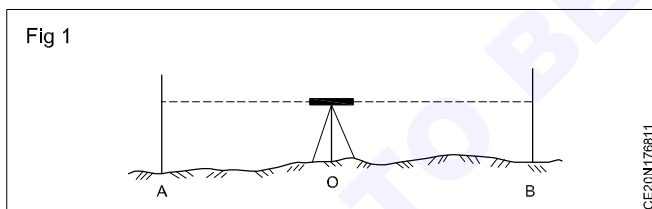
Direct levelling

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

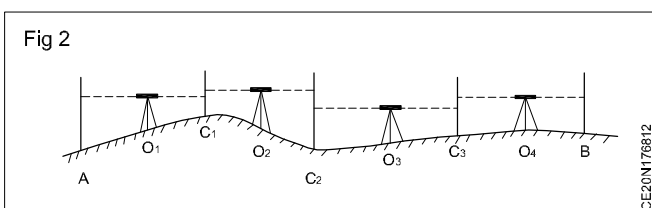
Simple levelling (Fig 1)



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

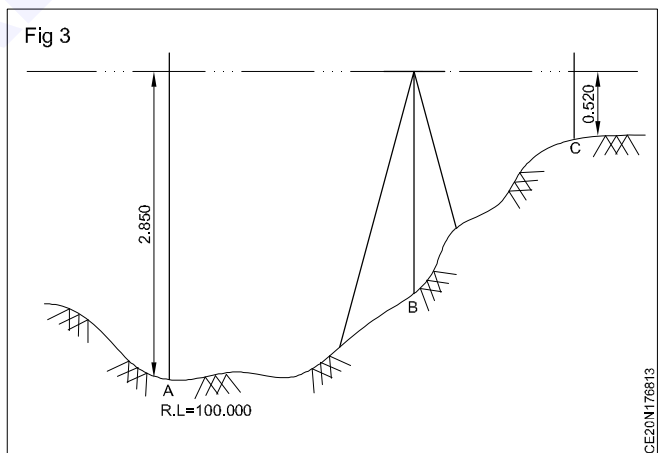
- i the points are at a great distance apart
- ii the difference of elevation between the points is large
- iii there are obstacles between the points.

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 O₁, O₂, O₃, etc. After temporary adjustments, staff readings are taken at every set up. The points C₁, C₂ and C₃ 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)



Example 1

In a simple levelling the Back sight taken 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
$$= 2.850 - 0.520$$
$$= 2.330$$

$$\begin{aligned}
 \text{Height of collimation} &= \text{R.L at point A} + \text{B.S. taken from point A} \\
 &= 100.000 + 2.850 \\
 &= 102.850 \text{ m}
 \end{aligned}$$

ii R.L. at point C

$$\begin{aligned}
 &= \text{Height of collimation} - \text{Foresight reading at C} \\
 &= 102.850 - 0.520 \\
 &= 102.330 \text{ m}
 \end{aligned}$$

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

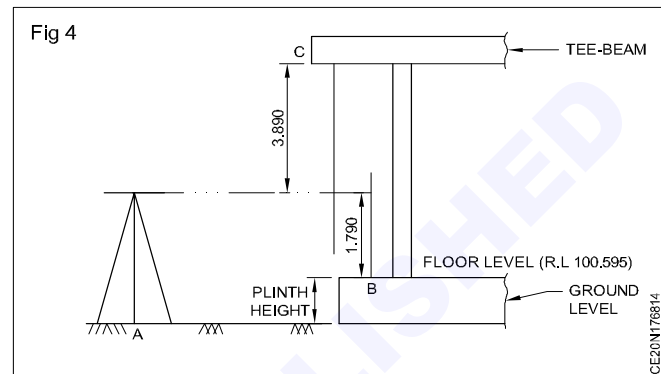
In this case, it occurs when the underside of a string course or sunshade is made a Benchmark, or when the elevation of the underside of girder, and arch or the

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. (Fig 4)



Solutions

- Sketch
- Tabulation

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 the beam

Calculation

$$\begin{aligned}
 \text{R.L of the floor} &= 100.595 \text{ m} \\
 \text{Staff reading on the floor (B)} &= 1.790 \text{ m} \\
 \therefore \text{Height of collimation at A} &= \text{R.L of the floor} + \text{Staff reading on the floor} \\
 &= 100.595 + 1.790 \\
 &= 102.385 \text{ m} \\
 \text{R.L. of the underside of the tee beam} &= 102.385 \\
 &= 102.385 - (-3.890) \\
 &= 106.275 \text{ m} \\
 \text{Height of the tee beam above the floor level} &= 106.275 - 100.595 \\
 &= 5.680 \text{ m (Ans)}
 \end{aligned}$$

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

$$\begin{aligned}
 &= \text{R.L. of B.M} + \text{Back sight} \\
 &= 100.000 + 2.045 \\
 &= 102.045 \text{ m}
 \end{aligned}$$

R.L of point 1

$$\begin{aligned}
 &= \text{HCL} - \text{I.S reading on point 1} \\
 &= 102.045 - 2.680 \\
 &= 99.365
 \end{aligned}$$

R.L. of point 2

$$\begin{aligned}
 &= \text{HCL} - \text{I.S. reading on point 2} \\
 &= 102.045 - 2.860 \\
 &= 99.185
 \end{aligned}$$

R.L. of Point 3

$$\begin{aligned}
 &= \text{HCL} - \text{I.S. reading on point 3} \\
 &= 102.045 - 2.120 \\
 &= 99.925
 \end{aligned}$$

R.L. of point 4

$$\begin{aligned}
 &= \text{HCL} - \text{I.S. reading on point 4} \\
 &= 102.045 - 2.975 \\
 &= 99.070
 \end{aligned}$$

R.L. of point 5

$$\begin{aligned}
 &= \text{HCL} - \text{F.S. reading on point 5} \\
 &= 102.045 - 2.860 \\
 &= 99.185
 \end{aligned}$$

Arithmetic 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.

$$\begin{aligned}
 \sum \text{B.S} - \sum \text{F.S} &= \text{Last R.L} - \text{First R.L} \\
 2.045 - 2.860 &= 99.185 - 100.000 \\
 &= -0.815
 \end{aligned}$$

Rise and fall method

B.S	I.S.	F.S	Rise	Fall	Reduced level	Remarks
2.045					100.00	Reading 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

$$= 2.045 - 2.680$$

$$= 0.635 \text{ (Fall)}$$

ii I.S. on point 1 – I.S. on point 2

$$= 2.680 - 2.860$$

$$- 0.180 \text{ (Fall)}$$

iii I.S. on point 2 – I.S. on point 3

$$= 2.860 - 2.120$$

$$= 0.740 \text{ (Rise)}$$

iv I.S. on point 3 – I.S. on point 4

$$= 2.120 - 2.975$$

$$= -0.855 \text{ (Fall)}$$

v I.S. on point 4 – F.S. on point 5

$$= 2.975 - 2.860$$

$$= 0.115 \text{ (Rise)}$$

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

$$\Sigma \text{B.S.} - \Sigma \text{F.S.} = \Sigma \text{Rise} - \Sigma \text{fall}$$

$$= \text{Last R.L.} - \text{First R.L.}$$

$$2.045 - 2.860 = 0.855 - 1.670$$

$$= 99.185 - 100.000$$

$$-0.815 = -0.815$$

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

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

$$\Sigma BS - \Sigma FS = \text{Last R.L.} - \text{First R.L.}$$

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:

$$\text{First reading} - \text{Second reading} = \pm \text{Rise / Fall.}$$

(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 $\pm$ 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.

$$\Sigma \text{B.S.} - \Sigma \text{F.S.} = \Sigma \text{Rise} - \Sigma \text{Fall} = \text{Last R.L.} - \text{First R.L.}$$

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 committed 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			

$$H.I. = R.L. + B.S. = 100.00 + 0.785 = 100.785$$

$$R.L. = H.I. - I.S. / F.S. = 100.785 - 1.367 = 99.459$$

Arithmetical check

$$\Sigma B.S. - \Sigma F.S. = 02.152 - 5.092 = -2.940$$

$$\text{Last R.L.} - \text{First R.L.} = 97.060 - 100.00 = 2.940 \text{ Ans.}$$

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	
ΣB	2.152	$\Sigma F.S$	5.092	1.094	4.034		

Arithmetical checks

$$\Sigma B.S. - \Sigma F.S. = 2.152 - 5.092 = -2.940$$

$$\Sigma \text{ Rise} - \Sigma \text{ Fall} = 1.094 - 4.034 = -2.940$$

$$\text{Last R.L.} - \text{First R.L.} = 97.060 - 100.00 = 2.940 \text{ Ans.}$$

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

$$= 201.030 + 3.370 = 204.400$$

$$\text{R.L. of a point 5} = 204.400 - 2.975 = 201.425$$

$$6 = 204.400 - 1.415 = 202.985$$

$$\text{R.L. of B.M.2 (7)} = 204.400 - 0.695 = 203.705$$

Arithmetical check

$$\sum \text{B.S.} = 1.430 + 3.370 = 4.800$$

$$\sum \text{F.S.} = 0.400 + 0.695 = 1.095$$

$$\sum \text{B.S.} - \sum \text{F.S.} = 4.800 - 1.095 = 3.705$$

$$\text{Last R.L.} - \text{First R.L.} = 203.705 - 200.000 = 3.705$$

$$\sum \text{B.S.} - \sum \text{F.S.} = \text{last R.L.} - \text{First R.L.}$$

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 = $\pm$ Rise / Fall.

R.L. of any point = R.L. of the previous point $\pm$ Rise/Fall

Difference in levels for station 2

$$= 1.430 - 2.015 = -0.585 \text{ (Fall)}$$

For Station 3 = $2.015 - 1.005 = +1.010$ (Rise)

$$4 = 1.005 - 0.440 = +0.605 \text{ (Rise)}$$

$$5 = 3.370 - 2.975 = +0.395 \text{ (Rise)}$$

$$6 = 2.975 - 1.415 = +1.560 \text{ (Rise)}$$

$$7 = 1.415 - 0.695 = +0.720 \text{ (Rise)}$$

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

$$\sum \text{B.S.} = 1.430 + 3.370 = 4.800$$

$$\sum \text{F.S.} = 0.400 + 0.695 = 1.095$$

$$\sum \text{B.S.} - \sum \text{F.S.} = 4.800 - 1.095 = 3.705$$

$$\sum \text{Rise} = 1.010 + 0.605 + 0.395 + 1.560 + 0.720 + 4.290$$

$$\sum \text{Fall} = 0.585$$

$$\sum \text{Rise} - \sum \text{Fall} = 4.290 - 0.585 = 3.705$$

$$\text{Last R.L.} - \text{First R.L.} = 203.705 - 200.00 = 3.705$$

$$\sum \text{B.S.} - \sum \text{F.S.} = \sum \text{Rise} - \sum \text{Fall} = \text{Last R.L.} - \text{First R.L.}$$

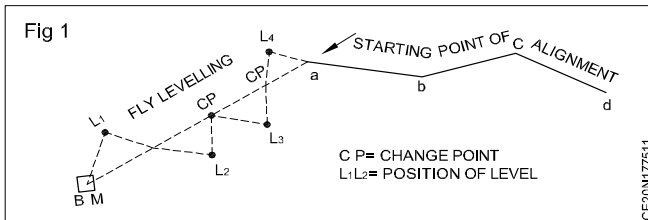
Hence OK.

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.

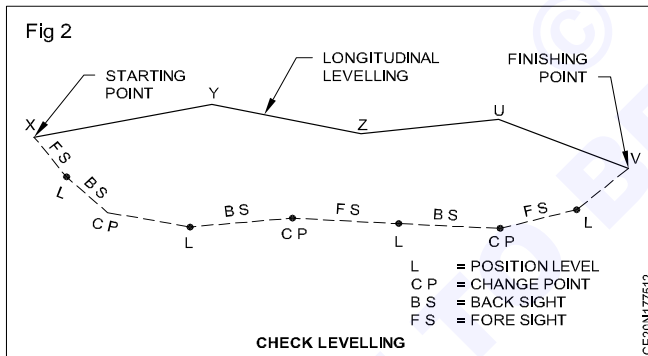
Fly Leveling (Fig 1)



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.

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)



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.

Problem on reduced levels

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

- compute the reduced levels of points and gradients of lines on sloping ground.

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 relative 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.

Refer Exercise No.1.7.70 - 74

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

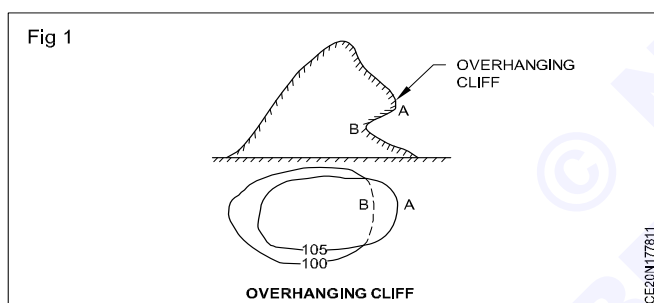
Objective: At the end of this lesson you shall be able to

- explain characteristics of contours.

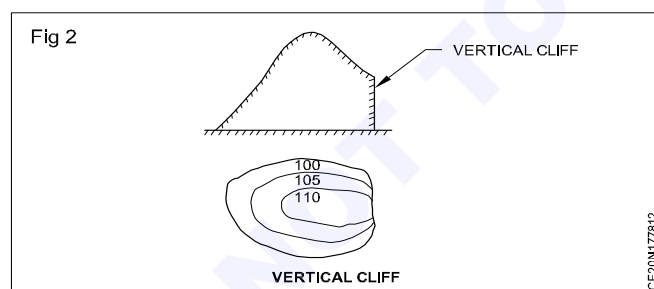
Characteristics of contours

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.

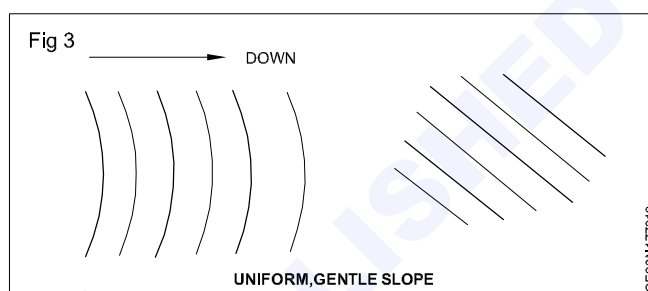
- All the points lying on one contour line have same elevation.
- Two contours of different elevations do not cross each other except in the case of overhanging cliff. (Fig 1)



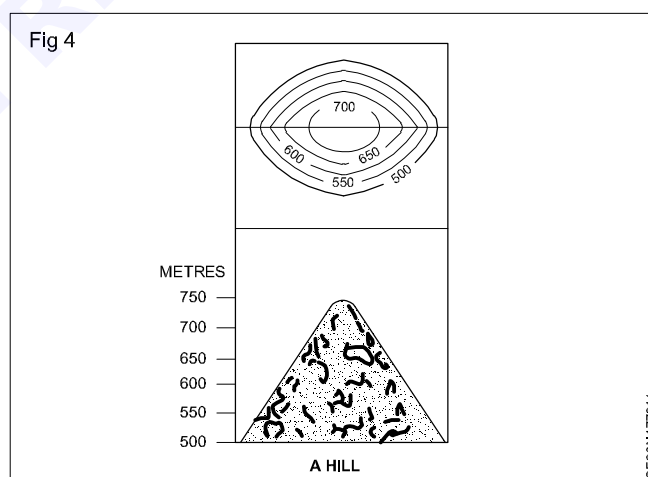
- Contours of different elevations do not unite to form one contour except in case of vertical cliff. (Fig 2)



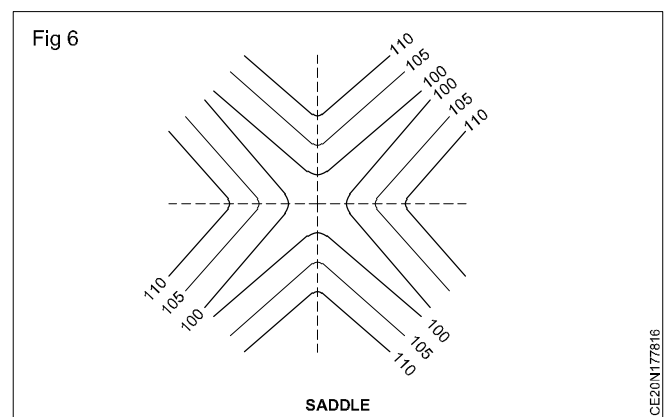
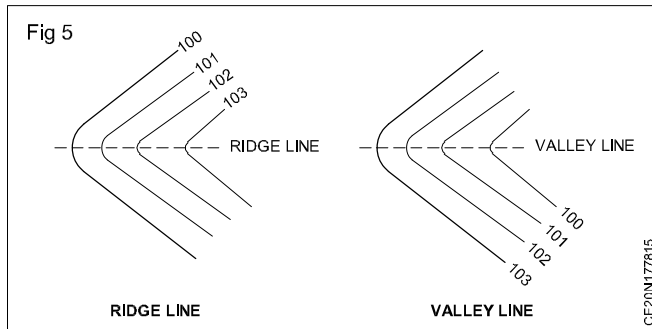
- Contours drawn closer represent a steep slope and if they are drawn far apart, represent a gentle slope. (Fig 3)
- Contours equally spaced represent a uniform slope. When contours are parallel, equidistant and straight they represent a plane area.
- The steepest direction through a point on the contour line is indicated by the perpendicular direction through that point.



- 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)



- 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)



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 methods by tachometric.
-

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 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 tachometry

1 By squares

This method is suitable for small and low undulating area. In this method the area to be surveyed is divided into a network of squares by running a series 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 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 upon the nature of the ground, contour interval and scale of plan. Usually the interval being 20 m in hilly area and 100m in flat country. Then, points at the 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 tachometric method

This method is suitable for contouring of hilly areas. An instrument station is chosen at the peak of that area. Set up the tachometer over that point and a number of radial lines at known angular interval are drawn on the ground. The interval may vary from 10^0 to 30^0 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 distances of these points from instrument station and reduced levels are calculated by using the tachometric formulae

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.

Interpolation of contours

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

- explain the term interpolation of contours
 - explain the various methods of interpolation of contours.
-

Interpolation of Contours

The process of placing or spacing the contour lines proportionally between the plotted ground points is known as interpolation of contours. It is based on the assumption that the slope of ground between two points is uniform.

Contours may be interpolated by the following methods.

- 1 By estimation
- 2 By arithmetical calculation
- 3 By graphical method.

1 By estimation

In this method the position of contour point is judged by estimation. The method is rapid. But it gives approximate results. It is used for small scale map.

2 By Arithmetical calculation

In this method of interpolation, the portion of contour points in between the plotted ground points are located by calculating their distance accurately based on their ratios of distance and level difference. This method is laborious and tedious. But it is the most accurate method.

E.g., let A and B are two points at a distance of 10 m and have reduced levels 41.3 and 43.6m respectively. Assuming 1 m contour interval, contours of 42 m and 43 m may be plotted between A and B.

Difference in level between A and B
 $= 43.6 - 41.3 = 2.5 \text{ m}$

Distance between A and B $= 10 \text{ m}$

Difference in level between A and B 42 m contour
 $= 42 - 41.3 = 0.7 \text{ m}$

Difference in level between A and B 43m contour
 $= 43 - 41.3 = 1.7 \text{ m}$

Distance of A and 42m contour
 $= 10 \times 0.7 / 2.5 = 2.8 \text{ m}$

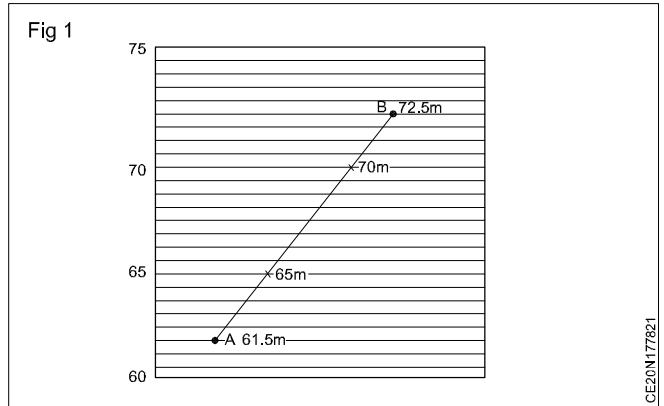
Distance of A and 43m contour
 $= 10 \times \frac{1.7}{2.5} = 6.8 \text{ m}$

Hence the point of reduced levels 42 m and 43m are 2.8m and 6.8 m distance away from A. The contour points are then plotted, by scaling these distances to the scale of the map.

3 By graphical method

Graphical methods of interpolation are simpler as compared to arithmetical methods and also the results obtained are accurate. Out of several graphical methods, the one in common use is explained below.

Suppose the contour interval is 5 m, then on a piece of tracing cloth, a number of parallel lines spaced at 0.5m (usually one tenth of the contour interval) are drawn, every tenth line being made thick (Fig 1). Suppose it is required to interpolate contours between two points A and B of elevations 61.5 and 72.5m respectively.



If the bottom line represents an elevation of 60m, then the successive thick lines will represent 65m, 70m and 75 m etc. Place the tracing cloth so that the point A is on the third line from the bottom. Now, move the tracing cloth until B is on the fifth line above the 70 m thick line. The intersections of the thick lines 1 and 2 representing elevations of 65 m and 70 m contours respectively and picked through on the plan with a pin.

Drawing of contour

After establishing points on the various contours, contour lines are drawn as fine and smooth free hand curved lines of uniform thickness. They may also be represented by broken lines. The line should be inked either in black or brown. Red or crimson may also be used for inking in special cases. Curves may be drawn with French curves as far as possible.

Usually every fifth contour is thicker than the rest. Elevations are in the uniform manner. The figures indicating the elevation of contour are written at the beginning, middle and at the end of the contour lines. The figures should be normal to the contours and they should be placed uniformly in such way, that they can be read from one or two ends on the contour map.

Contour gradient

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

- describe the term contour gradient
- explain the method of locating contour gradient
- explain the method of erecting grade stake.

Contour Gradient

Contour gradient may be defined as a line lying on the surface of the ground with uniform inclination to the horizontal at all points on it.

Locating a contour gradient on a contour plan

While locating a highway or railway or canal contour map a controlling factor is the gradient line. In portions of the location, the grade line ascends or descends at a uniform rate. At some places the grade line may be at the maximum gradient permissible. A uniform grade line can be drawn on the map by first calculating the horizontal distance corresponding to the contour interval and the given gradient.

Let A be the point on a contour line of RL 60.00m from which it is required to trace the contour gradient with ruling gradient of 1 in 30 (falling).

In the contour plan contour lines are drawn with a contour interval of 2 m. Since the contour interval is 2 m and the gradient is 1 in 30, the horizontal distance required between successive points on consecutive contours is 60 m (30 x 2m). With A as centre and the horizontal distance 60 m to the scale of the drawing as radius, draw an arc cutting 58 m contour at B and B¹.

Considering the point lying nearer to the progressive direction of the centre route, the point is selected. Let it be B. Then B as centre and with the same radius draw

another arc cutting the 56 m contour at C. Select the suitable point and repeat the same process up to the last contour. The line joining the points, A, B, C, D etc. gives the alignment for the given gradient.

The contour gradient thus established on the contour map can be then transferred to the field by the use of suitable surveying instrument.

Grade stakes

Stakes or pegs erected in ground in such a way that their top is at the formation level or their top at any whole number of metres above or below the formation level.

Setting grade stake

It is the process of erecting the stakes at a given elevation or gradient. They indicate cut or fill required to bring the surface of the ground to a given grade. Knowing the formation level at each chainage from the profile and height of instrument calculate the staff reading required to set a given grade. Staff reading may be calculated by subtracting the formation level from the height of instrument. This staff reading is called grade rod.

Stake may be set out in several methods, one of which is explained below

Each stakes may be driven so that its top is any whole number of metres above or below grade for formation level.

Suppose the formation level of the point 130.000m and the ground level at that point is 132.265m. The height of instrument has been found to be 134.255

The grade rod or staff reading required

$$\begin{aligned} &= \text{HI} - \text{formation level.} \\ &= 134.255 - 130.000 \\ &= 4.255\text{m} \end{aligned}$$

The surface of ground is raised

$$\begin{aligned} &= \text{GL} - \text{formation level.} \\ &= 132.265 - 130.000 \\ &= 2.265 \text{ m above ground.} \end{aligned}$$

As the ground is above the formation level we cannot erect the pegs at formation level A. So it may be erected at some whole numbers of metres above formation. Let the stake may be erected 2.5 m above the formation level.

The staff reading required to establish the stake 2.5m above grade or formation level.

- Compass
- Abney level
- Pedometer
- Clinometer
- Ghat 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 elevation 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.

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 intervals in plain terrain and at about 50m intervals in rolling terrain should be taken.

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 the 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 up to 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 shoulder 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	8.0 m
Village Roads	7.5 m

Introduction to theodolite and vernier 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 angles. Later further additions were made to make possible of several uses such as prolonging a line, establishing line, levelling, measuring the distance indirectly (tachometry) etc.

It is sometimes referred to as universal instrument. Theodolite is a 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.

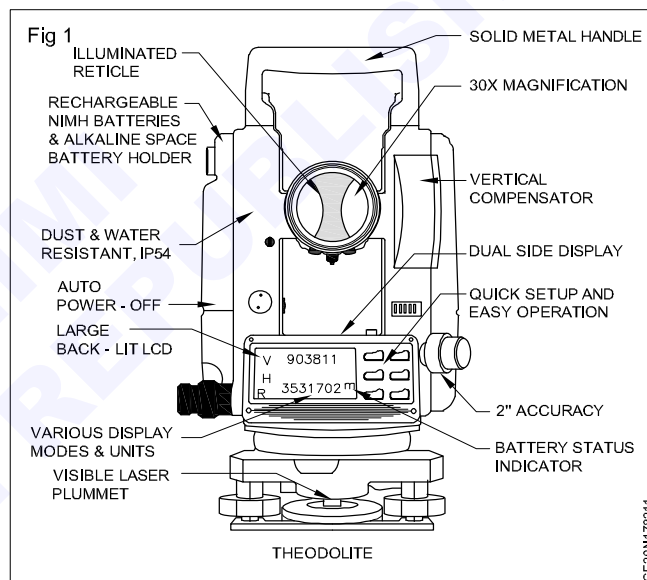
1 Transit or engineer's theodolite

A theodolite is said to be transit one when its telescope can be revolved through 180° 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 be revolved through 180° in a vertical plane about its horizontal axis. Non transit theodolites are obsolete nowadays

2 Designation of theodolite (Fig 1)

The size of a theodolite is defined by its diameter of the graduated circle of the lower plate. For example, a 25cm theodolite means the diameter of the lower graduated circle is 25cm.



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)

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.

Fig 1

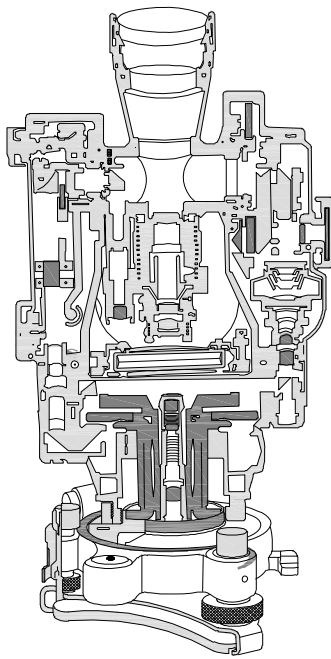
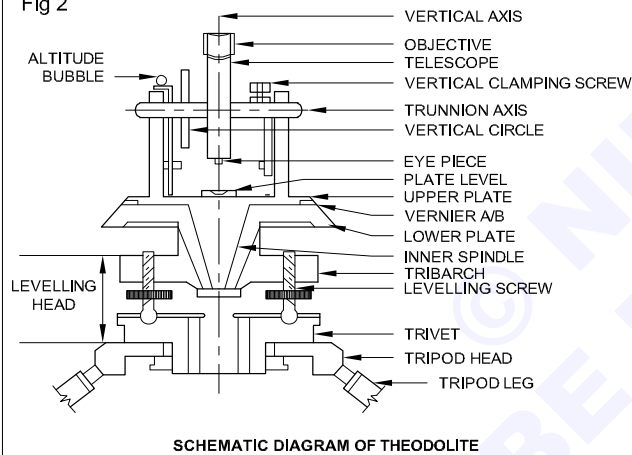


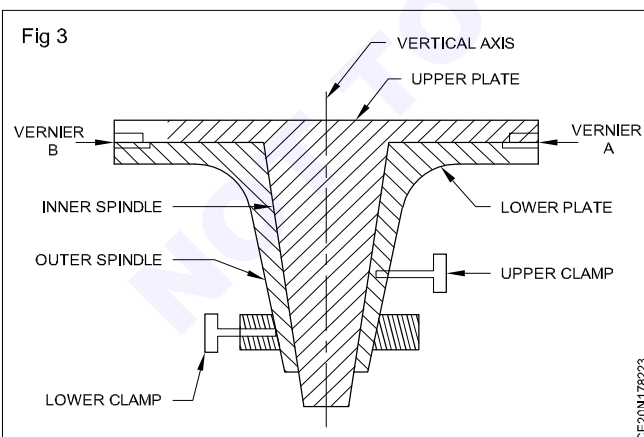
Fig 2



SCHEMATIC DIAGRAM OF THEODOLITE

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

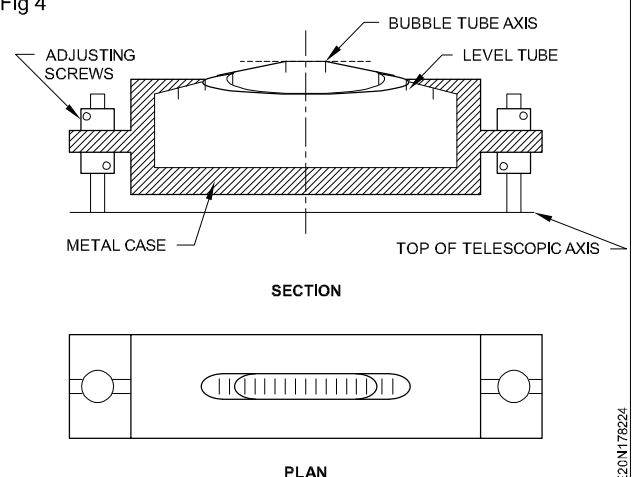
- 1 Upper and lower circles are locked together using upper clamping screw and small differential movement of plates is achieved using upper tangent screw.
- 2 Lower plate is clamped to the outer spindle using lower clamping screw and small differential movement between lower plate and spindle is achieved 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.

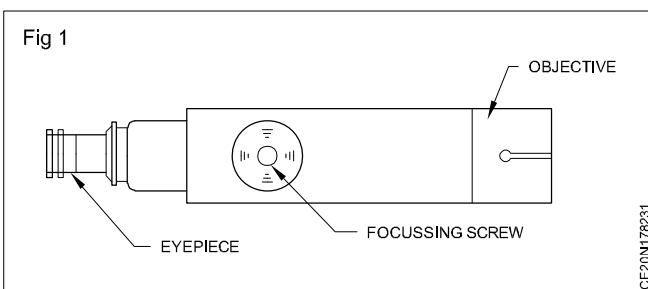
The bubble of the plate level is centered with help of the foot screws. These level help to make the vertical axis of the instrument truly vertical.

Main parts of a vernier theodolite -II

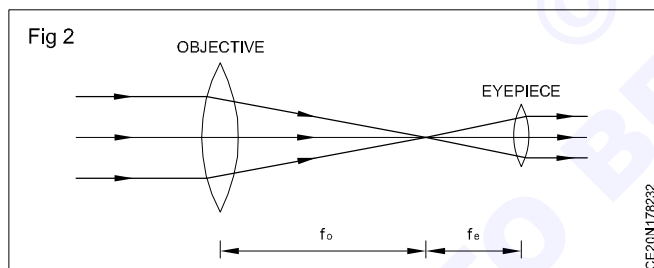
Objectives: At the end of this lesson you shall be able to

- explain working principle of telescope
- type of telescope
- state main functions 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,



- An eye piece (held next to the eye when sighting through telescope)
- A diaphragm and
- 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.

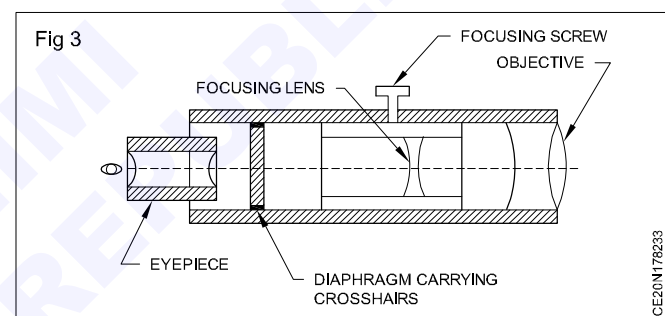
The principle of telescope is that in a lens all rays passing through the optical centre of the lens go straight without any bending while the other rays get deflected and go through the principle focus F.

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 noting 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.

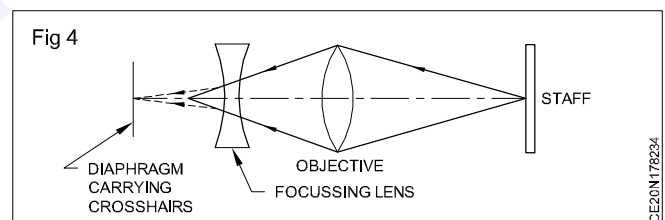
Types of telescope

Telescope of theodolite may be internal focusing type or external focusing type. Now a days the most commonly used telescopes are internal focusing type.

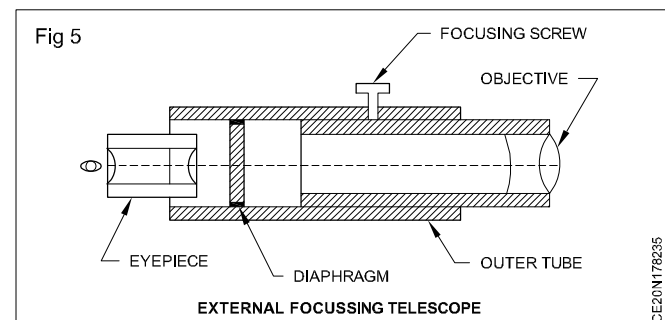
Internal focusing telescope (Fig 3)



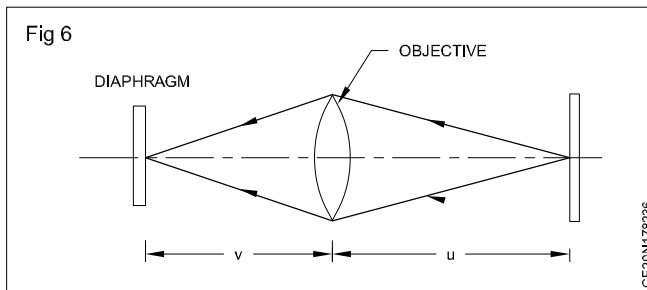
Ray diagram of internal focusing telescope (Fig 4)



External focusing telescope (Fig 5)



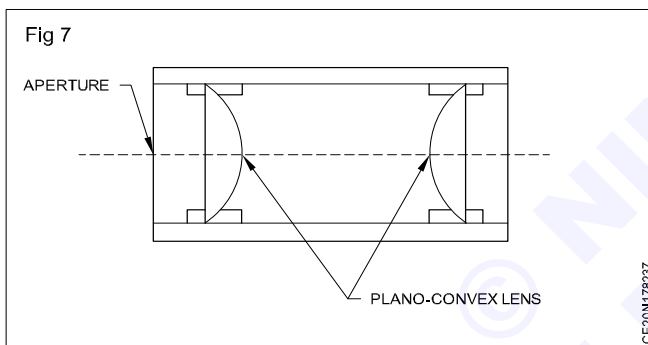
Ray diagram of external focusing telescope (Fig 6)



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 reticle 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 tachometry surveying.

Main parts of a vernier theodolite -III

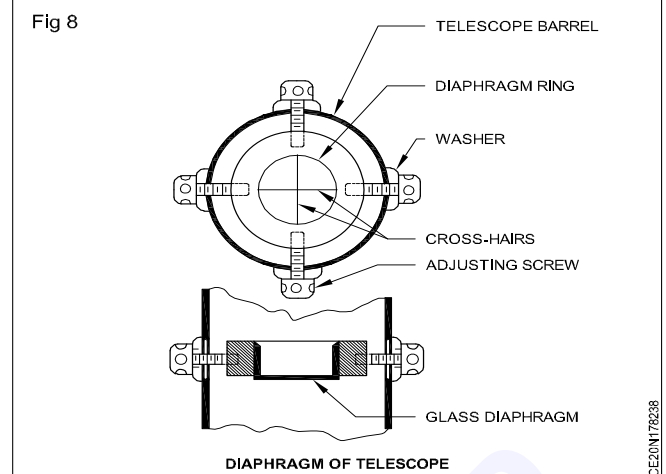
Objectives: At the end of this lesson you shall be able to

- state graduations of vertical circle
- state main parts of theodolite
- differentiate a frame and frame.

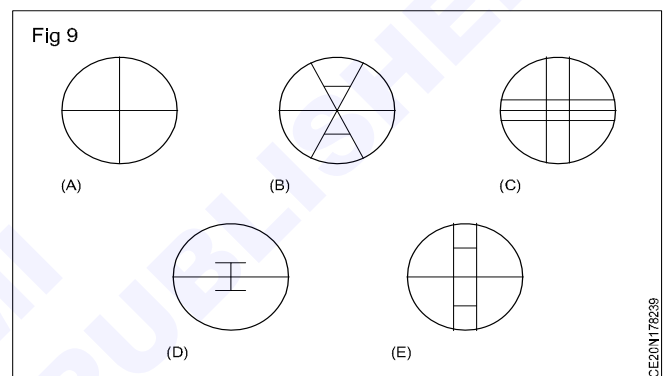
Vertical circle

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.

Diaphragm of telescope (Fig 8)



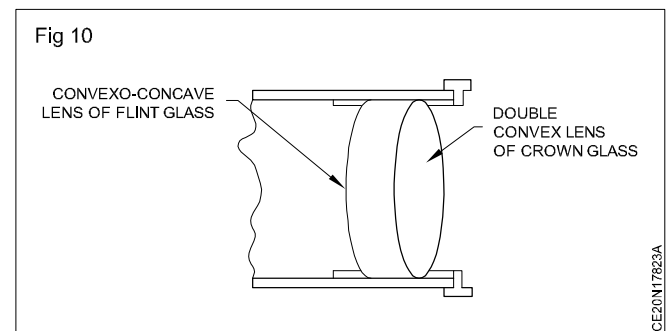
Commonly used cross hairs (Fig 9)



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.

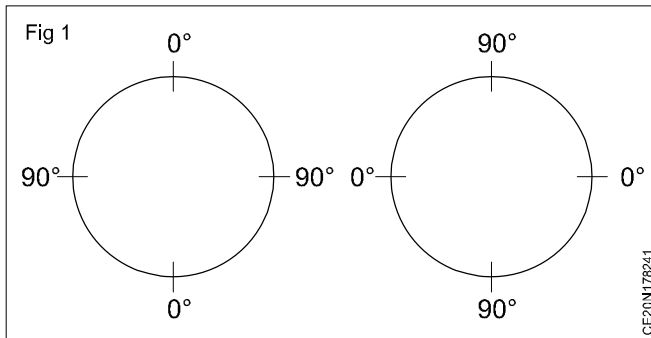
Objective glass (Fig 10)



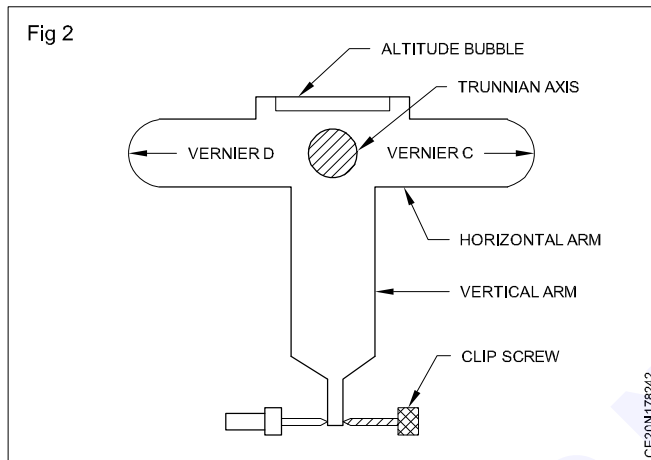
- 1 The vertical circle is divided into four quadrants from 0° to 90° in both the directions. The $0^\circ - 0^\circ$ line is a vertical line.

- 2 The vertical circle is divided into four quadrants from 0° to 90° in both the directions. The $0^\circ - 0^\circ$ line is a vertical line.

Graduation systems of vertical circle (Fig 1)

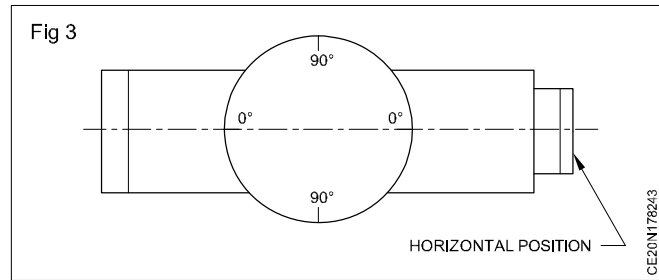


Index frame (or 'T' frame or vernier frame) (Fig 2)

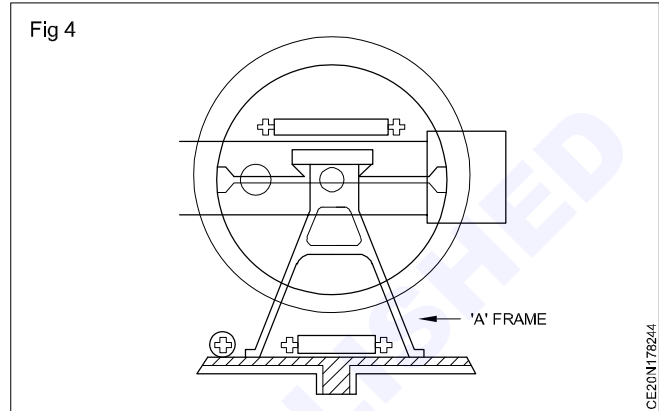


It resembles the English letter T and is centered on the horizontal axis of the instrument. It consists of a vertical arm and a horizontal arm. The vertical arm is called dipping arm and a horizontal arm is called an index arm. Clipping arm is provided with a fork and two clipping screws at its lower 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)



The standards or ('A' Frame) (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.

Terms used in theodolite survey

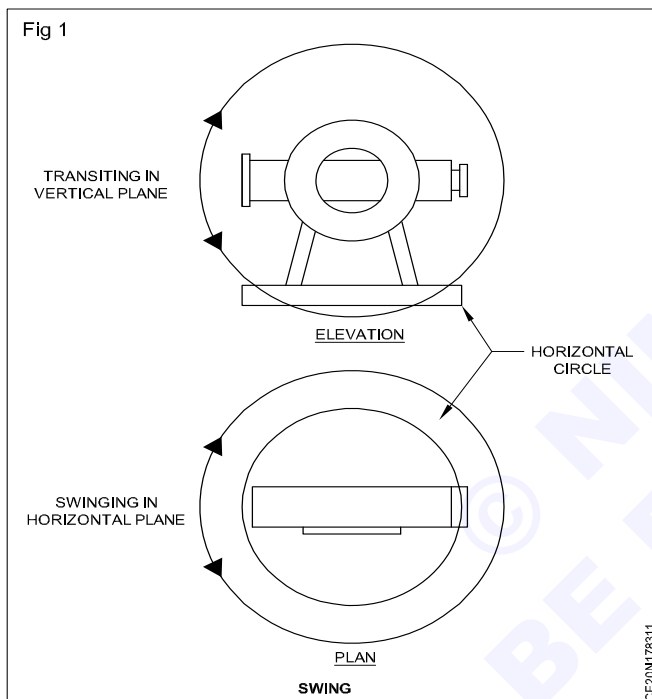
Objectives: At the end of this lesson you shall be able to

- 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)



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.

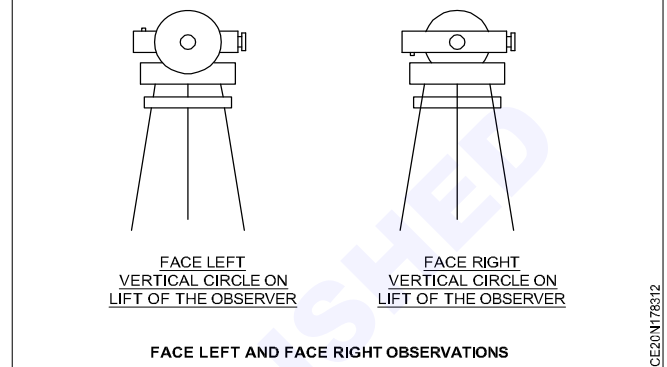
When the telescope is rotated anti-clockwise it is called left swing.

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 circle of the instrument on the left side of the telescope is known as face left observations.

Fig 2



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.

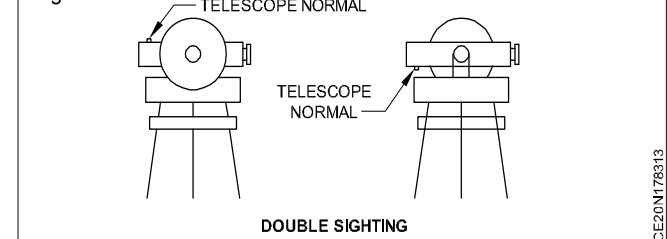
Lining in

The process of establishing intermediate points with a theodolite on a given straight line, whose both ends are inter visible 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 inter visible (e.g. forest) is called balancing in.

Fig 3



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 Focusing
 - a Focusing the eyepiece
 - b Focusing 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

Focusing

Focusing is done to eliminate parallax error

Focusing 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 distinct.

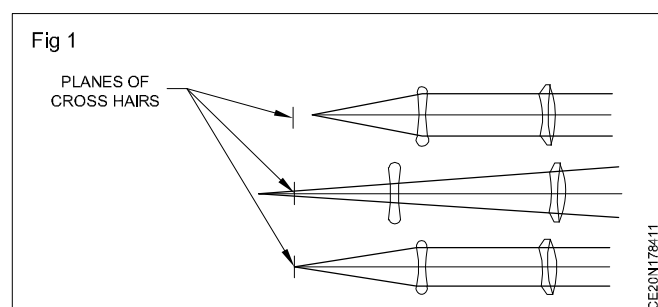
Focusing the objective

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 sign brings the lens in proper position and parallax eliminated (c)



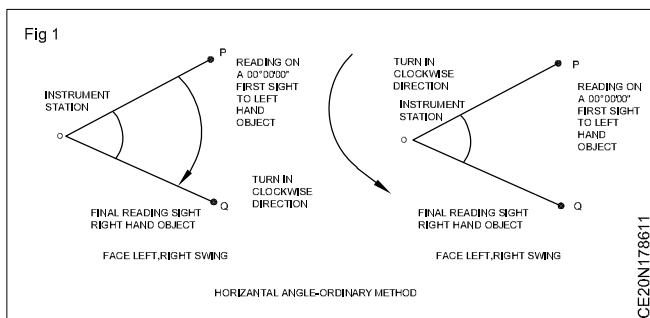
Theodolite - measuring horizontal angle - ordinary method

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 00°00'00". 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.
- 4 Theodolite should swing in clockwise direction (Right swing) for face left observation and swing in anticlockwise direction (Left 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.

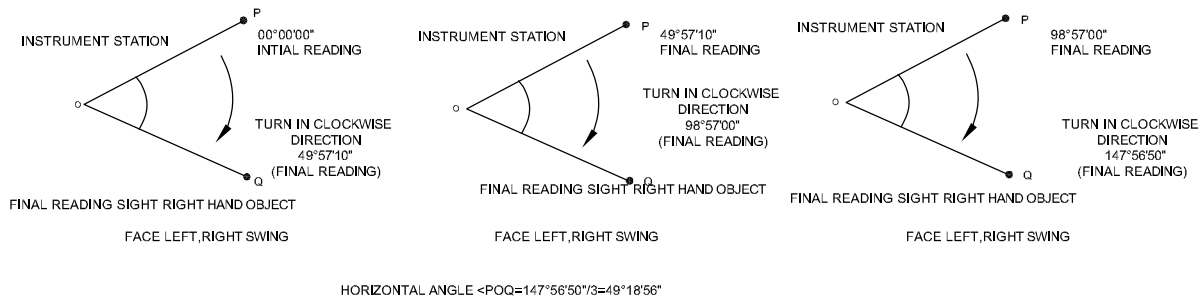
Fix two stations, P and Q on the ground and set up the instrument (Fig) at the point, 'O'. Perform all temporary adjustments. Set vernier A 00°00'00". Sight the left hand station (Fig 1) chose the upper clamp, sight the right

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 the above steps (Fig 2). The mean of the face left and face right observations is the final required angle.

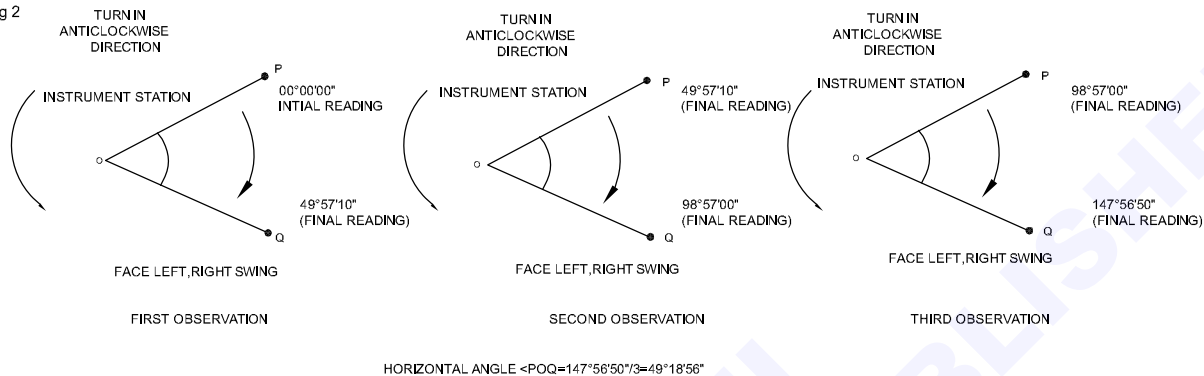
Suppose that, for measuring a horizontal angle θ , 'n' times repetitions are done. Then angle $\theta = (n \times \theta) \div n$.

Fig 1



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Fig 2



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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, 00°00'00", 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 $\angle QOR$ by deducting $\angle POQ$ from $\angle POR$. Thus determine the remaining three angles separately for both face observations. Average of the two face observations

is the required angle. Sum of all the four angles to check whether the sum is 360° . 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 of depression. Angle of depression is a negative angle (-).

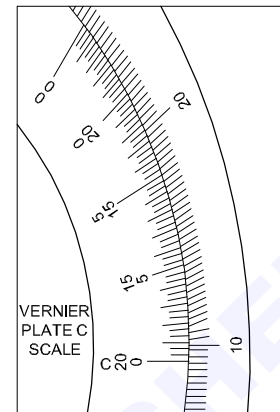
The method of measuring vertical angle varies according to the type of the instrument used. Engineer's transit measures vertical angle with respect to horizontal line. Electronic theodolites can measure vertical angle with respect to horizontal line or with respect to zenith.

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 90° 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 90° 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.

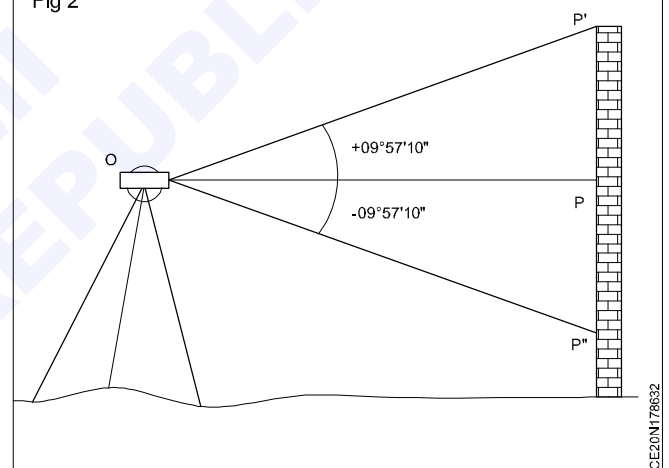
The object to which the vertical angle is required is bisected using the vertical clamping screw and its tangent screw. The reading on the vertical circle is now read. Change face of the instrument and take another reading. Mean of the readings is the vertical angle.

Fig 1



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Fig 2



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Point to remember

- 1 Carefully read Vernier C and Vernier D
- 2 Signs of angles should be noted down very carefully.

To eliminate or minimize errors due to in adjustments of the instrument, both face readings should be taken.

Angle of elevation, $\angle POP' = +09^\circ 57' 10''$

Angle of depression, $\angle POP'' = -09^\circ 57' 10''$

Included vertical angle, $\angle POP'' = \angle POP' + \angle POP'' = 19^\circ 54' 20''$

240

[illegible]

Measurement of vertical Angle

Instrument at	Sight to	Face Left								Left Right								Average Vertical Angle			Rough Sketch																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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Permanent adjustments of theodolite

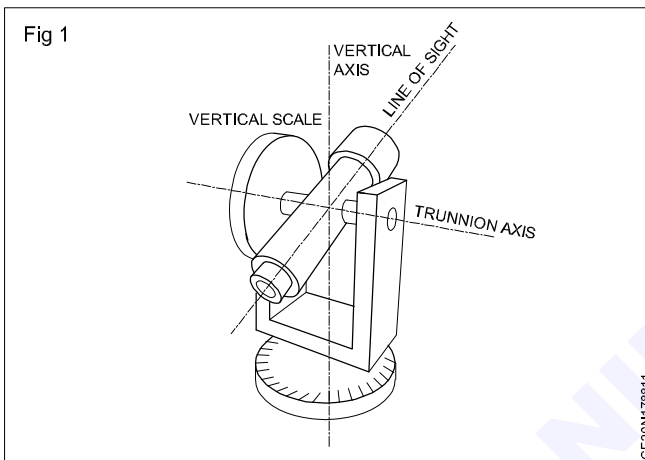
Objectives: At the end of this lesson you shall be able to

- 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. Manufacturers 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 theodolite. However, the prolonged use of theodolite and mishandling of instrument in field will make the fundamental lines relations altered, there by observations become erroneous.

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 lie 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 centre when the line 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.

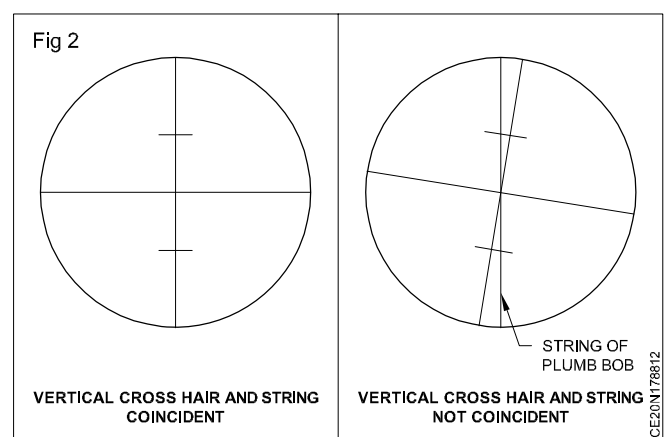
Test

To test, the instrument is levelled and the telescope is rotated through 180° . 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)



Relation established

The vertical cross-hair should lie in a plane perpendicular to the horizontal axis.

Test

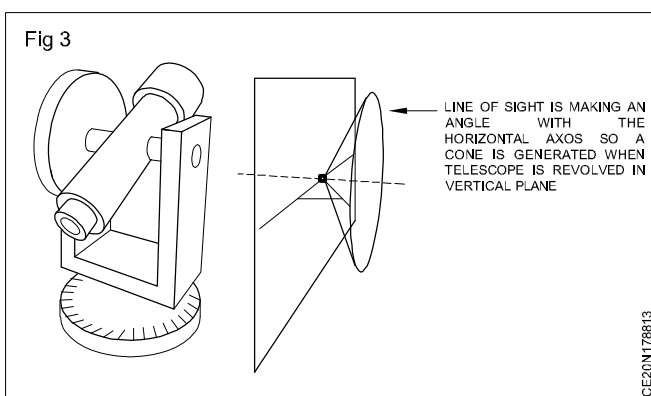
Instrument is levelled. The telescope is directed towards a plumb bob string at rest. The string is bisected and telescope is rotated slightly in a vertical plane. If the relation is in perfect condition, the image moves off the cross hair it means the relation is not in adjustment.

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.

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 pass 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

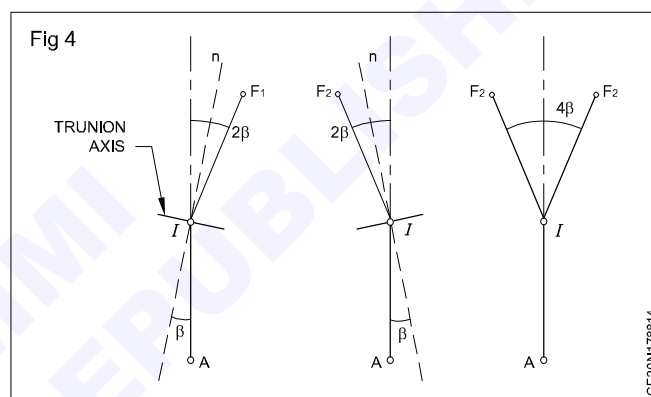
Fix the new point. Measure the distance between points, Measure a quarter of the distance from the last point.

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

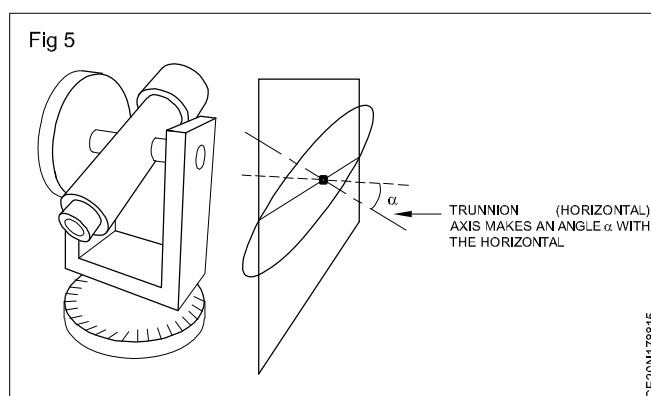
The horizontal axis should be perpendicular to the vertical axis.

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)



Test

Set up the instrument near any tall object which has a well defined point available at 60° to 70° 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.

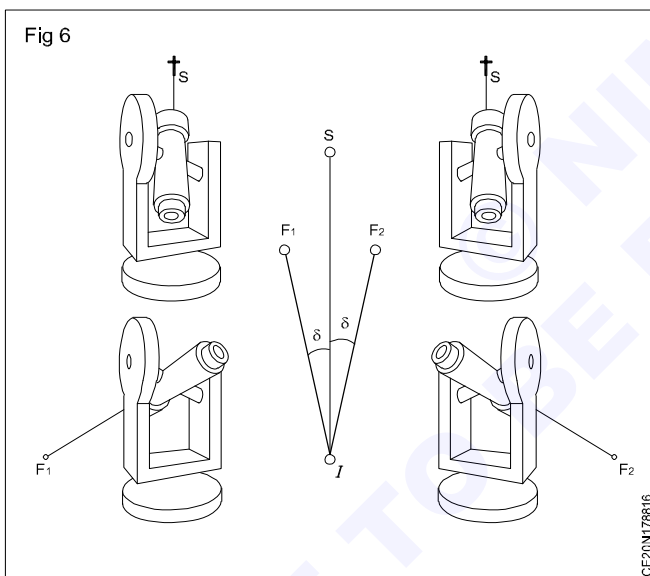
Adjustment

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 is 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.

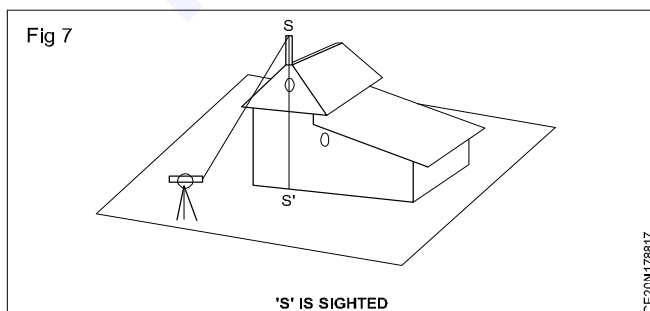
Figure 6 showing well defined point 'S' is sighted and foot F_1 and F_2 established at ground.

Spire test (Fig 6)

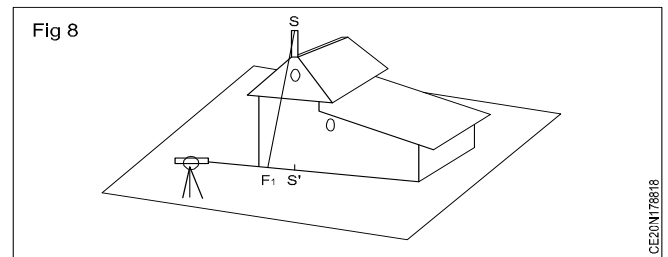


The deflection error, refer the difference between the back sight and foresight directions. It is not a measure of the axis tilt. An angle of 2δ will be subtended between the two foresights.

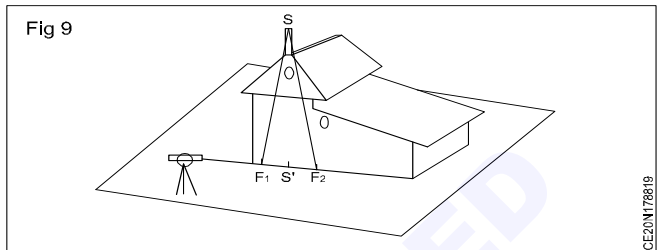
'S' is sighted (Fig 7)



Find foot of S by face left observation (Fig 8)



Find foot of S by face right observation (Fig 9)



Vertical Circle index test

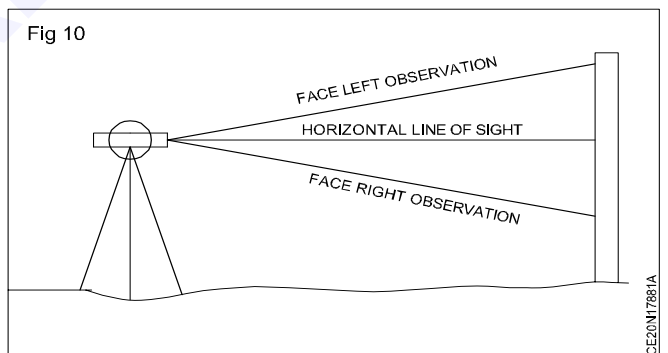
Relation Established

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.

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)



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.

Introduction to total station

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

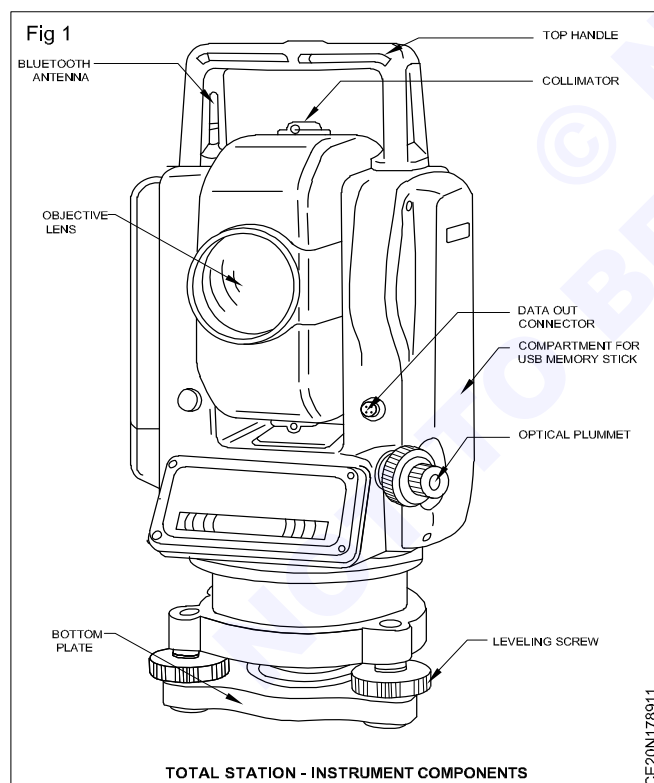
- get introduced to the total station, benefits and uses.

General

At present the analogue methods of recording data for conventional surveying is changed to digital data collection methods. Previously plane table is used as the best way to map a small area. But the output of a plane table is just a low precision analogue drawing in case of plane table the map is drawn directly on a sheet in a fixed scale, there was no way to replot the map to different scales and the quantity of topographic data collected was few. But these limitations can be overcome by the use of modern electronic total stations. With the use of total stations, we can use fastest digital data collection methods.

Definition

Total station is an assembly of a short to medium range EDM instrument installed in the framework of an electronic theodolite with all components under the control of a built-in micro-processor. This single instrument permits observing distances and directions from a single setup. (Fig 1)



Important parts of total station

Features of total station

- 1 The theodolite is offering a complete product family. It is easy for a user to switch between models without learning a new operation.

- 2 Absolute circle reading.
- 3 Excellent hardware features, such as laser plummet, endless drives on both sides for Hz and V, brilliant optics with 30x magnification.
- 4 Dual-Axis compensation for reliable Hz and V reading
- 5 New and intuitive software.
- 6 Unique levelling guidance for fast and convenient setup.
- 7 High resolution LCD display.
- 8 Audible notice for 900 turns and layout.
- 9 Electronic laser distance measurement.
- 10 Graphic sketches.
- 11 Hassle-free EDM measurement with red laser on any target or on the flair-prism.
- 12 Enter the data at the office and simply call up at the site.
- 13 Upload and transfer data via on board data connection.
- 14 Data editing and exchange in total stations.
- 15 Connectivity to 3rd party devices.

Use of total station

The instrument is mounted on a tripod and is levelled by operating levelling screws. Within a small range instrument is capable of adjusting itself to the level position. Then vertical and horizontal reference directions are indexed using onboard keys. It is possible to set required units for distance, temperature and pressure (FPs or SI). Surveyor can select measurement mode like fine, coarse, single or repeated.

When target sighted, horizontal and vertical angles as well as sloping distances are measured and by pressing appropriated keys they are recorded along with point number. Heights of instrument and targets can be keyed in after measuring them with tapes. Then processor computes various information about the point and displays on screen. This information is also stored in electronic note book. At the end of the day or whenever downloaded to computers, the point data downloaded to the computer can be used for further processing. There are software's like auto civil and auto plotter clubbed with AutoCAD which can be used for plotting contours at any specified interval and for plotting cross-section along any specified line.

Types of total station

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

- explain the advantages and disadvantages of total station
- explain the types of total stations
- explain the precautions to be taken while using total station.

Advantages of total station

The advantages of total station include:

- 1 Quick setting of the instrument on the tripod using laser plummet.
- 2 On-board area computation programmed to compute the area of the field.
- 3 Greater accuracy in area computation because of the possibility of taking arcs in area computation.
- 4 Graphical view of plots and land for quick visualization.
- 5 Coding to do automated mapping. As soon as the field jobs are finished, the map of the area with dimensions is ready after data transfer.
- 6 Enormous plotting and area computation at any user.
- 7 Integration of database (exporting map to GIS packages)
- 8 Automation of old maps.
- 9 Full GIS creation (using map info software)
- 10 Local language support

Disadvantage of total station

- 1 Their use does not provide hard copies of field notes. Hence it may be difficult for the surveyor to look over and check the work while surveying.
- 2 For an overall check of the survey, it will be necessary to return to the office and prepare the drawings using appropriate software.
- 3 They should not be used for observations of the sun, unless special filters, such as the Troelof's prism, are used. If not, the EDM part of the instrument will be damaged.
- 4 The instrument is costly, and for conducting surveys using total station, skilled personnel are required.

Types of total stations

In the early days, three classes of total stations were available - manual, semi-automatic and automatic.

Manual total stations

It was necessary to read the horizontal and vertical angles manually in this type of instrument. The only value that could be read electronically was the slope distances.

Semi-automatic total stations

The user had to manually read the horizontal circle for these instruments, but the vertical circle readings were shown digitally. Slope distances were measured electronically and the instruments could, in most cases be used to reduce the values to horizontal and vertical components.

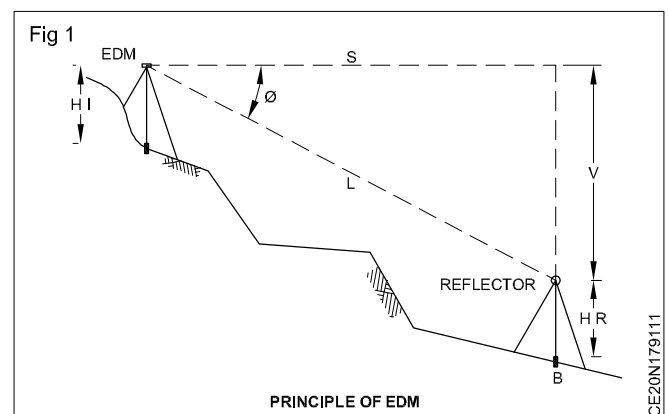
Automatic total stations

This type is most common total station used now-a-days. They sense both the horizontal and vertical angles electronically and measure the slope distances, compute the horizontal and vertical components of those distances, and determine the coordinates of observed points, it is necessary to properly orient the instrument of some known directions such as true north, magnetic north or to some known bearing. The coordinate information obtained can either be stored in the total station's memory or by using an external data collector.

Manual total stations and semi-automatic total stations are obsolete now. At present, it is the age of fully automatic total stations and robotic total stations.

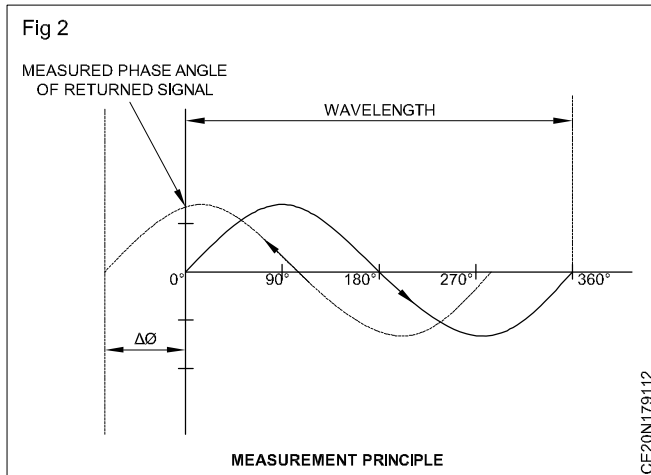
Almost all total stations in the market use infrared as the carrier for distance measurement. The less expensive unit with a single prism reflector can measure distances up to 1000 m. Those in higher price range are capable of measuring distances up to 2000 m, when single prism is used. the accuracies of measurements with the less expensive instruments probably run about 6 (5 mm / 5 ppm) and the expensive total stations can run about 6 (1 mm / 1 ppm)

Principle of EDM

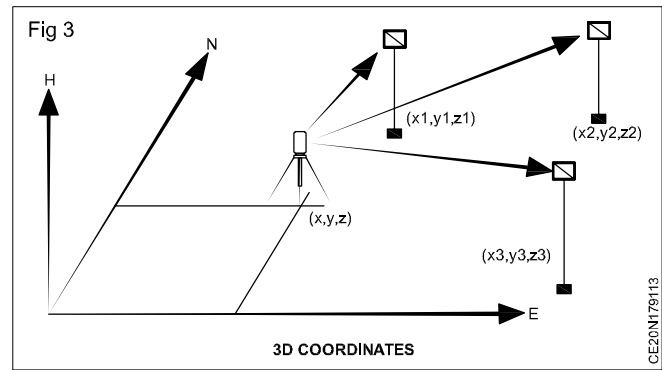


Measurement of distance is accomplished with a modulated microwave or infrared carrier signal, generated by a small solid-state emitter within the instrument's optical path, and reflected by a prism reflector or the object under survey. The modulation pattern in the returning signal is read and interpreted by the onboard computer in the total station. The distance is determined by emitting and receiving multiple frequencies, and determining the integer number of wavelengths to the target for each frequency. Most total stations use purpose-built glass Porro prism reflectors for the EDM signal, and can measure distances to a few kilometers. The typical total station can measure instances to about 3 millimeters or 1/1000th of a foot.

Basics of total station



- Angles and distances are measured from the total station to points under survey, and the coordinates (X, Y and Z or northing, easting and elevation) of surveyed points relative to the total station position are calculated using trigonometry and triangulation.
- Most modern total station instruments measure angles by means of electro-optical scanning of extremely precise digital bar-codes etched on totaling glass cylinders or discs within the instrument. The best quality total stations are capable of measuring angles to 0.5 arc-second. Inexpensive "construction grade" total stations can generally measure angles to 5 or 10 arc-seconds.
- Total Station - requires line of sight observations and must be set up over a known point or with line of sight to 2 or more points with known location.

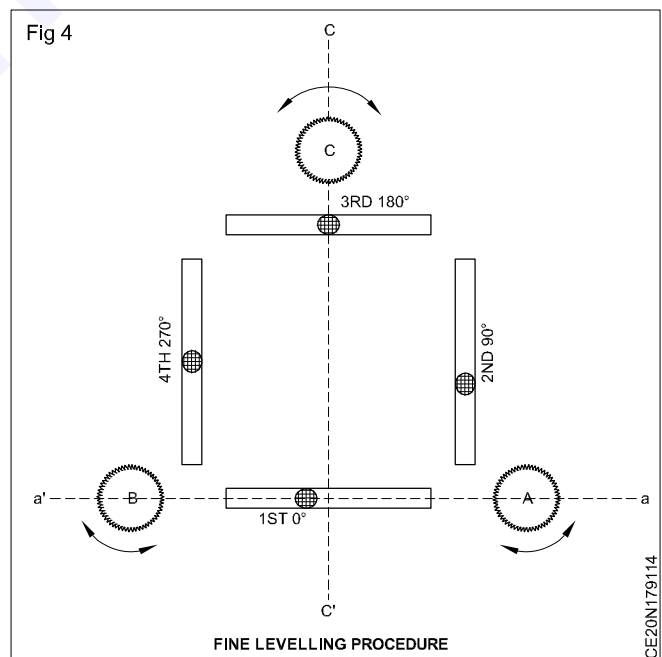


From the above figure

- Where E & N gives the position and Z gives the reduced level
- Suppose we know (x, y, z)
- We need an algorithm to calculate positions of x_1, y_1, z_1 ; x_2, y_2, z_2 & (x_3, y_3, z_3) w.r.t. (x, y, z) .
- For this algorithm we need inputs.

Inputs for the algorithm are

- Co-ordinates at which the instruments stand.
- Height of the instrument
- Orientation of the instrument ($H_z = 0$).
- Height of the reflector
- Angle at which the prism is placed w.r.t. orientation.
- or
- $00^\circ 00' 00''$
- $D^\circ M' S''$
- H_i



Characteristic and features of total station

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

- **define features of total station**
- **state the characteristics of total station**
- **advantages and disadvantages of total station.**

Features of total stations

Total station is capable of measuring angles and distances simultaneously and combine an electronic theodolite with a distance measuring system and a microprocessor.

Angle management

All the components of the electronic theodolite described in the previous lectures are found total stations.

The axis configuration is identical and comprises the vertical axis, the tilting axis and line of sight (or collimation). The other components include the tribrach with levelling foot screws, the keyboard with display and the telescope which is mounted on the standards and which rotates around the tilting axis.

Levelling is carried out in the same way as for a theodolite by adjusting to centralise a plate level or electronic bubble. The telescope can be transited and used in the face left (or face I) and face right (or face II) positions. Horizontal rotation of the total station about the vertical axis is controlled by a horizontal clamp and tangent screw and rotation of the telescope about the tilting axis.

The total station is used to measure angles in the same way as the electronic theodolite.

Distance measurement

All total station will measure a slope distance which the onboard computer uses, together with the zenith angle recorded by the line of sight to calculate the horizontal distance.

For distances taken to a prism or reflecting foil, the most accurate is precise measurement.

For phase shift system, a typical specification for this is a measurement time of about 1-2s, an accuracy of (2mm + 2ppm) and a range of

3-5km to a single prism.

Although all manufacturers quote ranges of several kilometres to a single prism.

For those construction projects where long distances are required to be measured, GPS methods are used in preference to total stations. There is no standard difference at which the change from one to the other occurs, as this will depend on a number of factors, including the accuracy required and the site topography.

Rapid measurement reduces the measurement time to a prism to between 0.5 and 1's for both phase shift and pulsed systems, but the accuracy for both may degrade slightly.

Tracking measurements are taken extensively when setting out or for machine control, since readings are updated very quickly and vary in response to movements of the prism which is usually pole-mounted. In this mode, the distance measurement is repeated automatically at intervals of less than 0.5s.

For reflector less measurements taken with a phase shift system, the range that can be obtained is about 100m, with a similar accuracy to that obtained when using a prism or foil.

Characteristics of total station

- 1 Angle units degree or gon
- 2 Distance units ft or m
- 3 Pressure unit mHg or mmHg
- 4 Temperature units °F or °C
- 5 Prism constant -30 or -40mm
- 6 Offset distances
- 7 Face 1 or Face 2 selection
- 8 Height of instrument (HI)
- 9 Height of reflector (HR)
- 10 Automatic point number incrementation
- 11 Point numbers and code numbers for occupied and sighted stations
- 12 Date and time settings

Capabilities of a total station

- Monitors battery status, signal attenuation, horizontal and axes status, collimation factors
- computes coordinates
- Traverse closure and adjustment
- Topography reductions
- Remote object elevation
- Distance between remote points
- Inversing
- Resections

- Horizontal and vertical collimation corrections
- Setting out
- Vertical circle indexing
- Records, search and review
- On-board software
- Transfer of data to the computer
- Transfer of computer files to data recorder

Field procedures for Total Station in topographic surveying

- A set routine should be established for a survey crew to follow
- Standard operating procedure should require that control points be measured and noted immediately on the data collector and/or in the field book after the instrument has been set up and leveled
- This ensures that the observation to controlling points are established before any outside influences have had an opportunity to degrade the setup
- In making observations for an extended period of time at a particular instrument location, reobserve the control points from time to time
- This ensures that any data observed between the control shot are good or that a problem has developed and appropriate action can be taken to remedy the situation
- As a minimum, require survey crews to observe both vertical and horizontal control points at the beginning of each instrument setup and again before the instrument is picked up
- One of the major advantages of using a total station equipped with data collection is that some errors previously attributed to blunder can be minimized or eliminated.
- Even if the wrong reading is set on the horizontal circle on the field or the wrong elevation is used for the bench, the data itself may be precise
- To make the data accurate, many software packages will allow the data to be rotated and/or adjusted as it is processed.
- The only way to assure that these corrections and/or observations have been accurately processed is to compare the data to control points
- Without these observation in the recorded data, the orientation of the data will always be in question.
- The use of a total station with a data collection can be looked upon as two separate and distinct operations.

Following is the typical procedure for data collection in total station

- Set up and level instrument
- Turn on total station

- Create a file or open existing file
- Record Occupied station Name and instrument height
- Set Coordinate for Occupied Station
- Set back sight name and reflector height and observe the coordinate of the back sight (known) station and record the data
- Give name for foresight station and set reflector height
- Measure the foresight station and record the data
- For detailing, set detail point name and reflector height and start recording the data of different location.
- After completion of recording the data, Power off the machine and transfer the instrument to next station and procedure as above.

Total station consists of an electronic theodolite, an electronic distance measuring device (EDM) and a micro processor having a memory unit. By using this instrument, it is possible to find out the coordinates of a reflector adjusting the cross hair of the instrument and at the same time measuring the vertical angles, and slope distances. A micro processor deals with the recording, readings, and the fundamental calculation of measurements.

Advantages of total station

- 1 Quick setup of the instrument on the tripod by utilizing the laser plummet.
- 2 Programmed with on board area computation for computing the area of a field.
- 3 It supports local languages.
- 4 It shows the graphical view of land and plots.
- 5 No recording and writing errors.
- 6 It gives more accurate measurements than other conventional surveying instruments.
- 7 Data can be saved and transferred to a PC
- 8 It has integrated database.
- 9 Computerization of old laps.
- 10 All in one and multitasking instrument, from surveying to GIS creation by using the appropriate software.
- 11 Faster work, saves time, quick finishing off the job.

Disadvantages of total station

- 1 The instrument is costlier than other conventional surveying instruments.
- 2 It might be troublesome for the surveyor to investigate and check the work when surveying.
- 3 Working with total station is not so easy, as more skilled surveyors are required to conduct a total station survey.
- 4 To check the survey work thoroughly it would be necessary to come back to the office and prepare the drawings by using the right software.

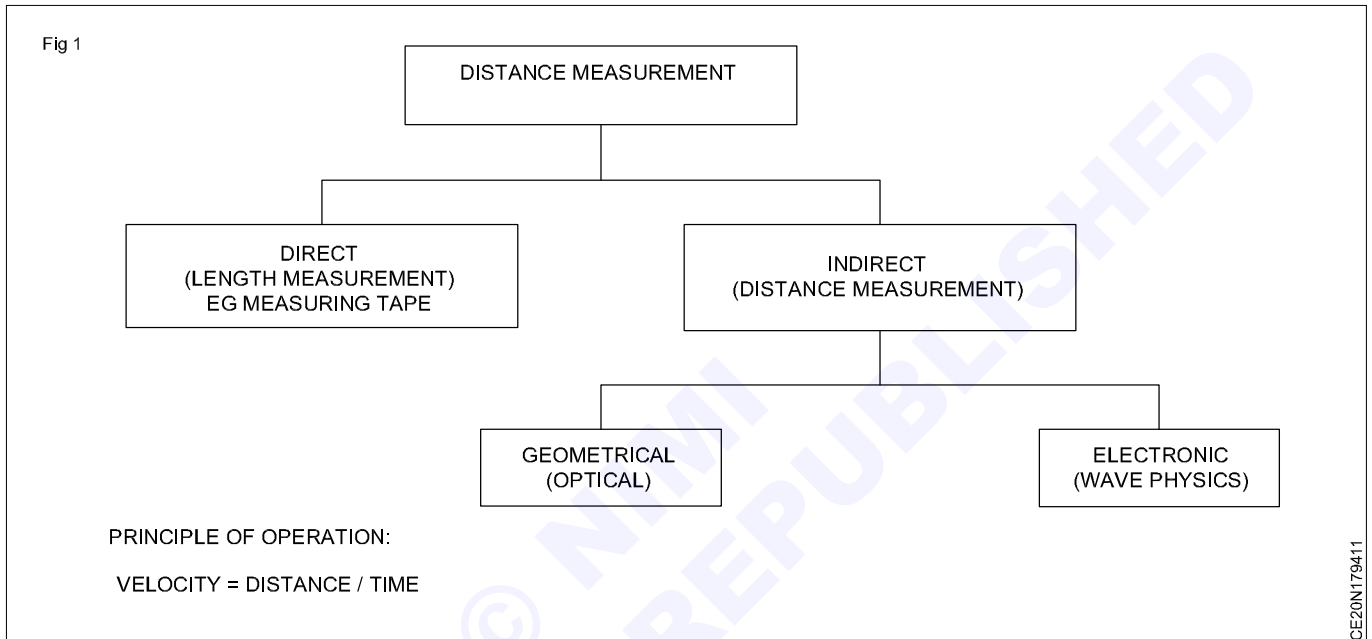
Principle of EDM - Working need setting and measurement

Objectives: At the end of this lesson you shall be able to
• define EDM, principle and features.

What is EDM?

EDM is the electronic distance measuring device, measures from the instrument to its target. EDM sends out laser or in framed beam which is reflected back the

unit and the unit used velocity measurements to calculate the distance traveled by the beam.



History

Theodolite & Tape
Stadia
EDM & Theodolite
EDM, Theodolite & Data Collector

Prior to these systems, optical (stadia) and manual (tape) systems were used to measure distances.

History

- First introduced in the late 1950's
- At first they were complicated, large, heavy and suited primarily for long distances
- Current EDM's use either infrared (light waves) or microwaves (radio waves)
- Microwaves require transmitters/receivers at both ends
- Infrared use a transmitter at one end and a reflecting prism at the other and are generally used more frequently.

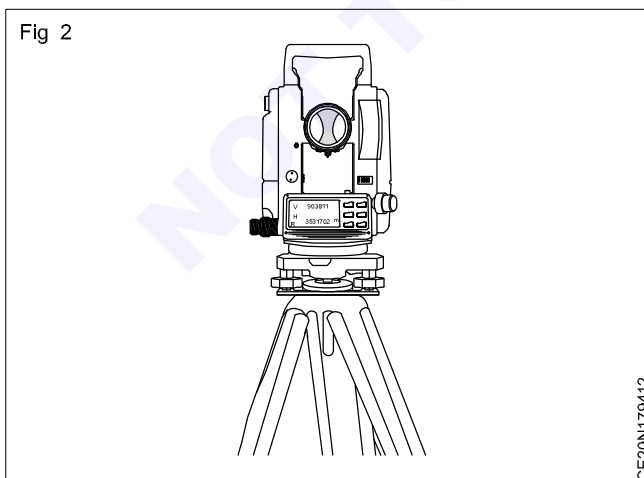
EDM properties

- They come in long (10-20 km), medium (3-10 km), and short range (.5-3 km). Range limits up to 50 km
- They are typically mounted on top of a theodolite, but can be mounted directly to a tribrach.

Total station =

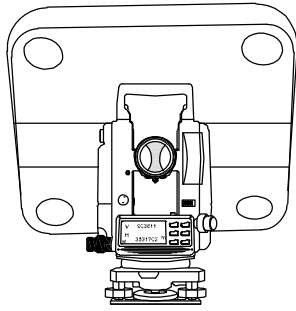
Theodolite with built in EDM ± Microprocessor

Fig 2



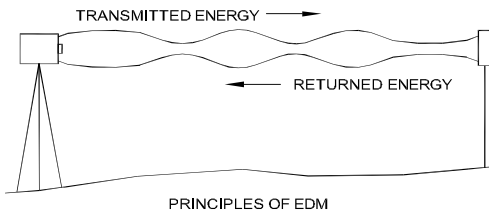
Prior to the total station, Theodolite with EDMs and data collectors were used to record number of points, and for measuring long distances. The systems were heavy, prone to failure, and many times the parts incompatible.

Fig 3



CE20N179413

Fig 4



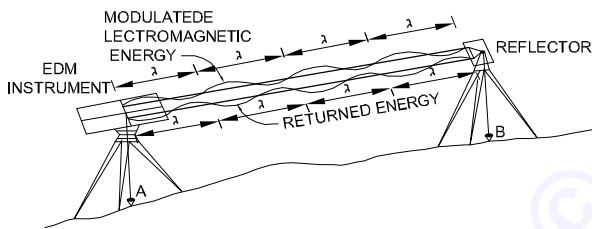
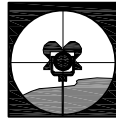
PRINCIPLES OF EDM

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Fig 5

PRINCIPLES OF EDM

OPERATION:
A WAVE IS TRANSMITTED AND THE RETURNING WAVE IS MEASURED TO FIND THE DISTANCE TRAVELED.



CE20N179415

Principles of EDM

General principles of EDM

Electromagnetic energy

Travels based on following relation

$$v = f\lambda \text{ so } \lambda = \frac{v}{f} \quad v = c/n$$

Intensity modulate EM energy to specific frequency

Principles of EDM

Advantage of using EDM

- 1 Precise measurement of distance
- 2 Capable of measuring long distances
- 3 Electroless are single person operation

Electronic distance measurement (EDM)

Disadvantage of using EDM

- 1 Electronic = batterers
- 2 Accuracy affected by atmospheric conditions.
- 3 Can be expensive

Use of EDM

(a) measuring distance

(b) setting distance

Different Wavelength Bands Used by EDM

Usually, EDM uses three different wavelength bands and

their characteristics are:

Microwave Systems

Range up to 150 km

Wavelength 3 cm

Not limited to line of sight

Unaffected by visibility

Light Wave Systems

Range up to 5 km (for small machines)

Visible light, lasers

Distance reduced by visibility

Infrared Systems

Range up to 3 km

Limited to line of sight

Limited by rain, fog, other airborne particles

Total station :

tripod

theodolite

hammer

plumber

peg

traverse

procedure

Full transcript

Things to remember in total station

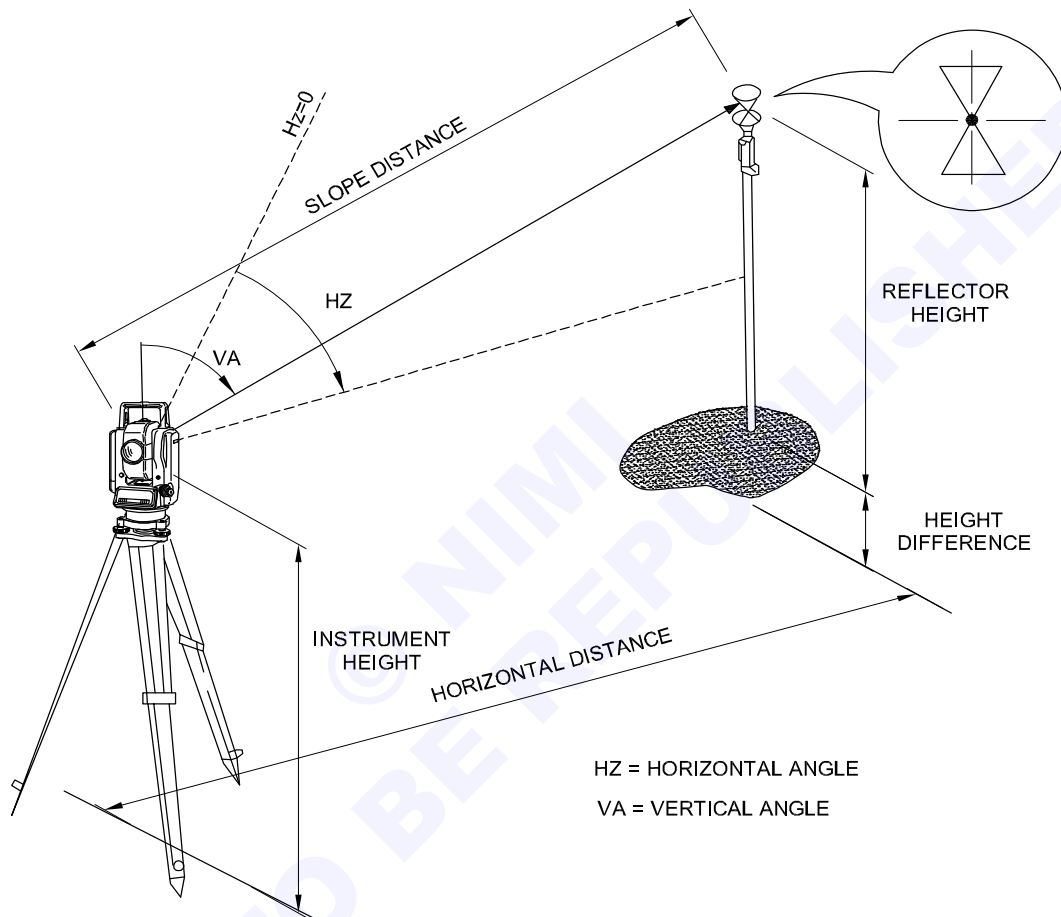
- A total station is an electronic optical instrument widely used in modern surveying
- Total station instrument combine three basic components
- An EDM instrument, and electronic digital theodolite and a computer or microprocessor into one integral unit
- They digitally observe and record horizontal directions, vertical directions and slope distances
- These digital data observations can be adjusted and transformed to local X,Y and Z coordinates using an internal or external micro procesor.
- Various atmosphere corrections, grid and geodetic corrections and elevation factors can be input and applied
- The total stations may internally perform and save the observation or these data may be download to an external data storage
- Angles can be electronically encoded to one are-second with a precision down to 0.5 arc-second
- Digital readouts eliminate the uncertainty associated with reading and interpolating scale and micrometer data
- The electronic angles - measurement system minimizes some of the horizontal and vertical angle errors that normally occur in conventional
- The modern versions of survey total station called robotic total station, let user control the instrument from a distance with the help of remote control.
- These instruments are also equipped with dual - axis compensator, which automatically correct both horizontal and vertical angles for any deviation in the plumb line.

Electronic display & data recording

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

- define electronic data recording
- explain field computers
- define recording modules that is internal memories.

Fig 1



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Electronic data recording

The conventional method of recording surveys is overtaken by development in computer mapping and survey instrumentation which made electronic data recording and transfer essential.

The following are some methods of recording data electronically.

Data recorders

These are dedicated to a particular instrument and can store and process surveying observations. These are also referred to as electronic field books. They use solid-state technology enabling them to store large amounts of data in a device of the size of a pocket calculator.

Field computers

These are hand-held computers adapted to survey data collection. Comparing with a data logger, they offer a more flexible approach to data collection since they can be programmed for many forms of data entry.

Recording modules

These are also called memory cards which take the form of plug-in cards onto which data is magnetically encoded by a total station. Data is transmitted to the memory card using a non-contact magnetic coupling system which eliminates the need to attach sockets or point to the card.

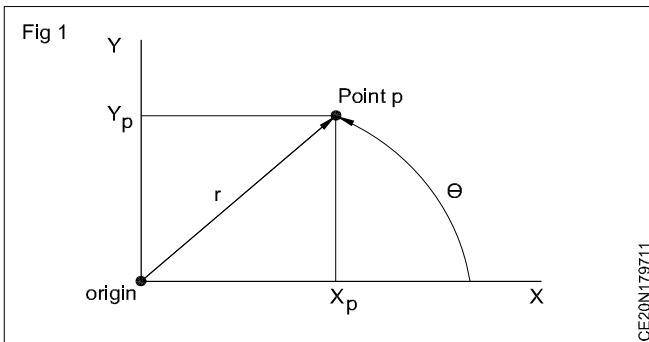
Internal memories

A total station can be fitted with an internal memory capable of storing 900 to 10,000 points. This enables data to be collected without the need for a memory card or data recorder.

Rectangular and polar co-ordinate system

Objectives: At the end of this lesson you shall be able to
 • illustrate rectangular and polar coordinates.

Rectangular and polar co-ordinates (Fig 1)



Point p can be located relative to the origin by Rectangular Coordinates (X_p, Y_p) or by Polar Coordinates.

$$X_p = r \cos(\theta) \quad r = \sqrt{X_p^2 + Y_p^2}$$

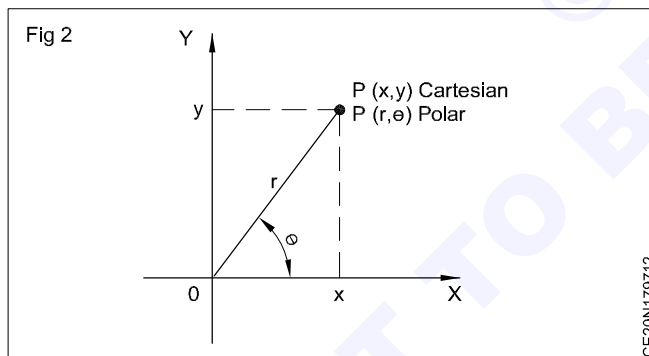
$$Y_p = r \sin(\theta) \quad \theta = \tan^{-1}(Y_p / X_p)$$

Converts from Polar to Cartesian coordinates.

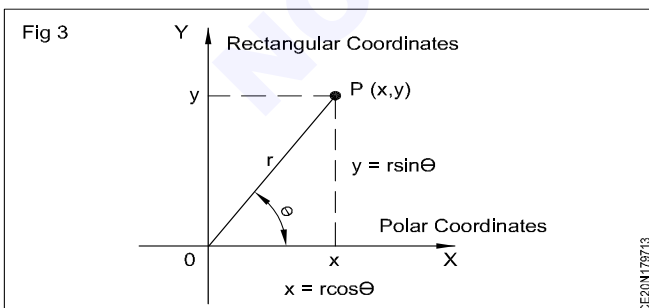
Transformation coordinates (Fig 2)

Polar $(r, \theta) \rightarrow$ Cartesian (x, y)

$$x = r \cos \theta \quad y = r \sin \theta$$



Rectangular Coordinates (Fig 3)



Polar Coordinate System

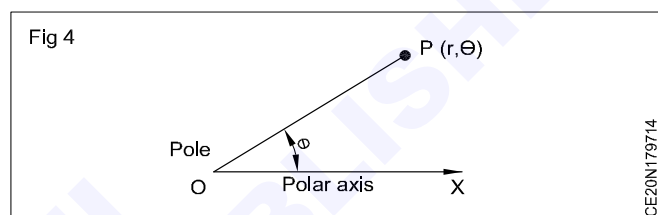
The **Pole:** point O

Polar Axis: ray from point O (Fig 4)
 (along positive x-axis)

Polar Coordinates: (r, θ)

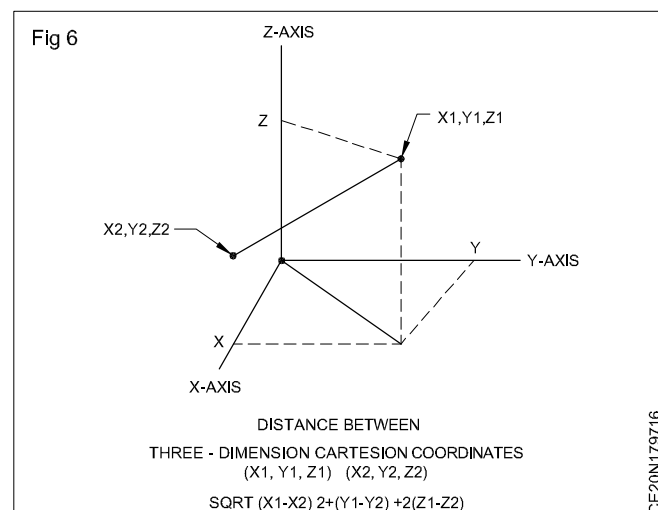
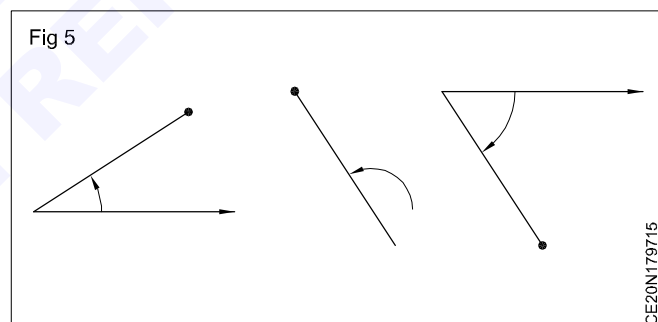
r: directed distance from O

θ: directed angle from polar axis



Plot the points with the given polar coordinates (Fig 5)

$P(2, \pi/3)$ $Q(-1, 3\pi/4)$ $R(3, -45^\circ)$

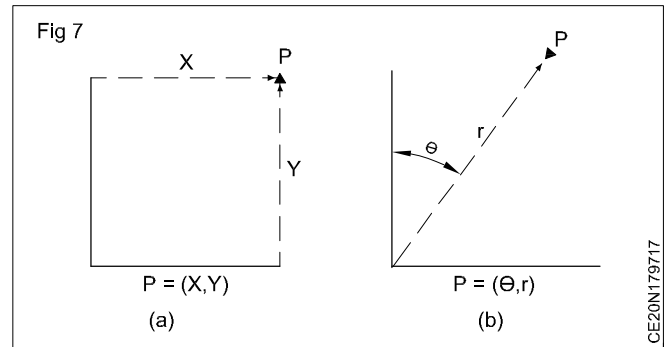


Cartesian coordinates

(Fig 7a)

Polar coordinates

(Fig 7b)



Termmology of open and closed traverse

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

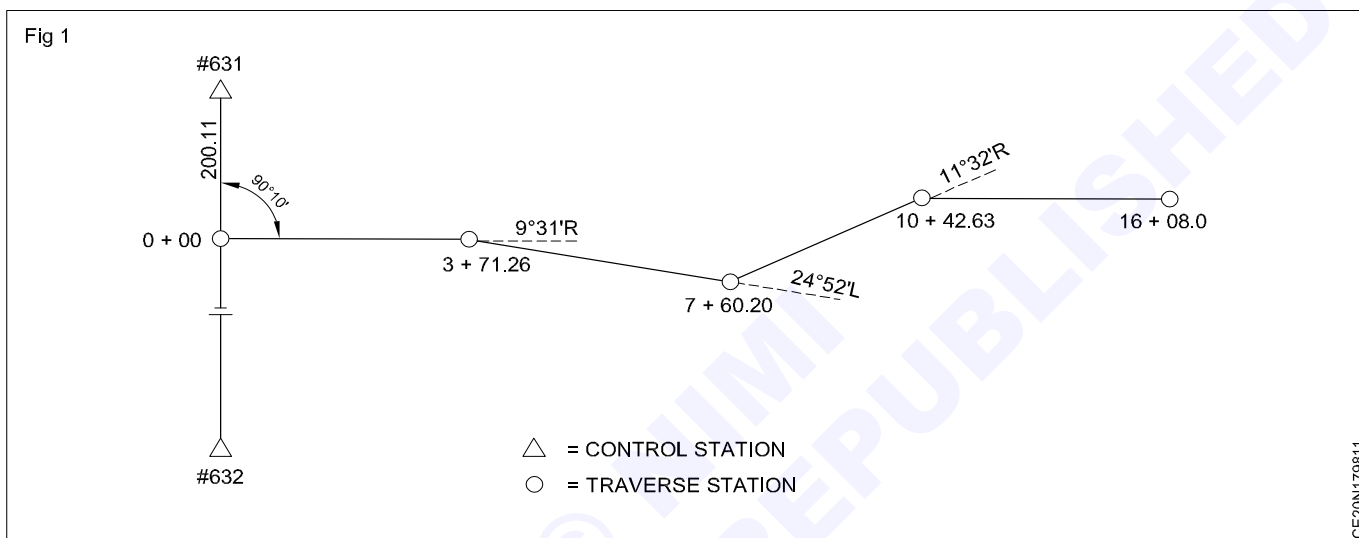
- explain open and closed traverse in surveying
- explain the difference between close and open traverse.

Open and closed traverses in surveying

Background

A traverse is a form of control survey used in a wide variety of engineering and property surveys. Essentially, traverses are a series of established stations tied together by angle

and distance. Angles are measured by theodolites or total stations; the distances can be measured by electronic distance measurement (EDM) instruments, sometimes by steel tapes. Traverses can be open, as in route surveys, or closed, as in closed geometric figures (Fig 1 & 2).



Open traverse (Fig 1)

Traverse computations are used to do the following: balance field angles, compute latitudes and departures, compute traverse error, distribute the errors by balancing the latitudes and departures, adjust original distances and directions, compute coordinates of the traverse stations, and compute the area enclosed by a closed traverse. In modern practice, these computations are routinely performed on computers and/or on some total stations or their electronic field books/data collectors. In this article, we will perform traverse computations manually (using calculators) to demonstrate and reinforce the mathematical concepts underlying each stage of these computations.

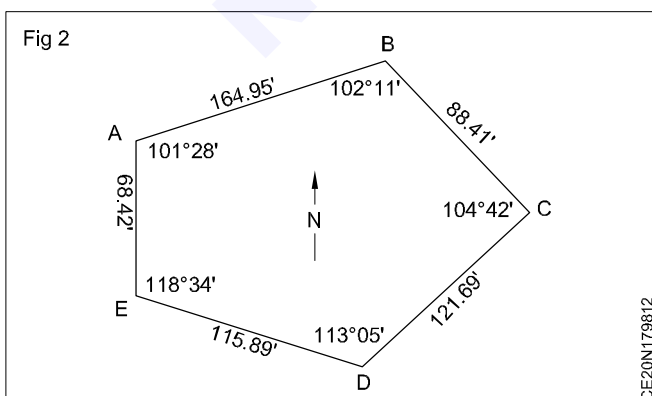
In engineering work, traverses are used as control surveys

- 1 To locate topographic detail for the preparation of topographic plans and engineering design plan and profiles,
- 2 To lay out (locate) engineering works, and
- 3 For the processing and ordering of earthwork and other engineering quantities. Traverses can also help provide horizontal control for aerial surveys in the preparation of photogrammetric mapping.

Open traverse

An open traverse (Figure 1) is particularly useful as a control for preliminary and construction surveys for highways, roads, pipelines, electricity transmission lines, and the like. These surveys may be from a few hundred feet (meters) to many miles (kilometers) in length. The distances are normally measured by using EDM (sometimes steel tapes). Each time the survey line changes direction, a deflection angle is measured with a theodolite or total station. Deflection angles are measured from the prolongation of the back line to the forward line (Figure 1); the angles are measured either to the right or to the left (L or R), and the direction (L or R) is shown in the field notes, along with the numerical values.

Closed traverse or lop traverse (Fig 2)



Field notes for open traverse

Angles are measured at least twice to eliminate mistake and to improve accuracy. The distance is shown in the form of stations (chainages), which are cumulative measurements referenced to the initial point of the survey, 0 + 00. See Figure 3 for typical field notes for a route survey. Open traverses may extend for long distances without the opportunity for checking the accuracy of the ongoing work. Thus, all survey measurements are repeated carefully at the time of the work, and every opportunity for checking for position and direction is utilized (adjacent property surveys and intersecting road and railroad rights-of-way are checked when practical.) Global positioning system (GPS) surveying techniques are also used to determine and verify traverse station positioning.

Many states and provinces have provided densely placed control monuments as an extension to their coordinate grid systems. It is now possible to tie in the initial and terminal survey stations of a route survey to coordinate control monuments. Because the Y and X (and Z) coordinates of these monuments have been precisely determined, the route surveys changes from an open traverse to a closed traverse and is then subject to geometric verification and analysis. Of course, it is now also possible, using appropriate satellite-positioning techniques, to directly determine the easting, northing, and elevation of all survey stations.

Closed Traverse

A closed traverse is one that either begins and ends at the same point or begins and ends at points whose position have been previously determined (as described above). In both cases, the angles can be closed geometrically, and the position closure can be determined mathematically.

A closed traverse that begins and ends at the same point is called a loop traverse (Figure 2). In this case, the distances are measured from one station to the next and verified, using a steel tape or EDM instrument. The interior angle is measured at each station, and each angle is measured at least twice. Figure 4 illustrates typical field notes for a loop traverse survey. In this survey, distances are booked simply as dimensions, not as stations or chainages.

Explain the difference between closed and open traverse. Comment on the advisability of using open traverses?

Answer: The difference between the two is that a closed traverse starts and ends on points with known location and an open traverse starts with a known point, but ends on a point with unknown location. An open traverse is usually not used since the error in location measurements cannot be computed. However, if an open traverse is used, measurements should be taken repeatedly.

What is the sum of the interior angles of a closed polygon traverse that has a) 6 sides b) 8 sides and c) 12 sides?

Answer:

Sum of interior angles = $(n-2) \times 180^\circ$

a $(6-2) \times 180 = 720^\circ$

b $(8-2) \times 180 = 1080^\circ$

c $(12-2) \times 180 = 1800^\circ$

d The interior angles in a five sided closed polygon travers were measured and found to be: A = $139^\circ 10' 11''$, B = $126^\circ 17' 43''$, C = $94^\circ 28' 30''$, D = $71^\circ 04' 59''$ and E = $108^\circ 58' 31''$. Compute the angular misclosure. For what order and class is this survey?

Common Indian timbers, defects, diseases of timber, knots, shakes and grains

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

- **state the types of common Indian timbers and uses**
- **state the causes for defects, diseases of timber**
- **explain the knots, shakes and grains.**

Teak

It is a very valuable timber. It is a large tree with light coloured leaves.

The wood is straight grained and of rich brown yellow colour.

Sap wood is pale yellowish and heart wood is golden brown. Suitable for any work, ship building furniture and cabinet making etc.,

Deodar

It has straight tall trunk having short branches and pointed leaves. The tree has lofty straight trunk with small branches. The sap wood is white and heart wood is light yellowish brown.

Uses

Construction purposes, furniture, packing cases, railways sleepers, carriages etc.,

Chir

It is similar to deodar but is inferior in quality. The sap wood is white and heart wood is light yellowish brown.

It is medium and uneven textured with straight to spiral or twisted grain.

Uses

Construction purposes, furniture, height packing and cabinet making.

Kail

It is an ever-green tree.

Kail is similar structure to chir. The sap wood is white and heart wood is light and pinkish red.

It is closely grained hard and durable.

Uses

Cabinet making, furniture, packing cases, drawing boards and railways sleepers etc.,

Shisham (sissoo)

It is a tree having short trunk and large branches.

Sap of sissoo is pale yellowish and heart wood is golden or dark brown. It generally grows along the road side.

It has medium coarse texture with fairly straight inter locked grains.

Sal

It is a straight growing up right tree.

The sap wood is pale yellowish and heart wood is brown or reddish brown. The wood is hard and heavy.

It is a coarse textured with inter locked grains.

Uses

It is a valuable timber and recommended for all.

Construction purposes and railways sleepers.

Babul

It has small leaves and not available in large shapes.

It is available in abundance all over India. The wood is closed grained and tough colour of wood is pale red.

Uses

Tool handles, wheels and bodies of carts, ploughs and other structural works.

Mango

Mango is found all over India. The wood is of inferior quality, colour of wood is yellowish gray.

Uses

Inferior quality doors and windows, packing case etc.,

Bamboo

This tree is found practically all the parts of India. It is a flexible and strong material.

Bamboo grows naturally on soils which are neither too acidic nor too alkaline. The greater concentration of Bamboo is however found in Assam Region.

It is used for making the poor man's hut all over the country.

Uses

Walls, portions, flooring, ceiling, roofing ladder, basket making mats, walking sticks, umbrella handle, toys and paper pulp.

Advantages of timber

- 1 It can be easily converted to any size and shape.
- 2 It has a high resale and salvage value.
- 3 Timber construction is light in weight.
- 4 Timber has better insulating properties.
- 5 Timber can be used for loading and loading elements.
- 6 Timber connections are easy to make.
- 7 In terms of specific strength timber is better to many other building materials.
- 8 Durability of timbers is very high, if properly seasoned and pressed.

Defects and Diseases of timber and knots, shakes and grains

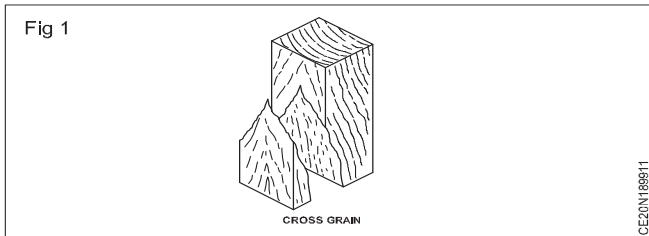
Objectives: At the end of this lesson you shall be able to

- identify the defects in timber
- explain the knots, shakes and grains
- state the causes for defects in timber.

Refer Ex No: 1.3.21

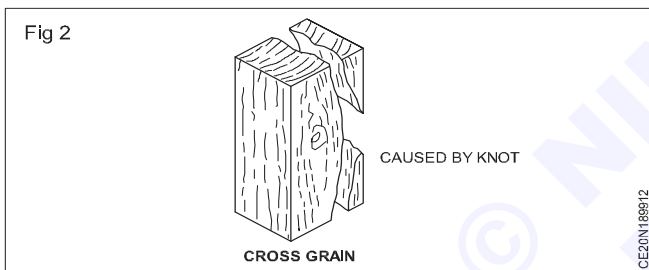
Types of Grains

Refers to the direction of the cells and vessels of the wood. (Fig 1)



Cross grain

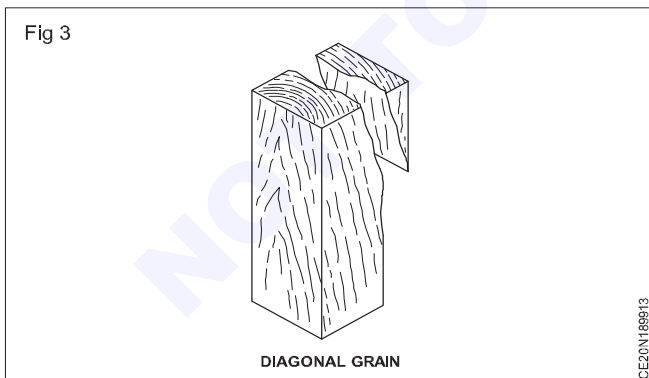
When have a varying inclinations to the axis of the piece due to cutting from timber in which the straightness of the grain is imperfect. (Fig 2)



Diagonal grain

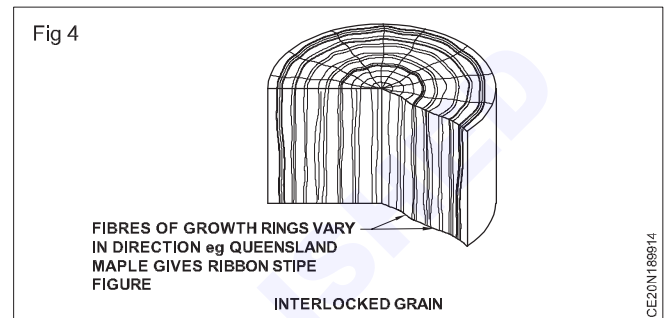
When the fibers do not run parallel to the axis of the piece, although cut from straight grained timber.

This is caused by cutting parallel to the axis of the log instead of parallel to the bark. (Fig 3)



Inter lock grain

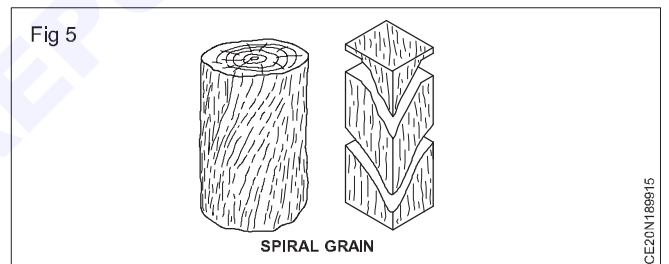
Caused by the fibers of adjacent layers of wood being spirally inclined in opposite directions. This grained surface is difficult to plane. (Fig 4)



Spiral grain

Occurs when the fibers have taken a spiral course in the tree trunk as if the tree have been twisted.

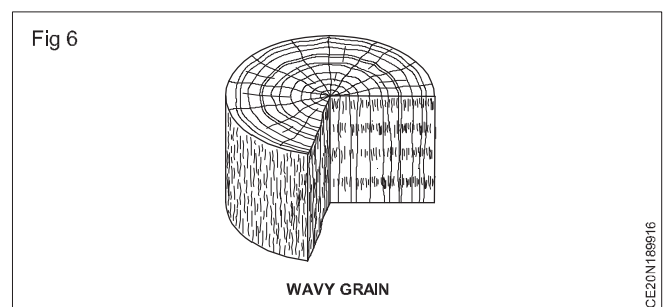
The cause is not definitely known. (Fig 5)



Wavy grain

A wavy arrangement of the fibers, also known as curly or fiddle back grain.

This grained surface is difficult to plane and work. (Fig 6)

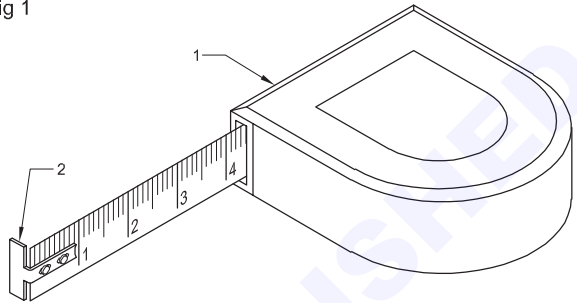
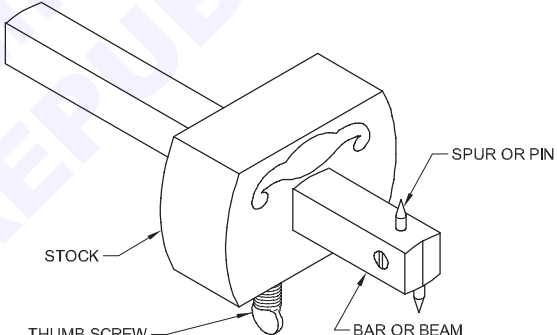
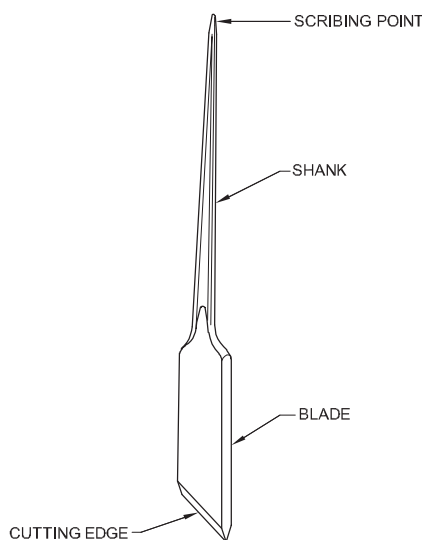


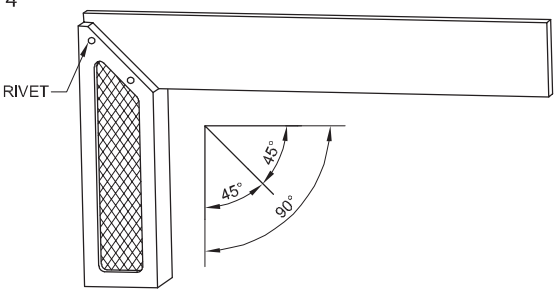
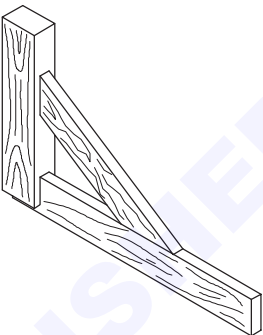
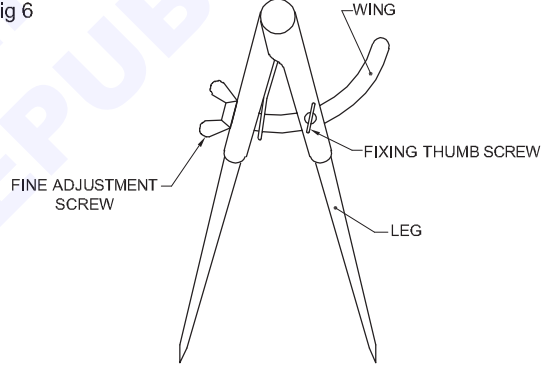
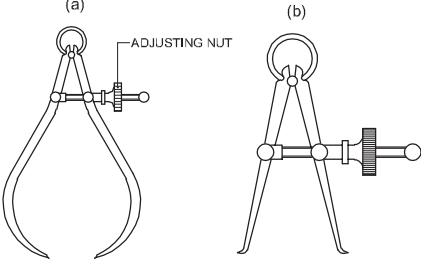
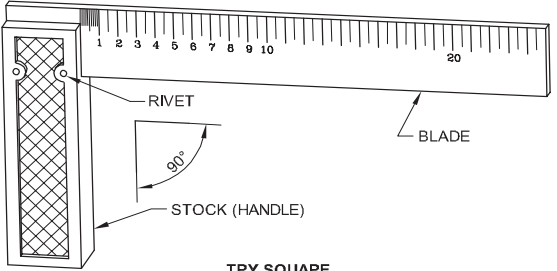
Carpentry hand tools and measuring tools and uses, work holding devices

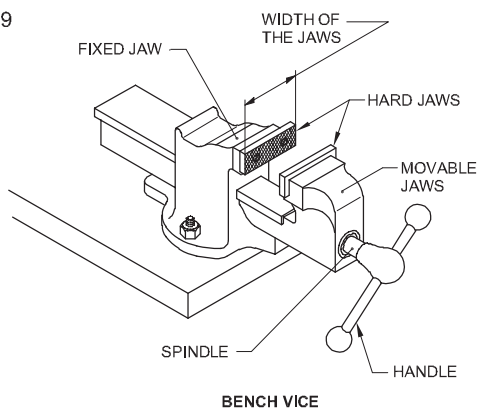
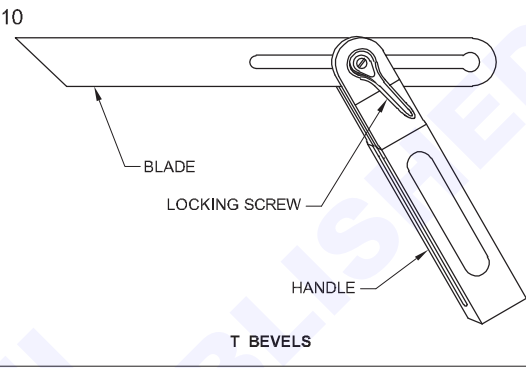
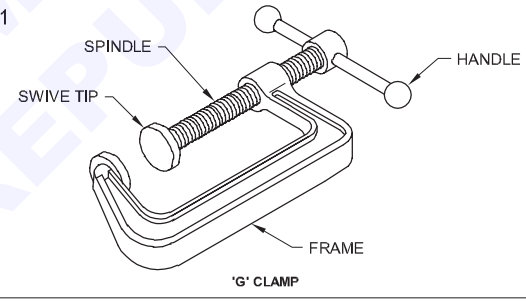
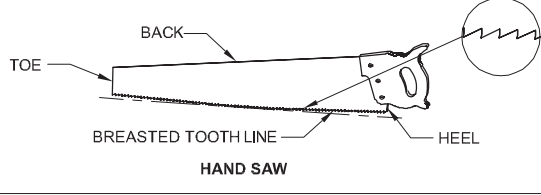
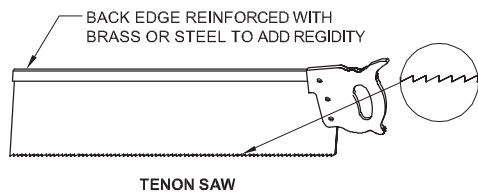
Objectives: At the end of this lesson you shall be able to

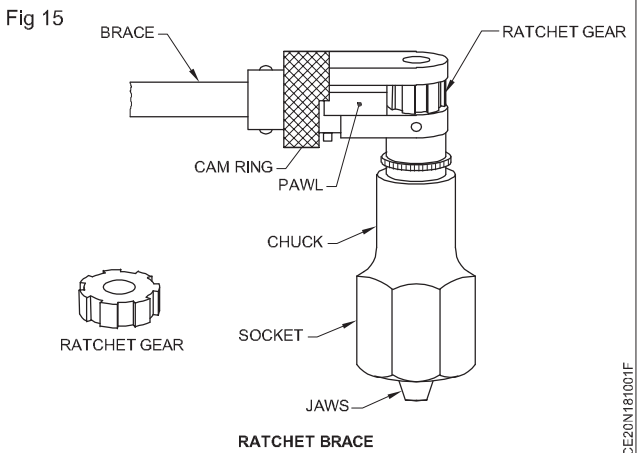
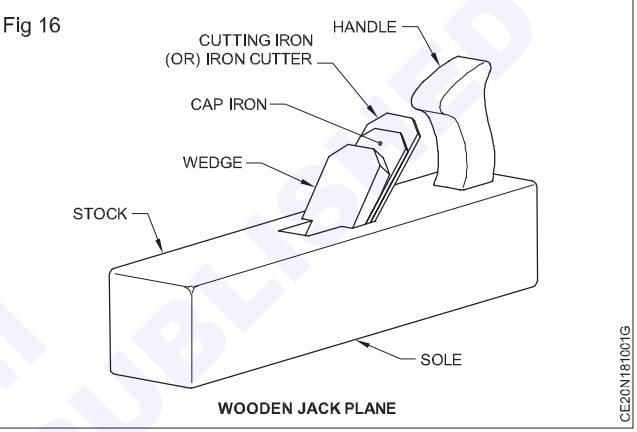
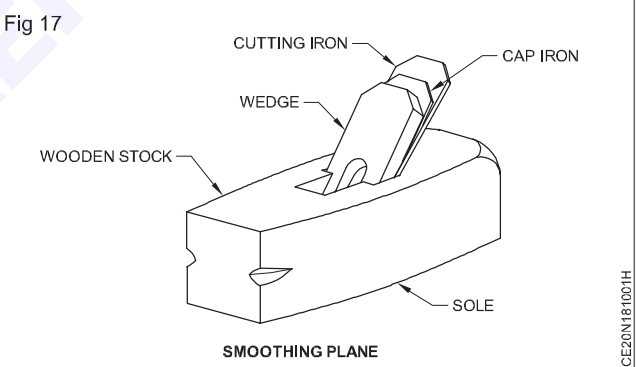
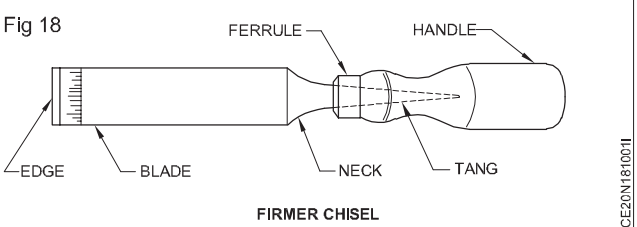
- state the different types hand tools used in carpentry work.

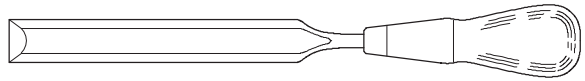
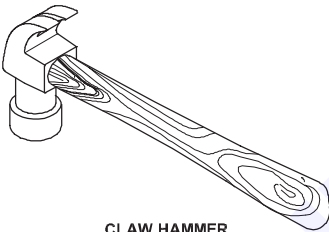
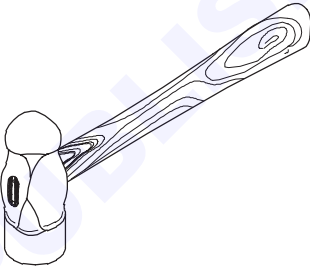
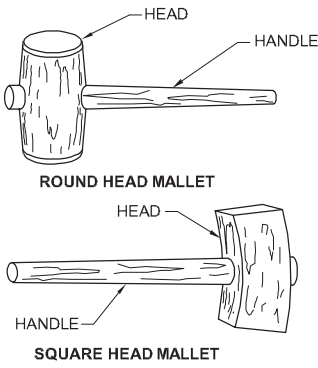
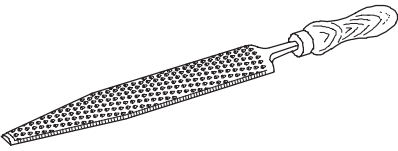
The hand tools used in general carpentry work.

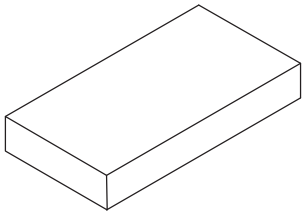
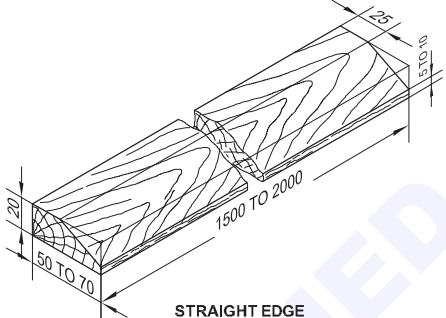
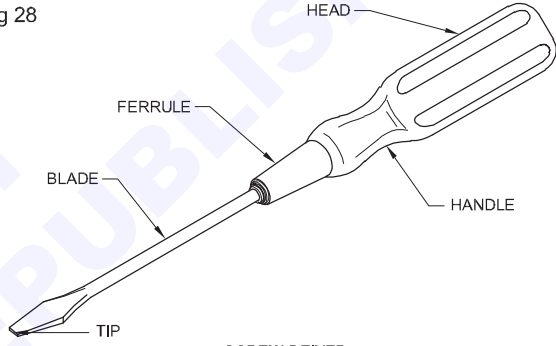
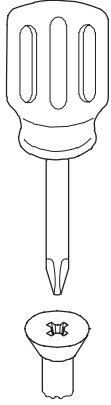
S.No.	Name of the tools and uses	Figures
1	Measuring tape • Tape measure are used for longer measurements • Tape measure has a sliding end piece for inside and outside measurements. (Fig 1)	Fig 1  MEASURING TAPE CE20N1810011
2	Marking gauge Marking gauge is used for marking lines parallel to a face and edge (e.g.) gauging width and thickness. (Fig 2)	Fig 2  MARKING GAUGE CE20N1810012
3	Marking knife Marking knife is used for marking distances and scribing lines. (Fig 3)	Fig 3  MARKING KNIFE (OR SCRIBING KNIFE) CE20N1810013

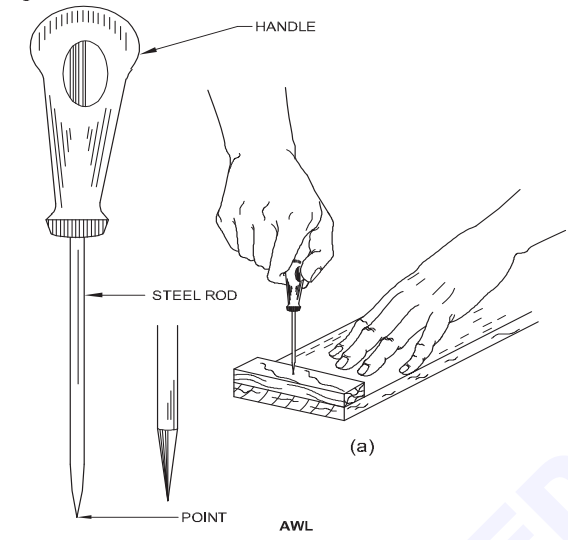
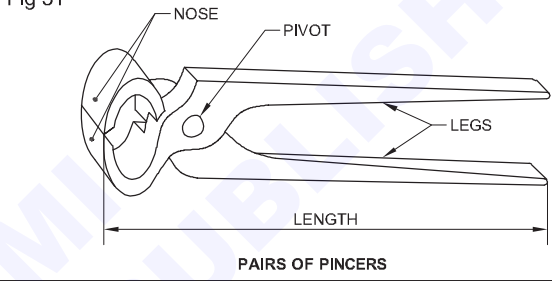
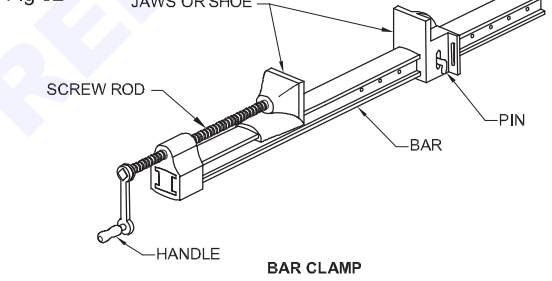
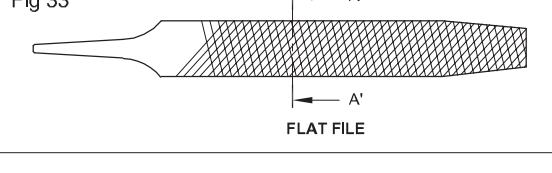
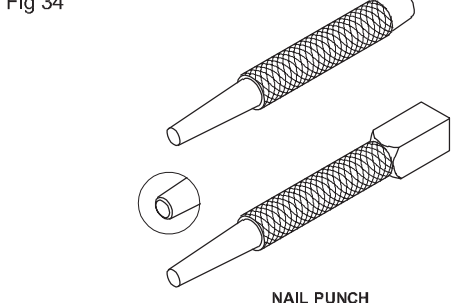
4	Try and miter square The try and miter square is also useful for angle 45°, 90° and 135°. (Fig 4)	Fig 4  RIVET TRY AND MITRE SQUARE CE20N1810014
5	Wooden try square The try square is fully made of wood. Its handle is slightly heavier than blade. The design of blade is 600mm and width is 50mm. This is used in carpentry works & building construction works. Large and wide planks are used to scribe, guide as sawing work. (Fig 5)	Fig 5  WOODEN TRY SQUARE CE20N1810015
6	Wing compass Wing compass setting out arcs of circles To transfer the measurement from measured rule to the job to mark curves. (Fig 6)	Fig 6  WING COMPASSES CE20N1810016
7	Calipers Calipers used for outside measurements are known as outside calipers. The calipers used for internal measurements are known as inside calipers. (Fig 7)	Fig 7  ADJUSTING NUT OUTSIDE INSIDE CALIPER CE20N1810017
8	Try square Try square is used to check flatness and squareness of surface. (Fig 8)	Fig 8  RIVET STOCK (HANDLE) BLADE TRY SQUARE CE20N1810018

9	Bench vice Vice are used for holding work pieces. They are available in different types. The vice used for bench work in the bench vice or called engineer vice. (Fig 9)	Fig 9  CE20N1810019
10	Bevel square The bevel square is used for laying out dove tails, chambers, bevels and transferring angles from the drawing to the work pieces. (Fig 10)	Fig 10  CE20N181001A
11	'C' Clamp Holding small joint and wooden gloving purpose. (Fig 11)	Fig 11  CE20N181001B
12	Spirit level Spirit level is used to test the perpendicular of walls doors and cabinets. (Fig 12)	Fig 12  CE20N181001C
13	Hand saw Hand saw is used for lighter sawing work. (Fig 13)	Fig 13  CE20N181001D
14	Tenon saw Tenon saw is rectangular in shape It is used for tiner works like tenon Main use is making short and straight cuts. (Fig 14)	Fig 14  CE20N181001E

15	Ratchet brace The brace is used for circular holes are drilled or bored in wood by means of drill. To penetrate into the wooden piece it is necessary to use the drill to cut a hole. (Fig 15)	Fig 15  RATCHET BRACE CE20N181001F
16	Jack plane This plane is used for planning the job to size quickly and truly. (Fig 16)	Fig 16  WOODEN JACK PLANE CE20N181001G
17	Smoothing plane This plan is used when the surface to be planed further to smoothness. (Fig 17)	Fig 17  SMOOTHING PLANE CE20N181001H
18	Bench firmer chisel This chisel is used for general chiselling purpose. (Fig 18)	Fig 18  FIRMER CHISEL CE20N181001I
19	Paring chisel It is most suitable for all paring work such as finishing off joints. (Fig 19)	Fig 19  PARING CHISEL CE20N181001J

20	Gouge chisel (Concave) This chisel is used to cut curves and hollow works. (Fig 20)	Fig 20  CONCAVE CHISEL CE20N181001K
21	Gouge chisel (Convex) This chisel is used for roughing out and heavy wood removal work.(Fig 21)	Fig 21  CONVEX CHISEL CE20N181001L
22	Claw hammer Claw hammer face is used to drive the nails into the wood and other shirking purpose and the claw is used for extracting the nails out of the wood. (Fig 22)	Fig 22  CLAW HAMMER CE20N181001M
23	Ball pein hammer This hammer is used for striking purpose. It is called as engineers hammer. (Fig 23)	Fig 23  BALL PEIN HAMMER CE20N181001N
24	Mallet Mallets are used for driving wood chisels and assembling and dismantling wooden article. (Fig 24)	Fig 24  ROUND HEAD MALLET HEAD HANDLE SQUARE HEAD MALLET HEAD HANDLE CE20N181001O
25	Rasp file The rasp is used for quick removal of a thick layer of wood. (Fig 25)	Fig 25  RASP FILE CE20N181001P

26	Oil stone Oil stone is used for sharpening wood chisels and plane blades. (Fig 26)	Fig 26  OIL STONE CE20N181001Q
27	Straight edge used for testing the straightness of surface and edges in plane wood. Also used as a guide in using portable power circular saw machine. (Fig 27)	Fig 27  STRAIGHT EDGE CE20N181001R
28	Screw driver Screw drivers are used to tighten or loosen screws in wood working. (Fig 28)	Fig 28  SCREW DRIVER CE20N181001S
29	Philips screw driver These are made with cruciform tips that are unlikely to slip from the matching slots. Used to tighten or loosen philips recess head screws in wood working. (Fig 29)	Fig 29  PHILIPS HEAD SCREW DRIVER CE20N181001T

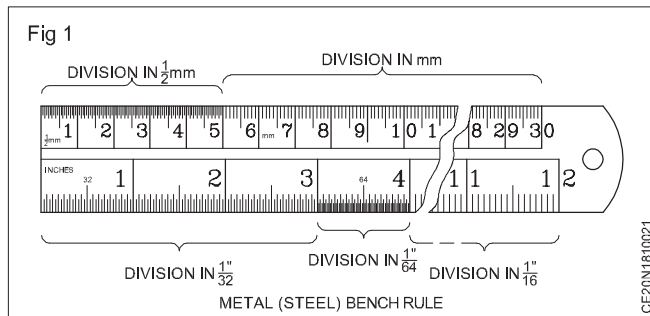
30	AWL AWL is used for marking or piercing holes in wood. (Fig 30)	Fig 30  CE20N181001U
31	Pincer Pincer is used for pulling out and removing nails. It is also used for cutting wire. (Fig 31)	Fig 31  CE20N181001V
32	Bar clamp T - Bar clamp is used for clamping up wide works and large frames. (Fig 32)	Fig 32  CE20N181001W
33	Flat file Flat file is used for filing the excess of bonding sun mica. (Fig 33)	Fig 33  CE20N181001X
34	Nail punch The nail punch is used along with the hammer to drive the head of nails below the surface of wood and to clench nails that go through to the other side of the board and stick out. (Fig 34)	Fig 34  CE20N181001Y

Measuring tools and uses

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

- state the different types of measuring tools
- explain the use of measuring tools
- brief the constructional and features of measuring tools.

The Rule (Steel) (Fig 1)



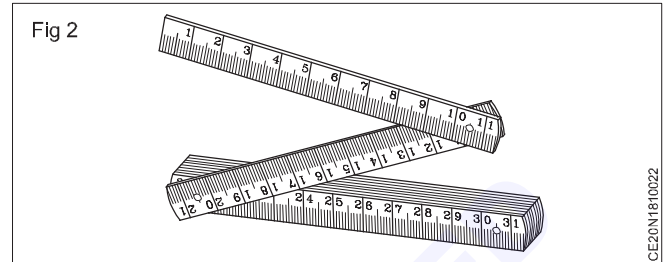
- In the workshop wooden or steel rules are used
- The division in cm is 30cm long and sub divided in mm (2) and half mm (3).
- The division in inches is 12 inches (12") long twelve inches equals one English foot 12" = 1'
- The Sub division is accurate in 1/16" (4) in 1/32" (5) and in 1/64" (6).
- For the conversion of parts of an Inch into the metric system (with units: m, cm, mm) a conversion table might be useful.

1/16"	=	1.6 mm
2/16"	= 1/8"	= 3.2 mm
3/16"		4.8 mm
4/16"	= 1/4"	= 6.35mm
5/16"		8.0mm
6/16"	= 3/8"	9.5mm
7/16"		11.1mm
8/16"	= 1/2"	= 12.7mm
9/16"		14.3mm
10/16"	= 5/8"	= 15.9mm
11/16"		17.5mm
12/16"	= 3/4"	= 19.05mm
13/16"		20.6mm
14/16"	= 7/8"	= 22.2mm
15/16"		23.8mm
16/16"	= 1"	= 25.4mm

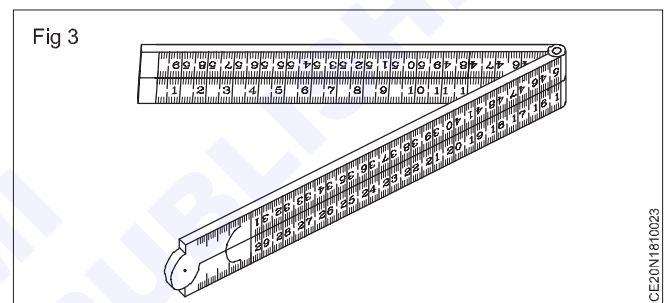
Collapsible Carpenter's rule (Zig-Zag) (Fig 2)

It is also called Zig-Zag rule. It consists of 10 pieces each loosely riveted to one another. Each piece is 10cm long and total length is 1 metre.

Longer distances can be measured with this rule. Some times it contains British system measurements on the other side.

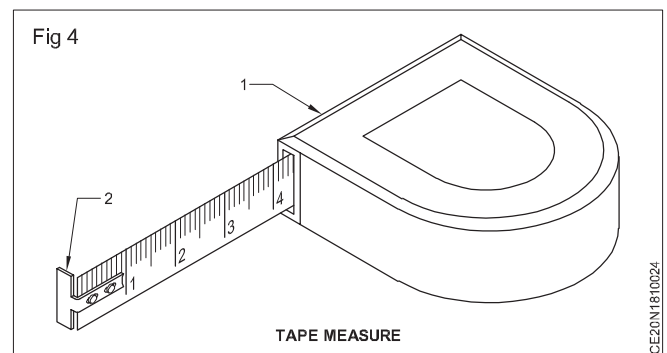


Folding Rule (Foot rule) (Fig 3)



It is also called foot rule. It has four folds each of which is 6 inches or 150mm long. It is joined in a plastic a metallic hinge. After taking measurement, keep the scale folded and free from dust. It can be easily carried in pockets. Metal clip is provided at the end of this rule to avoid wear and tear.

Tape measurement Rule (Fig 4)



Tape measures are used for longer measurements. The tape is made of steel and is durable and accurate. When not in use, the tape should be kept in the box. Divisions are made in centimeters or in inches.

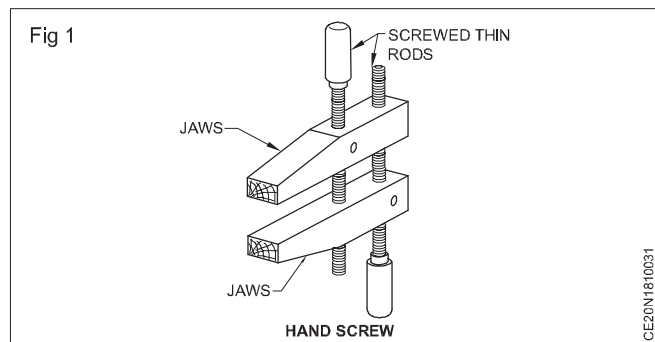
Tape measure has a sliding end piece for inside and outside measurement.

Work holding devices

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

- explain the uses of Hand screw
- state the uses of Bar clamp or 'C' clamp
- brief the uses of bench hold fast and the cleat.

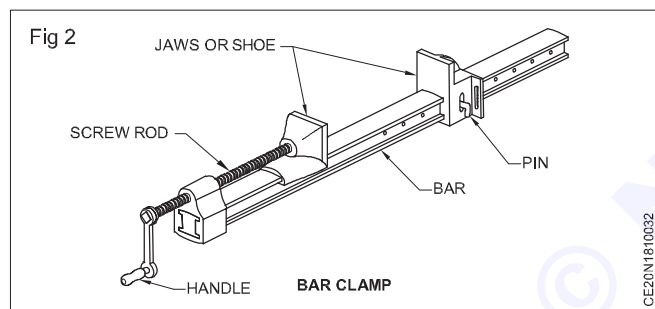
Hand screw (Fig 1)



The hand screw is a clamp consisting of a pair of jaws. This is made of either in steel or wood.

This is useful for small jobs and in gluing works.

Bar clamp (Fig 2)



Steel bar clamps are used generally in pairs for gluing purposes. The bar may be of rectangular or 'T' shape.

T-bar clamps are heavier. Extra pressure can be applied to the job by this device.

These are used for clamping up wide works and large frames.

T-clamps are available in clamping capacity of 160mm to 2500mm.

'G' or 'C' clamp (Fig 3 & 4)

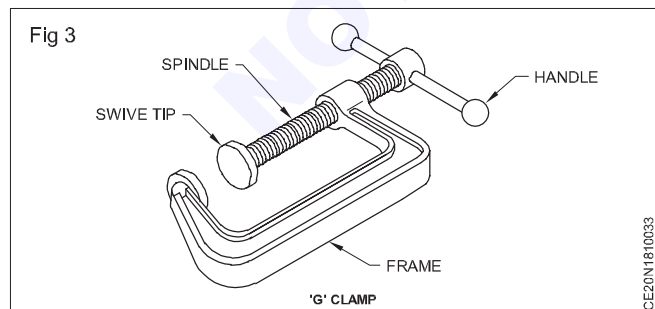
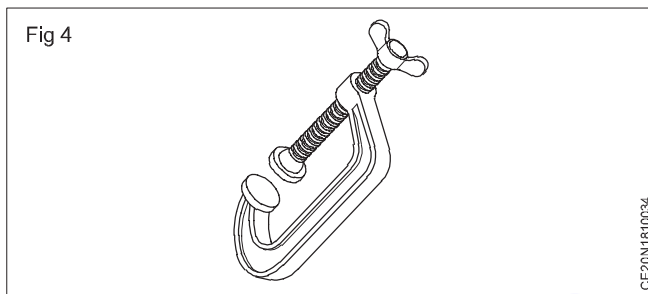
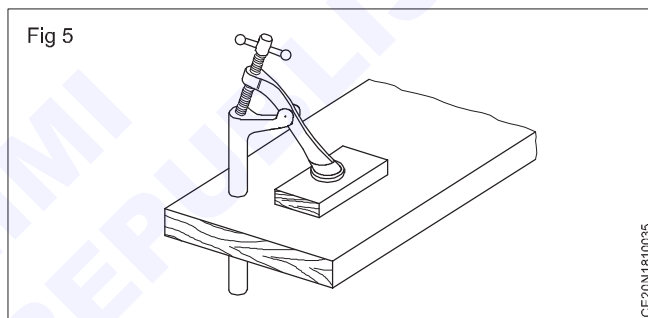


Fig 4



These are frequently used for smaller jobs and where the two hands are employed clamps have 'H' section iron and resists any tendency to distortion. The screw has a strong square thread and a round shoe on a ball which is socket joint in Wooden gluing device etc.

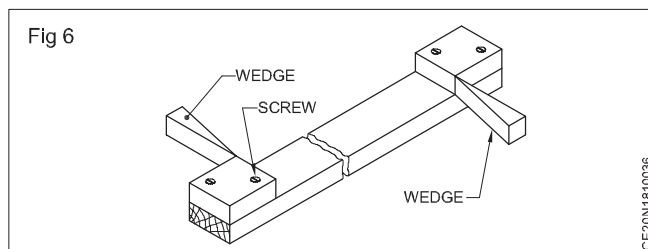
Bench hold fast (Fig 5)



In wooden planks to make holes the planks are held tightly without moving by this equipment. The stem is made of cast iron, screw rod, handle, hand one made of steel. This may be fixed in holes of the work table and planks can be tightened.

The cleat (Fig 6)

This is made of hard wood. This is 50mm longer than the plank to be tightened.



Power tools - Portable power saws and drilling machine

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

- state the different types of portable power sewing machine
- state the use of different types portable power drilling machine.

A power tool is a power driven light machine tool which is portable by hand while working. Like most hand tools, it is taken to the job. Portable power tools have an added advantage over machine tools as they do not require floor space for installation and use.

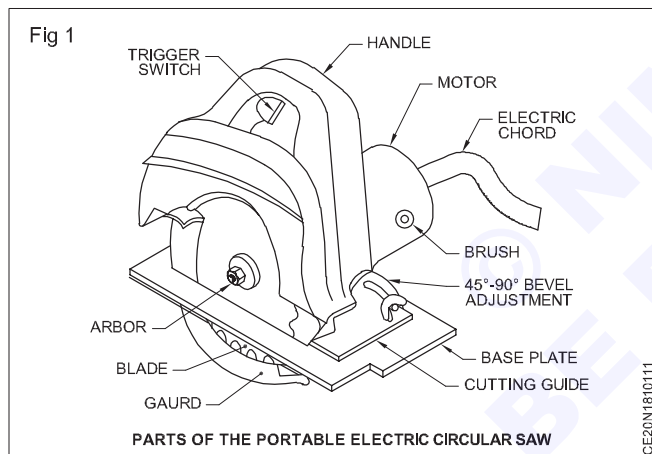
Portable power machines are manufactured in different shapes and sizes.

They differ from each other in appearance, construction and operation.

Types and uses

The most important portable power machine used in carpentry work.

Portable power circular saw (Fig 1)

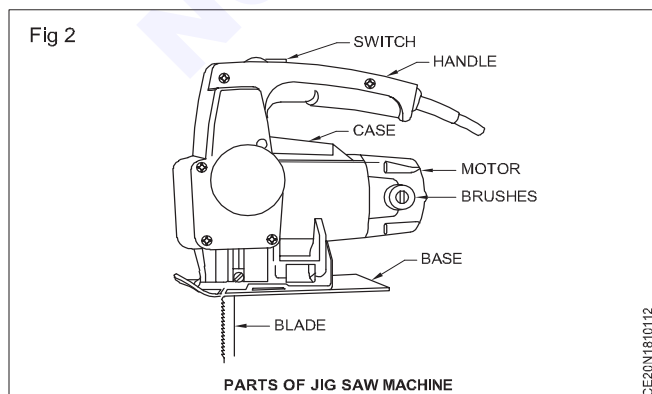


It is used extensively in building construction. Works on the site and wood working workshops

This power machine has been improved with the development of built in blade brake.

It is also useful to cut plywood, plank and sun mica, cutting grooves and rebates.

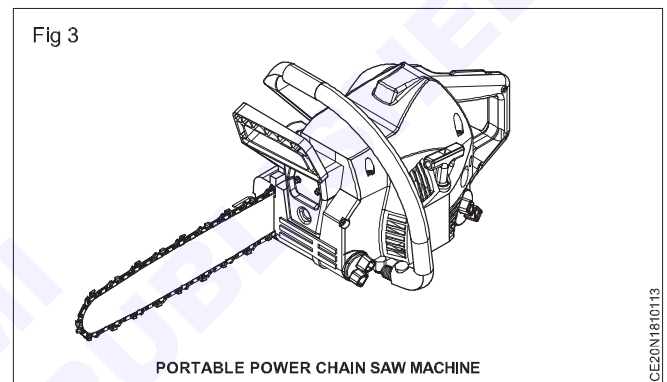
Portable electric jig saw machine (Fig 2)



The portable jig saw is a very convenient machine for cutting wood, composition board veneer, plastics card boards

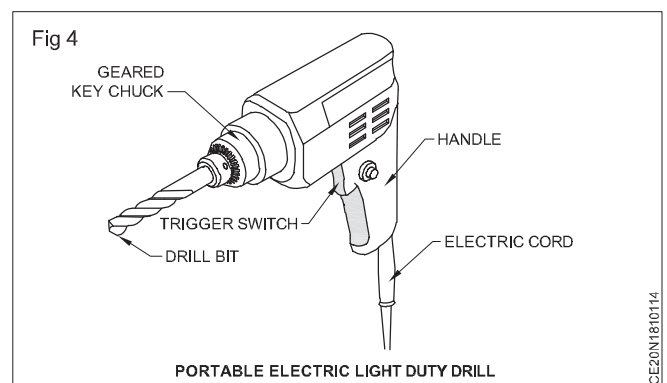
These broad ranges of possibilities are it is ideal portable electric saw for the use in cabinet making shops, electrical wiring factories

Portable power chain saw machine (Fig 3)



Modern chainsaws are typically gasoline electric or battery powered and are used in activities such as tree felling, limbing, bucking, pruning, cutting fire breaks in wild and fire suppression and harvesting of fire wood.

Portable electric drill light duty (Fig 4)

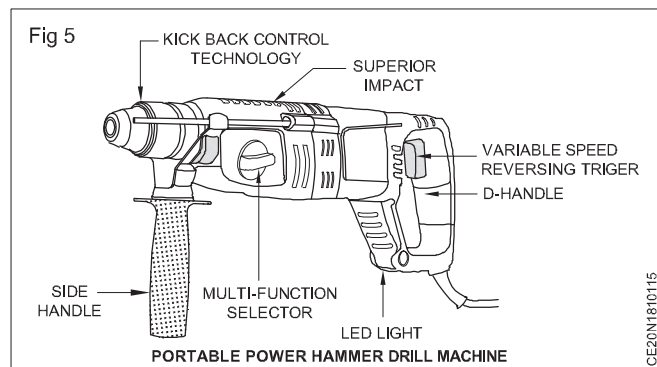


The portable electric drill is usually the first power tool selected for the home workshop.

These are available in different forms.

The portable drilling machines are used to drill small holes and are commonly used in the entire work shop. This type of drilling machine is operated by holding it in hand

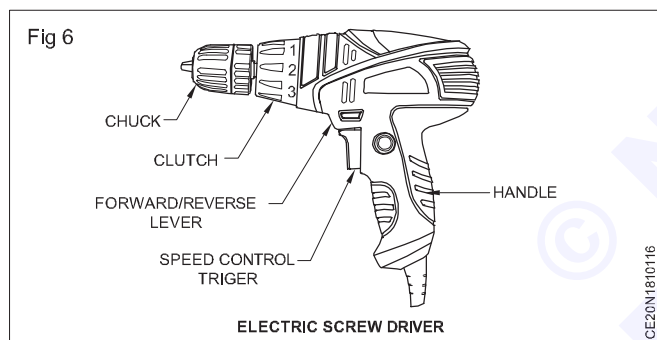
Portable power heavy duty hammer drill machine (Fig 5)



Hammer drill is a convenient device to have in your tool box as you can use it for several different applications

These tools are handy and help in carrying out relatively light duty jobs. They are competent to drill holes in concrete, brick, wood, stone, and other hard materials. Hammer drill machine uses a standard drill chuck and round shank bits it can be used in the drill only mode to penetrate wood and metal as well as in the hammer and drill mode to penetrate concrete and brick.

Portable Electric screw driver (Fig 6)



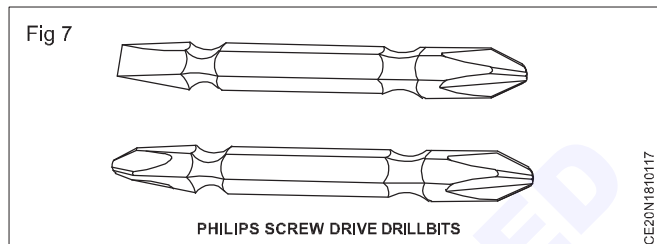
Electric screw driver is a portable electric driver that allows you to screw and unscrew effortlessly. The head of the screw driver is equipped with a bit holder which can be magnetic or have a quick release system. The bit holder allows you to quickly insert the bit that corresponds to the screw head.

Electric screw drivers also come with reverse action to remove screws if needed. Torque control on electric screw drivers is possible to change the rotating force (known as torque) for more control bigger, heavier screws often need more force behind them than smaller lighter ones.

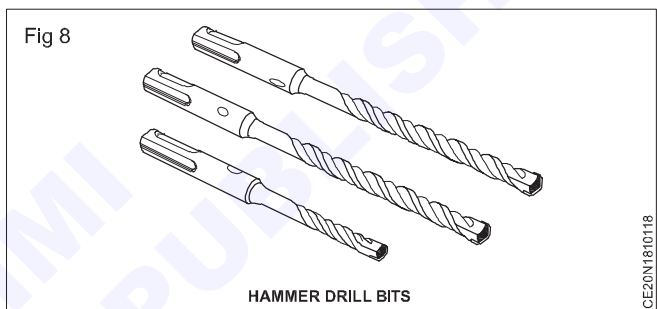
Pull the caller towards the body of the screw driver with your fingers hold it against the front of the screw driver. This releases the bit, pull the bit out of the screw driver.

Screw driver bit (Fig 7)

Screw driver bits are generally tools that are attached to the tip of an electric drill, pneumatic drill, or like the tip is of a shape that fits the groove in the head of the screw drivers with flat tip are called flathead screw drivers and those with a cross - head (Philips head screw) screw drivers.



Hammer drill bit (Fig 8)



Hammer drills are not typically used for production construction drilling but rather for occasional drilling of holes into concrete masonry or stone.

They are also used to drill holes in concrete footings to pin concrete wall forms and to drill holes in concrete floors to pin wall framing.

A hammer drill uses a particular type of drill bit designed specifically for these tough materials.

Description of carpentry joinery, planning, moulding, rebating, chamfering, sawing and types of saws

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

- describe joinery, planning, moulding, rebating, chamfering and sawing
- state the various types of saws and uses.

Wooden joints

The most common forms of joints are the majority of joints used in wood work were designed years ago to perform certain duties and by experience their proportions have become standard to maintain a maximum of strength with the parts they connect. Variations of these joints are occasionally necessary and designed to suit special jobs.

Planning

Planning is the most important basic operation connected with carpenter work. Constructions such as carcasses, frames, doors, drawers, etc., produced from accurately prepared timber are more likely to finish square and true than from badly prepared stock.

Moulding

Moulding plane is needed for cutting concave, convex, any other desired moulded shapes along the length of the wooden pieces. Moulding is required for photo frames and other decorative works.

Rebating

It is the process of making rebate or receive in the edge of the timber. A rebate is made in the frame to receive the shuttle. Rebate is also made in rash bus etc to fit the glass panels rebate plane is used for making rebate.

Chamfering

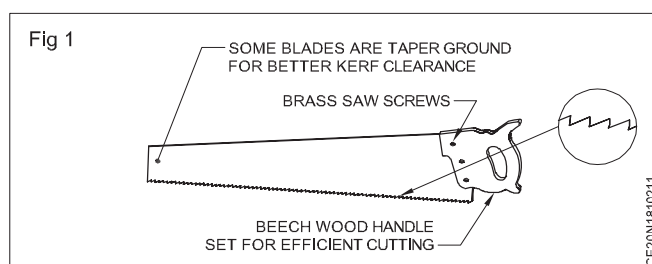
Chamfering is a precision machining operation by means of which a 45° cut is made on the ends or hole of a workpiece in order to eliminate sharp and brittle edges. This operation is one of the most common and wide spread and is performed on numerous.

Sawing

There are several types of saws for cutting wood. some are used to make straight cuts and others are used make curved cuts. As its name suggests, a cross cut saw is used cut wood perpendicular or at an angle to the wood grain.

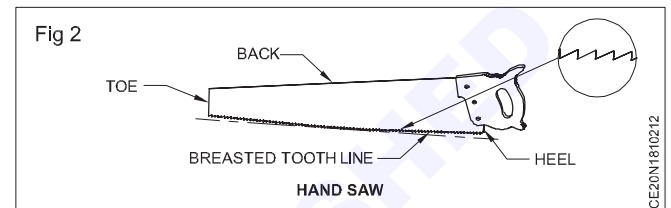
Types of Saw

Rip Saw (Fig 1)



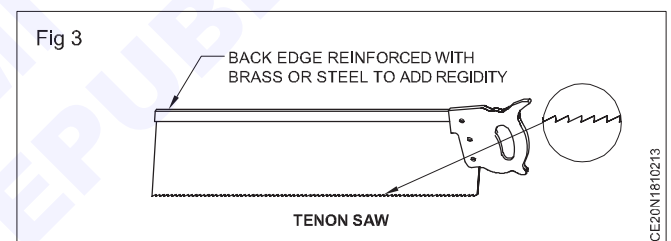
- Blade is made of thin spring steel.
- Used for sawing along the grain

Hand saw (Fig 2)



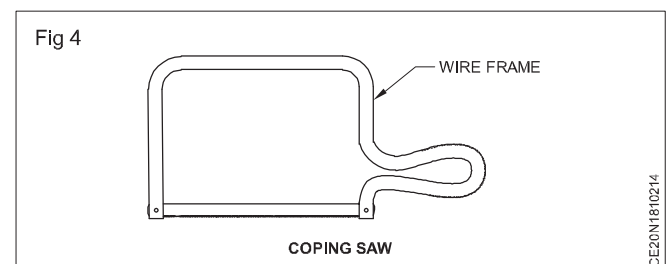
- Used for lighter work.

Tenon saw (Fig 3)



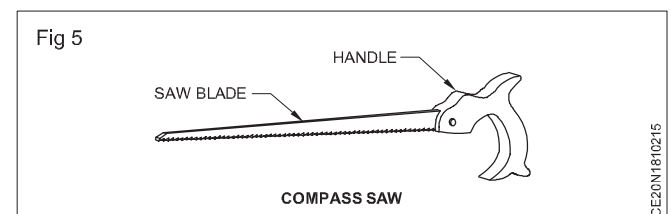
- Closed handle. It is used for finer works like tenop.

Coping saw (Fig 4)



- Used for cutting sharp and quick curves internal and externally

Compass saw (Fig 5)



- Used for cutting large interior curves

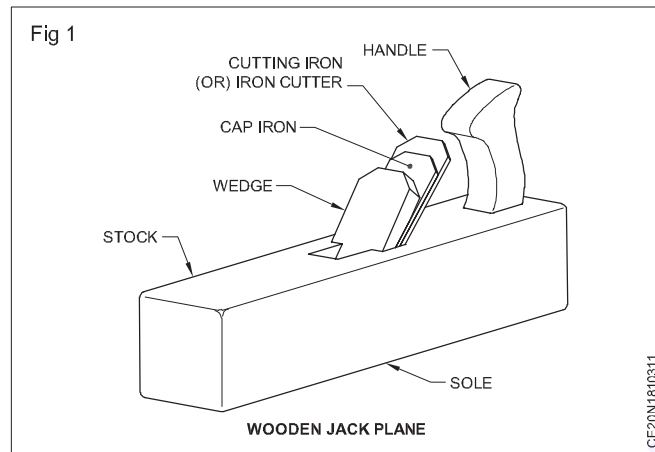
Types of wood working planes and uses, knowledge of sharpening and uses

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

- name the various types of planes
- state the uses of the various planes
- state constructional feature of various planes
- specify the planes.

A plane is a hand tool used for smoothing or shaping pieces of wood.

1 Jack plane (Fig 1)



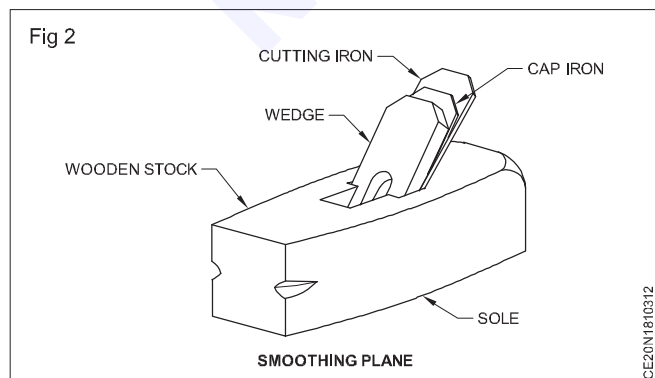
This plane is used for planning the job to size quickly and truly. Stock is made of wood or steel. Handle is fixed behind the cutting iron.

The size is 375 mm x 66mm x 47mm. The angle of cutting iron is 45°

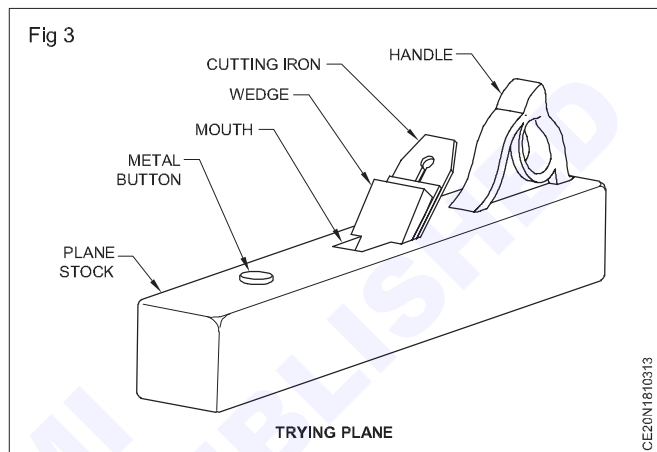
The size is 375 mm x 66mm x 47mm. The angle of cutting iron is 45° and the cutting iron is sharpened in a curve. The mouth of the plane is big enough to accommodate thicker wood shavings. The cutting iron further projects outside than in other planes.

2 Smoothing plane (Fig 2): This is used when the surface has to be planed further to smoothness.

- The size is 240 x 66 x 65mm
- The width of cutting iron is 48mm
- The angle of the cutting iron is 30°.

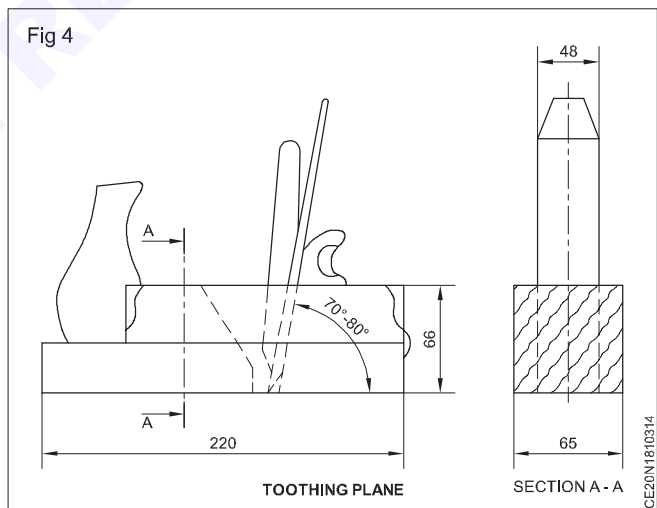


3 Trying plane (Fig 3)



It is larger and longer than other planes. Its length is 600 to 700mm. The blade is 46 to 56mm wide. This is used for producing a true and straight surface.

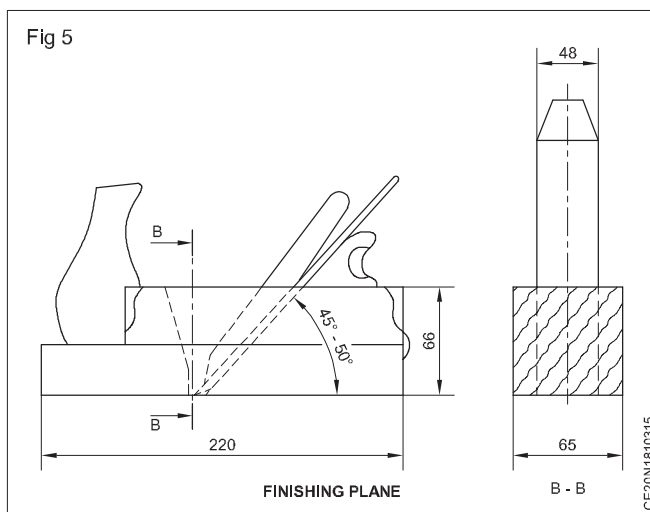
4 Tothing plane (Fig 4)



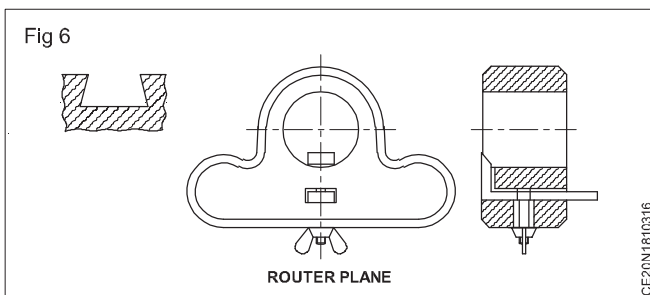
The purpose of this is to prepare a rough gluing surface. The cutting angle is set at 70° to 80°. The cutting edge is a series of teeth formed like 'V'. The plane is used diagonally across the work in both directions and in along the grain.

5 Furnishing plane/finishing plane (Fig 5)

This is slightly smaller than smoothing plane. Its cutting angle is 45 to 50°. It prevents the tearing of wood and gives a good finish. This is also called reform-finishing planes.

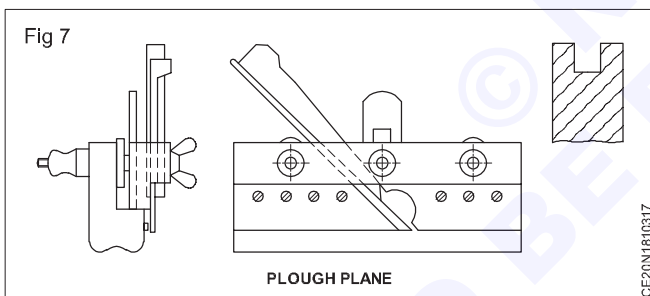


6 Router planes (Fig 6)



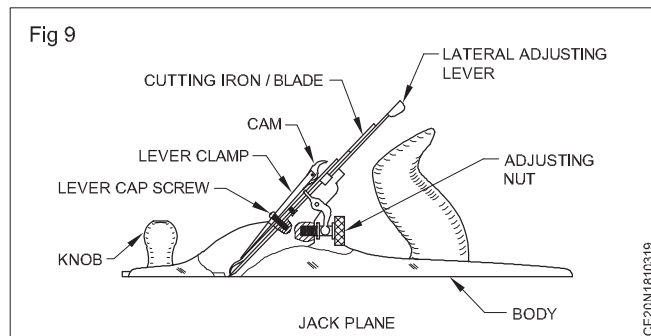
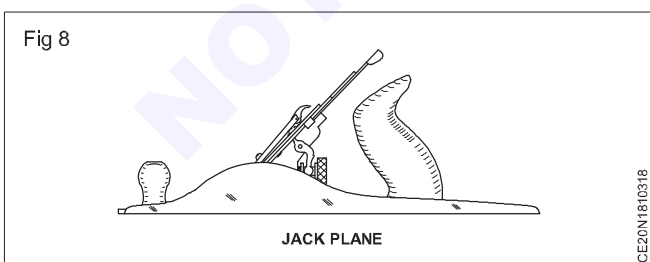
It is used to clean and level grooves and recesses. It is used across the grain.

7 Plough plane (Fig 7)



It is used to form grooves parallel with grain. The cutting-irons are available from 3mm to 16mm wide. It has no cap iron.

8 Adjustable metal jack plane (Fig 8 & Fig 9)



- This is just like wooden jack plane but the cutting iron adjustable.
- This plane is used for planing of timber to bring the size nearer to the required measurements.
- The size is body length 360mm and cutter width 50mm.

These parts are made of different materials as listed below.

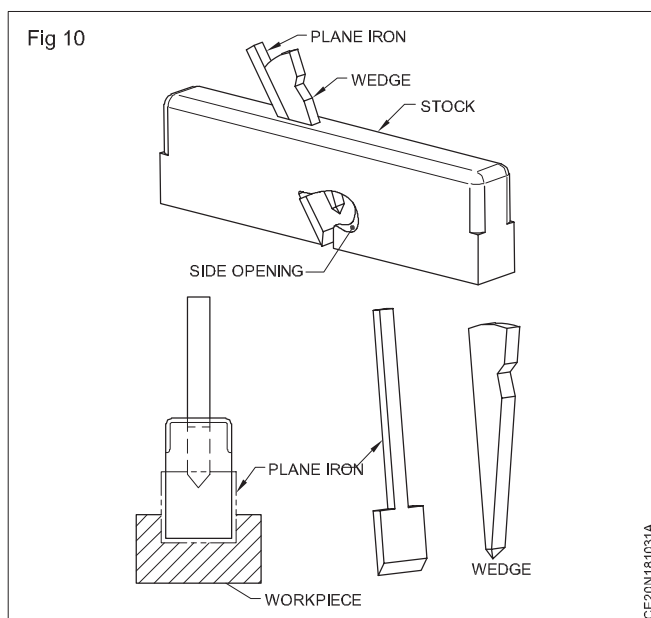
Body	- Cast iron
Handle	- Rose wood
Knob	- Rose wood
Cutting iron/blade	- Tungsten steel
All other parts	- Metal

Advantages of adjustable metal bench plane

- Easier to use than wood plane owing to low position of handle.
- Simple adjustments by means of adjustment screw and lateral adjustment lever.
- Cutting iron thinner speeding up grinding and sharpening.
- Body retains shape little wear.

A smear oil or wax on the sole of the plane reduces friction and makes planing easier.

Rebate planes (Fig 10)



Rebate planes are used for planing and smoothing rebates.

A rebate is a step on the edge of a piece of wood.

Setting a jack plane blade: A jack plane is used to plane the wood to the required dimensions with smooth surface finish.

Setting and adjusting the plane blade is necessary for even and uniform cuts while planing.

Step in setting: The two steps in setting the plane blade are:

- Setting the plane blade to the required depth of cut
- Adjusting the cutting edge of the plane blade parallel to the plane sole or bottom face.

Setting the plane blade to the required depth of cut

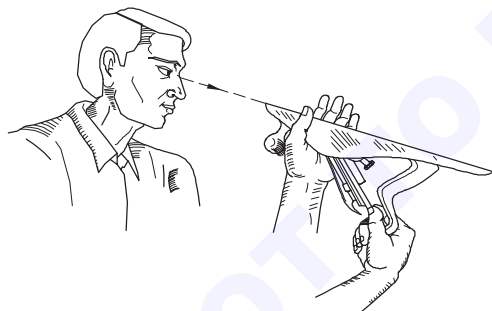
Hold the plane in the left hand keeping the sole of the plane in line with your sight at a convenient distance.

Turn the adjusting nut in an anticlockwise direction to the required depth of cut until the cutting edge of the blade projects above the sole or bottom face of the plane. (Fig 11)

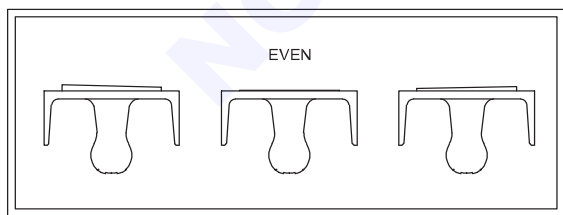
Adjust the plane blade parallel to the sole of the plane: Check whether the cutting edge of the blade is parallel to the bottom face of the plane. If not, move the adjusting lever gently to the left or right until it is parallel.

While setting the plane blade, face the source of light. For protection of the cutting edge of the blade, withdraw the plane blade into the plane before keeping the jack plane in the tool kit.

Fig 11



EVEN



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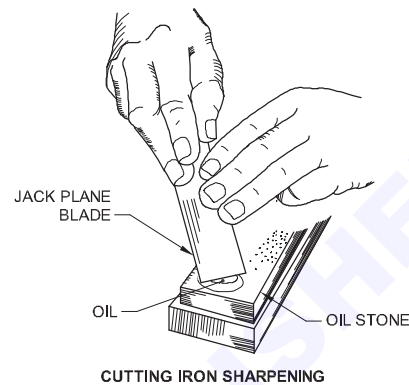
Knowledge of sharpening and uses

Sharpening of a plane blade or cutter is necessary to produce a keen cutting edge for good surface finish, and perfect planing with minimum effort.

Sharpening and honing

The process of sharpening is carried out on oilstone by rubbing the blade with its bevel down, maintaining a constant and correct angle, 25° to 30° . This rubbing is continued until a burr or wire edge is produced. (Fig 12)

Fig 12

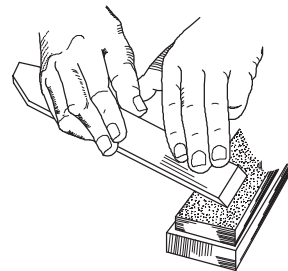


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The burr is removed by rubbing the back of the flat face of the plane blade on the oilstone, keeping its bevel up. (Fig 13)

During sharpening, oil is used to minimise the heat caused due to friction and to float off the metal particles from the pores of the oilstone so as to prevent clogging of the oilstone.

Fig 13



CE20N181031D

Knowledge of using marking gauge and mortise gauge

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

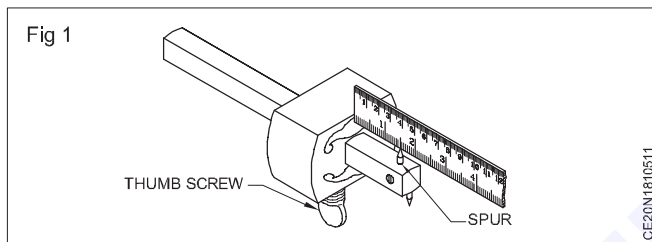
- state the using of marking gauge and mortise gauge.

Marking gauge: The marking gauge is used to make an accurate mark parallel to the planed edge or side of a piece of wood for the purpose of obtaining the width, thickness or depth of a groove.

Hold the gauge in left hand keeping the spur up.

Hold the foot rule in right hand and set the required distance between stock and spur. Keep the graduation of foot rule in front. (Fig 1)

Adjust the stock with the help of left hand thumb and index finger. Now the marking gauge is set. Tighten the thumb screw.



Check the measurement of accuracy.

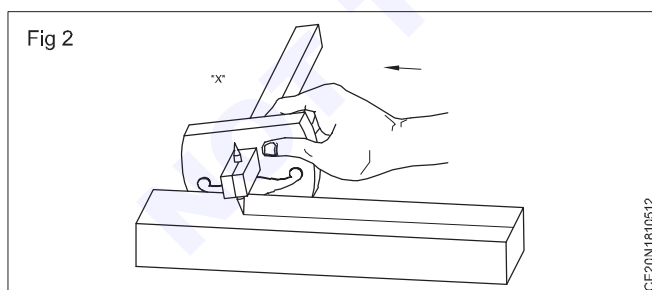
Hold the gauge stock in right hand thumb is behind the spur, the fore finger on the stock and the three other finger on the stem of the tool.

Place one end of the piece against the bench stop and other end in left plan.

Place gauge stock in contact with the face edge of the piece and spur touching the piece lightly in slanting position.

Give forward stroke on the stock near the end. (Fig 2)

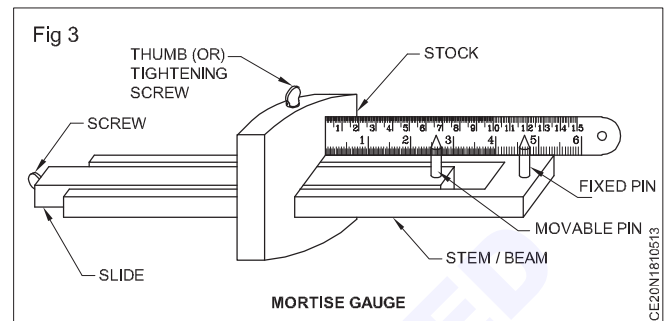
Hold the piece in left hand and complete the gauge mark.



Mortise gauge

Mortise gauge is used for marking mortise tenons and similar joints using paralleled lines.

The procedures for taking measurements and stock and spur adjustment are the same as marking gauge. (Fig 3)



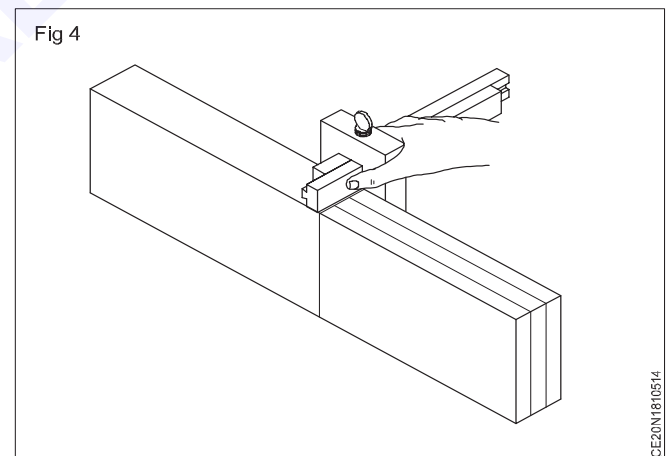
Check the measurement of accuracy

Hold the mortise gauge stock in right hand thumb is behind the spur, the fore finger on the stock and the three other finger on the stem of the tool.

Place one end of the piece against the bench stop and other end in left plan.

Place mortise gauge stock in contact with the face edge of the piece and spur touching the piece lightly in slanting position.

Give forward stroke on the stock near the end. (Fig 4)



Check the gauge mark with foot rule.

Precautions

Do not use a long spur for gauging.

Do not see the distance by keeping the rule flat.

Do not press spur while gauging.

Keep the stock face rubbing against the straight edge.

Do not put the spur at right angles with the face.

Checking flatness and twistness of surface, using winding strip

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

- state the necessity for checking flatness and twistness and use of winding strip
- explain the constructional features of a winding strip.

Necessity for checking flatness and twistness

- The planned wood must be free from twist and up and down.
- Before selecting the wood inspect the wood without twist and it should be flat.
- To find the up and down in the wood winding strip are used.
- Good wood without twist and up & down used for preparing good joints.
- The furniture legs will sit properly in the floor.
- If the wood is good the door & window can be closed properly without clearance.

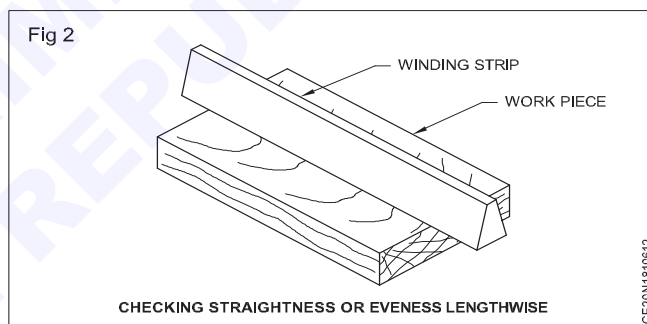
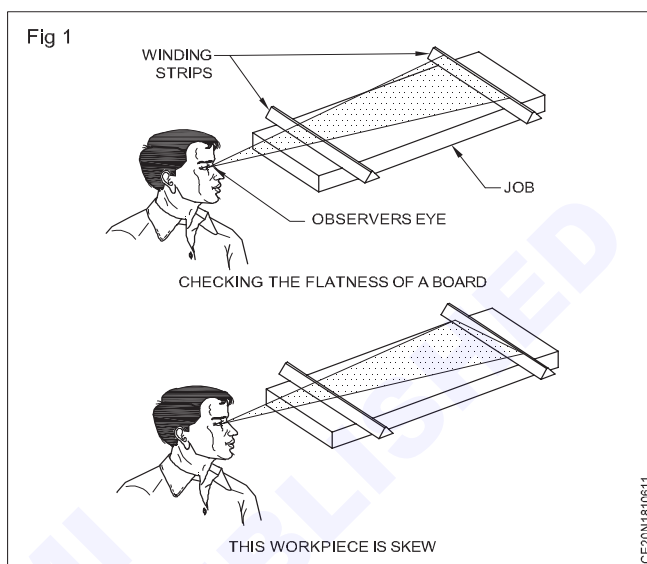
Winding strip is a pair of perfectly done straight pieces of timber, with parallel edges. Usually they are about 375 mm long and 35 mm wide and 20 mm thick.

For testing the job for flatness, one stick is placed across one end and the other stick is placed across the other end of job. (Fig 1)

The top edges of the sticks are sighted and if they are not parallel, the surface is said to be uneven, or they are said to be 'in winding'.

Again if the high levels of the job are planed the winding strips are placed on the job and the tops of the strips coincide then the level is said to be 'out of winding' and is perfectly flat.

To check the surface for wrinkles or unevenness breadth wise or lengthwise winding strips are used. (Fig 2)

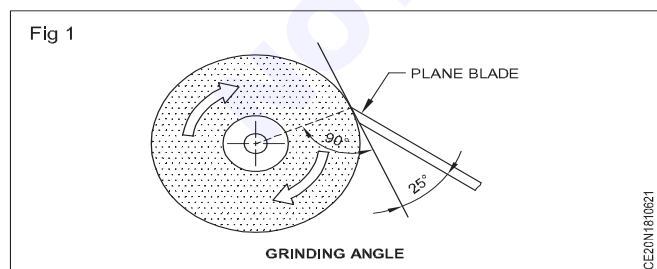


Sharpening and grinding angle of cutter

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

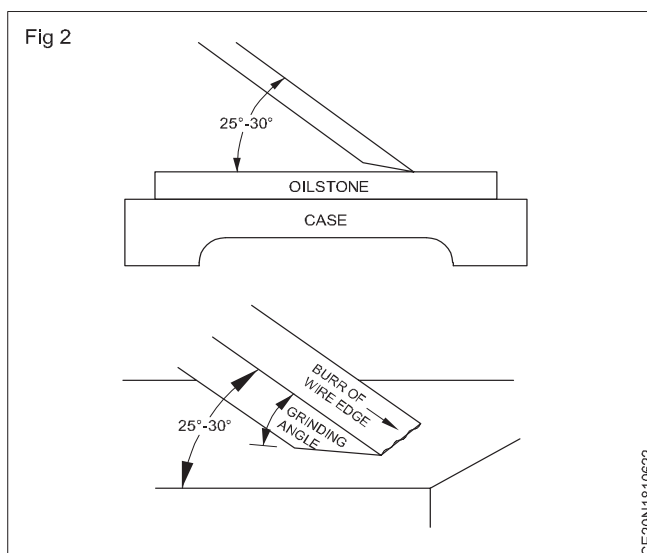
- state the grinding angle and sharpening angle of plane cutter.

Grinding (Fig 1): The process of removing the wearing away of worn or gapped cutting edge of the cutting tool to produce a new grinding bevel.



This is done by holding the plane blade at a constant angle of 20° to 25° to a rotating abrasive wheel.

Sharpening (Fig 2): The plane blade is held at a constant angle of about 25° to 30° (5° greater than the grinding bevel) to the stone and rubbed back and forth to produce a sharpening bevel.



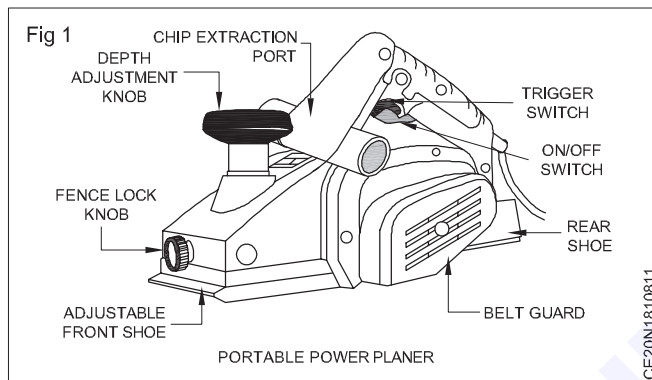
Portable power planer

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

- state the use of power planer in wood work.

Planning is the most important basic operation connected with carpenter work. Constructions such as carcasses, frames, doors, drawers, etc., produced from accurately prepared timber are more likely to finish square and true than from badly prepared stock.

The portable power planers used to make sure the surface to be smooth planned in face, Grain or side grain (Fig 1)



It is important that the planer should always be planning in the same direction as the grain of the wood (along the direction of the grain)

The proper feed rate will depend on the type of material being cut and depth of the cut

Power planes are available in sizes 50-125mm. Maximum width of cut the plane will make at one pass over the wood, (ie) the width of the sole which equals the length of the cutting blades.

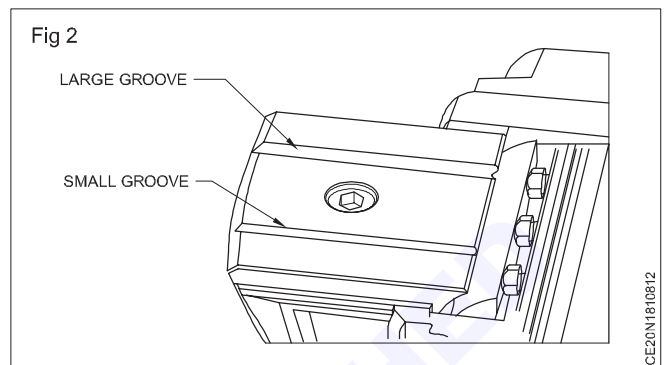
Generally two cutting blades are bolted to a cutter block which is revolved at high speed 12000 to 15000 rev/min. by gears or belts connected to an electric motor mounted on the body or the plane. Depth of cut (up to 6 mm) is regulated by a star wheel or knob which slides the front portion, "front shoe", of the sole on an inclined plane.

Most planes are fitted with a fence to guide the plane when squaring, beveling or mitring edges and ends. Bevel gauge can be fixed to either side 135° to the sole. The front shoe has a rebating groove machined along on edge for 9 mm wide by 9 mm deep wider rebates may be produced by making two or more passes of the plane

Front shoe

- The shoe can easily be adjusted to the depth of the cut.

The V-Grooves in the front shoe allow quick and easy chamfers, creating a sloping edge along the corner of the workpiece. There are two V-grooves, a



large and a small groove (Fig 2) to meet the needs of your particular project.

Rear shoe

- The rear shoe is not adjustable
- This shoe supports the board after it is planed.

Depth adjustment knob

- The cutting depth of a planer is determined by the height difference between the adjustable front shoe and the cutting edge of the blade.
- This knob retracts the front shoe to adjust the width blade is exposed
- This knob determines the amount of material that will be removed, to adjust the cutting depth.

Chip extraction port

- Used for wood planning adjust extracted through chip extraction port.

Safety precaution

- 1 Make sure the cutter bolts are tightened
- 2 Check electrical and mechanical parts.
- 3 Secure the job firmly so that both hands can guide and control the plane
- 4 Keep the fingers above the sole of the plane - keep the lead behind the plane
- 5 Allow the motor to attain full speed before operating-plane with grain.
- 6 Do not force the plane to cut rapidly - a fast forward movement produces a rippled surface due to rotating cutters.
- 7 When starting a cut, press the front shoe of the plane on the work. when cutting starts transfer the holding pressure to the rear handle. Make sure the cutters have stopped revolving before putting the plane down.

Civil Engineering Assistant - Carpentry**Description of different types of joints**

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

- state the various classification of joint used in wood work
- state the uses of joints.

The most common forms of joints are the majority of joints used in wood work were designed years ago to perform certain duties and by experience their proportions have become standard to maintain a maximum of strength with the parts they connect. Variations of these joints are occasionally necessary and designed to suit special jobs.

Lengthening joints

These joints are used for joining small lengths of wood pieces end-to-end to obtain large lengths many lap, butt and scarf joints come under this category.

Widening joints

These joints are used for joining wood pieces along their edges in order to obtain increased width. Rebate, butt, tongue and groove are quite commonly used for this purpose.

Framing joints

These joints are used to connect wood pieces at desired inclinations and commonly employed in frame work. This category includes, mortise and tenon, bridle, rafter, mitre, lap dovetail, notched and scarf joints.

Box joints

These joints enable joining of wooden planks and scantlings at desired inclination so as to obtain box shaped structures and wooden cases. Lap rebated open and secret dovetail, corner having mitre haunched mortise and tenon and corner locking joints are commonly used for this purpose.

Circular joint**Different types of joints - half - lap joints**

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

- explain various types half-lap joints and uses.

Half lap joints

- A half lap joint consists of half the thickness cut away from one component and half the thickness cut away from the other.

Corner half lap joint

- Half lap joints are frequently used to connect two wooden pieces such as boards, frames where an even surface is required.
- When it is fixed at the ends it is known corner half lap joint. (Fig 1)

These joints are used for connecting wood pieces to form a hollow cylindrical structure. The joints commonly used for this purpose are butt, hammer head key, blind mortise tenon scarf and dowelled joints.

Some common joints**Dowel joint**

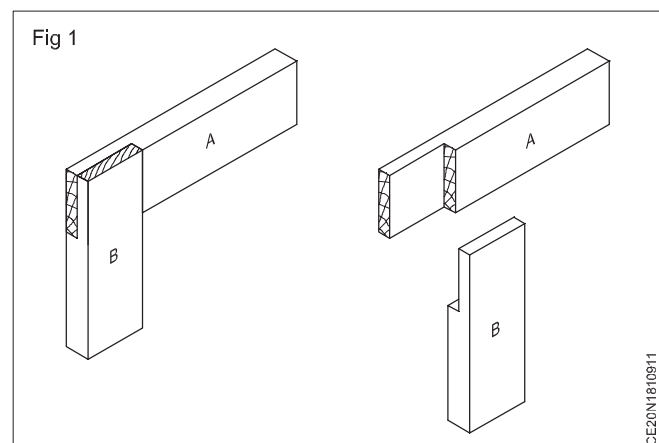
Dowels are thin small round sticks made from hard wood and are employed in various ways. Some common uses of dowels include their use as reinforcements for butt and mitre joints as a substitute for mortise and tenon joints in small articles in securing loose parts to a product and as strengtheners to circular, square and irregular forms. While making a dowel joint it should be ensured that the locations in the dowel holes in the two mating part are in perfect alignment.

Grooved joints

Many types of grooved joints are used in wood work. In some other the grooves run parallel to the grains and in other across the grains called 'dadoes'. Some of the grooved joints are concealed and some are open. A common example of this is tongue and grooved joint, which you can easily notice in filling of door panels. Other grooved joints include rebate and spline joints.

Mitre joints

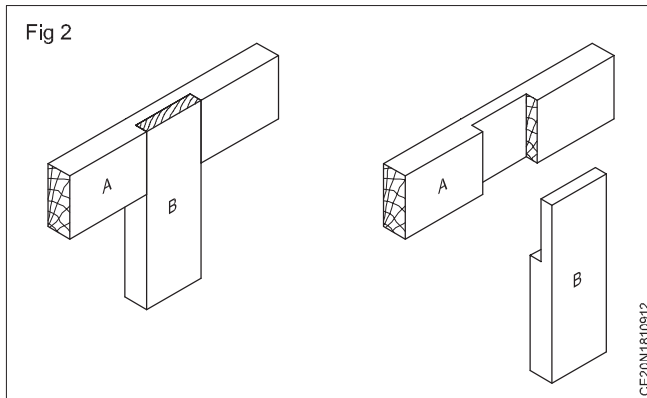
These joints can be readily noted on the corners of picture frames. Their use facilitates such joints at which no end grains of the wood pieces are visible. Apart from glueing, these joints are usually strengthened by means of dowels, nails or hard wood splines etc.



Tee-half lap Joint

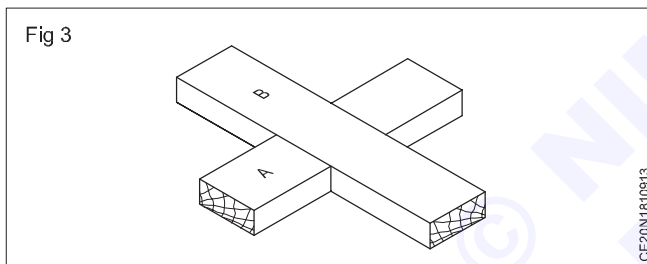
It is used in frames where the end of a rail meets another piece some distance from the end both faces of the pieces finishing flush.

The joint is used in cabinet frames and where a strong joint is not required. (Fig 2)



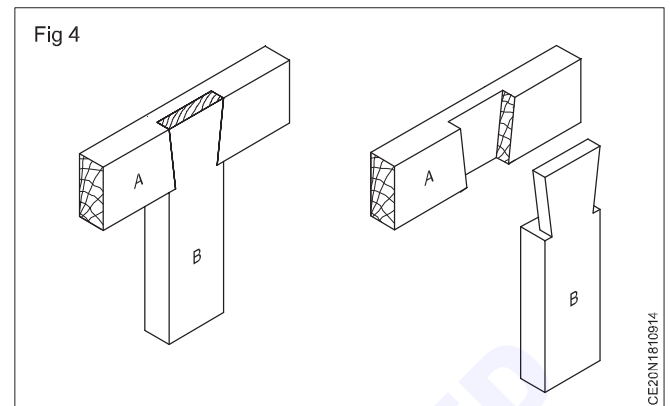
Cross half-lap joint

It is used where the members cross each other and the faces of the pieces are required to be flush as in diagonal stays of tables and chairs, and frames of cheap paneled doors. (Fig 3)



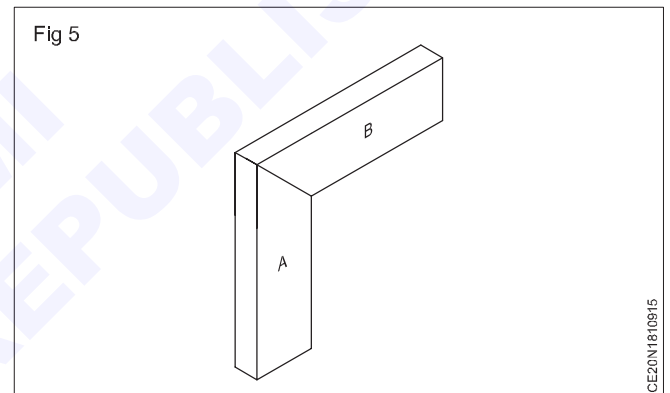
The dovetailed half lap

It is used for connecting the ends of cross rails in frame like construction where an outside strain occurs. This joint can be separated in only one direction. (Fig 4)



Mitre half lap joint

The mitre-half lap joint is used to hide end grains of woods in picture frames, mouldings rafter and drip caps etc. (Fig 5)



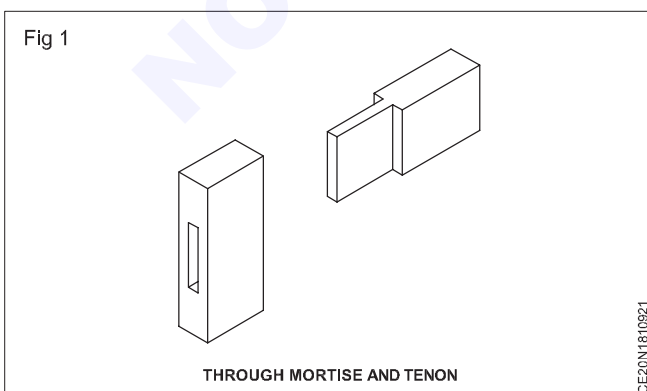
Mortise and tenon joints

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

- state the various types of mortise and tenon joints.

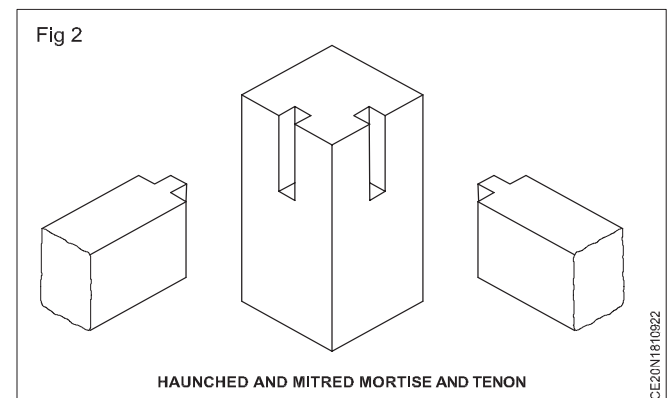
The most common and strongest form of framing joint. There are many forms of mortise and tenon joints. These are mainly used parallel frames of doors, carcasses of cabinets and for joining rails to leg of table and chairs.

Common mortise and tenon Joint (Fig 1)



They are used in same thickness and where a rail meets stile some distance from the end. The tenon is the full width of the rail and passes through the stile. The thickness of the tenon is usually about 1/3 the thickness of the timber depending upon the size of the mortise.

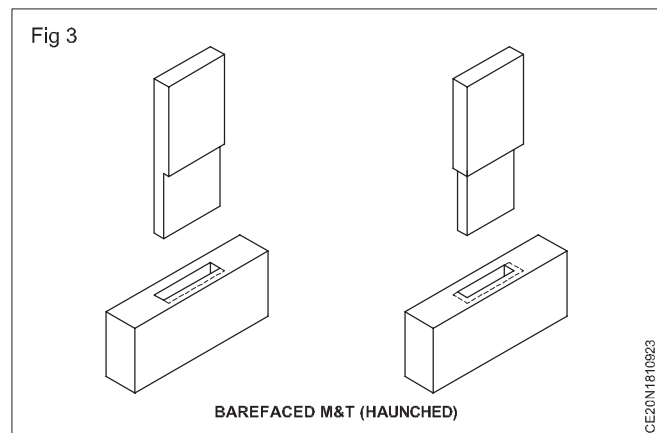
Haunched mortise and tenon (Fig 2)



It is used where the rail meets the stile or leg at the end. To prevent the tenon from slipping out of the end of the mortise, The length of the haunch is usually equal to the thickness of the tenon and its purpose is to prevent the rail from twisting.

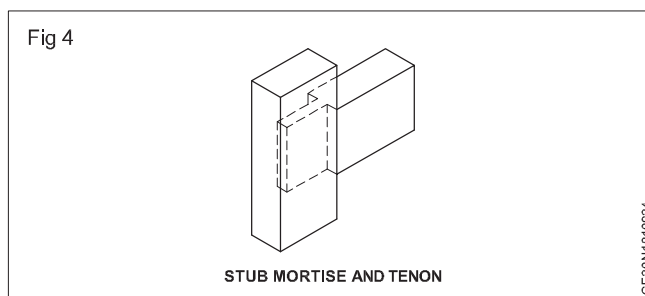
Barefaced mortise and tenon joint

This joint is used where the rail is of thinner material than the stile or the leg of ordinary table. The tenon has only one shoulder and is approximately half the thickness of the rail. (Fig 3)



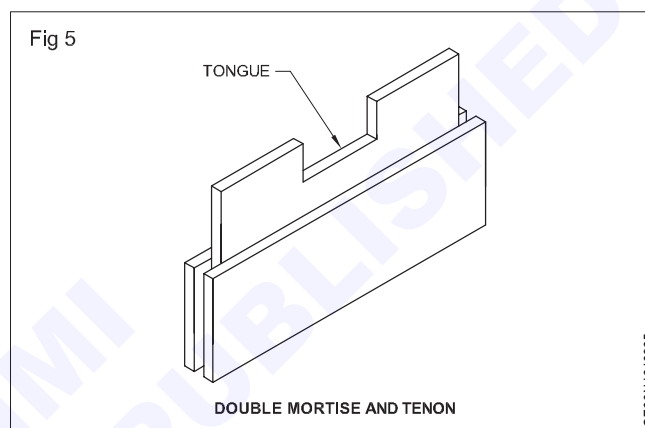
Stub mortise and tenon or (stump)

When the tenon does not pass right through the material it is known as stump or stub tenon. It is used in high class cabinet work, so that the end grain is not seen on the edge of the stile. (Fig 4)



Double mortise and tenon

Where the joining rail is wide, it is usual to divide the width of the rail in to two tenons so that the width of each tenon does not exceed 6 times its thickness. Usually left between the tenons to prevent the rail from warping and light showing through if the stile sinks. (Fig 5)



Different type of housing joints and uses

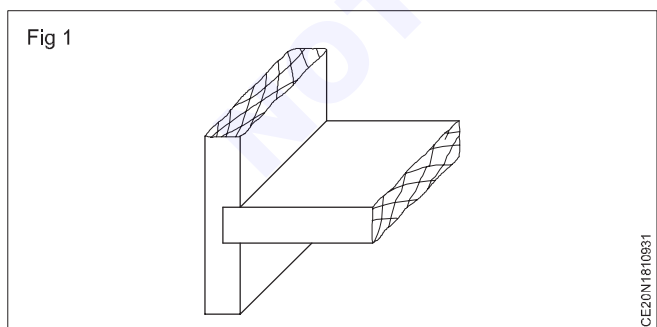
Objectives: At the end of this lesson you shall be able to

- state the types of housing joints and uses.

The housing joint consists of sinking the one end or edge of one member into a groove or trench in the face of another member. It is mainly used in fixing shelves or divisions in book-cases, cabinets, treads of step ladders, treads of stairs etc.,

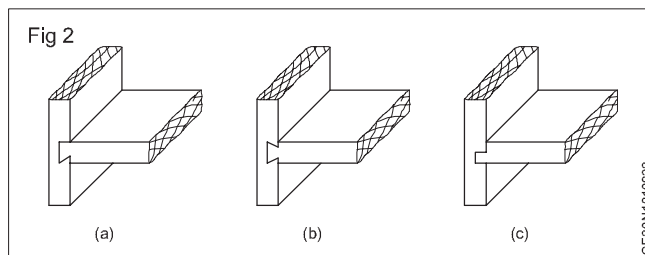
Types of housing joints

Full housing joints (Fig 1)



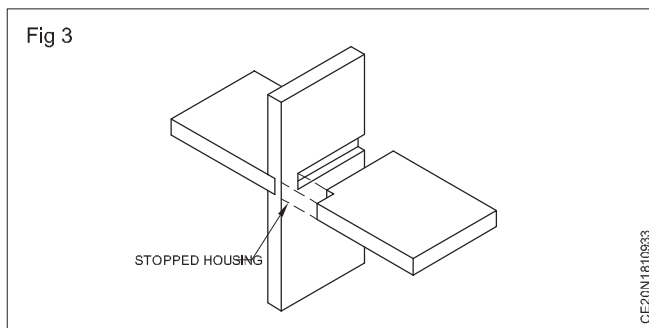
The whole end or edge is fitted into an enough trench and the joint is visible on both sides of edges.

Dovetailed housing joint (Fig 2)



Wherever a stronger joint is required it is used. The end of the shelf is dovetailed on one or both sides and fitted into dovetailed trench. The depth of the trench is about 1/3rd thickness of the plank.

Stopped housing joint (Fig 3): For improved appearance, this is used in preference to through housing. The end of the trench is stopped back from the front edge. The end of the shelf notched to suit so that in the assembled joint the trench is not seen.



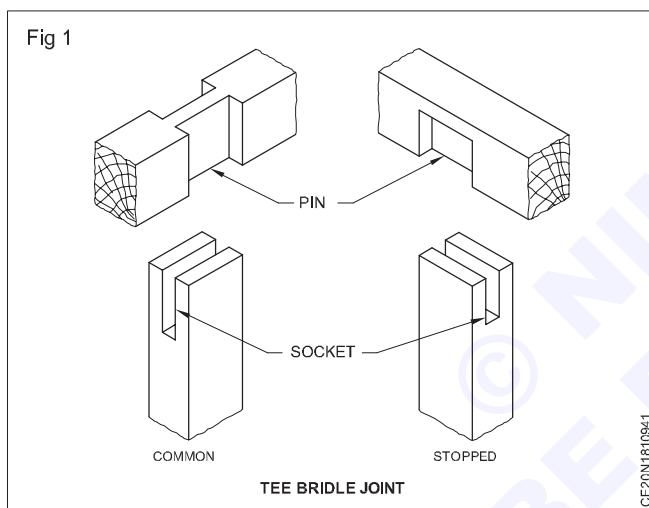
Bridle joints, types and uses

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

- state the various types bridle joint
- explain the uses of bridle joint.

These joints are sometimes used in place of mortise and tenon joints where a stronger joint than a halving is required.

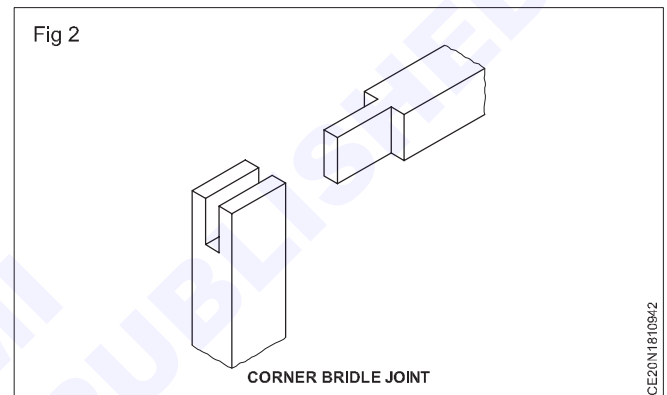
Common or Tee-bridle Joint (Fig 1)



In place of common mortise and tenon joint where one member meets the other some distance away from the end. Some times seen on small tables and stands where a leg meets the middle of rail.

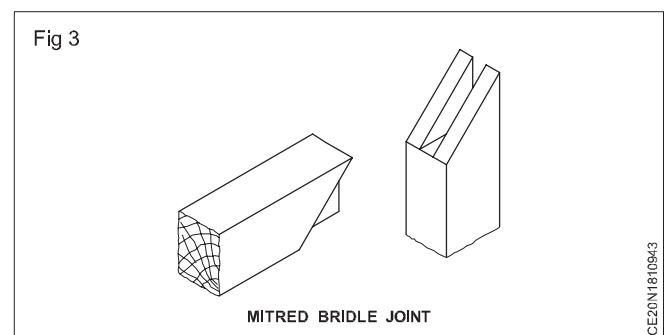
Corner bridle joint (Fig 2)

Some times it is called the open mortise and tenon joint. It is used as a substitute the haunched mortise and tenon at the corners of frames.



Mitre corner bridle joint (Fig 3)

One or both sides of the socket may be mitred as required. It is used where a stronger joint than the mitred halving joint is required on either plain or moulded timber as on mirror frames etc.



Dovetail joints and their function, uses

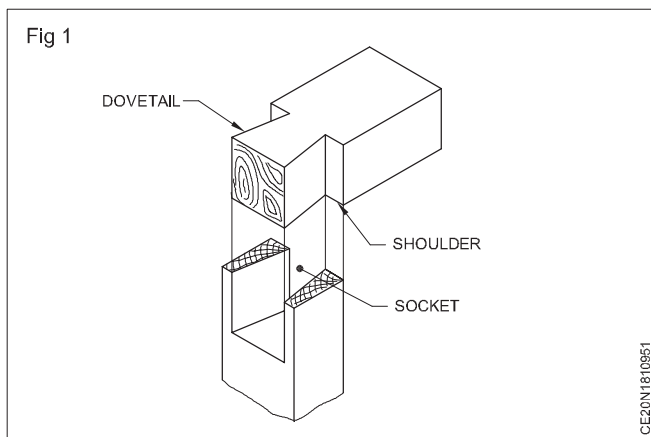
Objectives: At the end of this lesson you shall be able to

- state the various types in dovetailed joints and uses.

These are the strongest form of an angle joint used in cabinet work. The joint consist of one or more dovetails cut on the end of one member and a number of projections called pins on the end of the other piece, which are cut to fit into the recesses (pin sockets) on each side of the dovetails and the added amount of gluing surface compared with other angle joints.

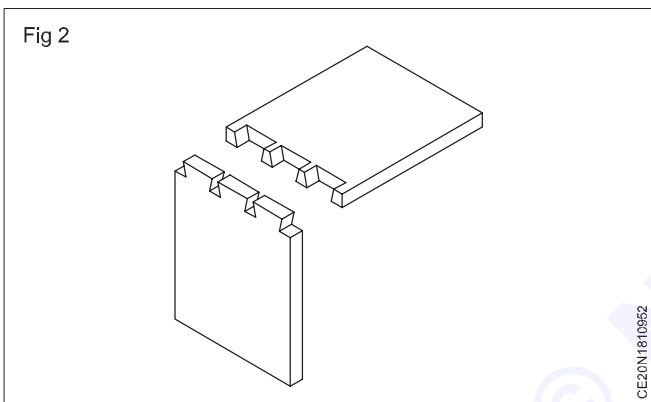
Single dovetail Joint (Fig 1)

This joint consists of only one dovetail filling into the dovetail socket in the second piece. A very strong joint used for narrow pieces such as brackets top, bottom rails of carcasses etc.



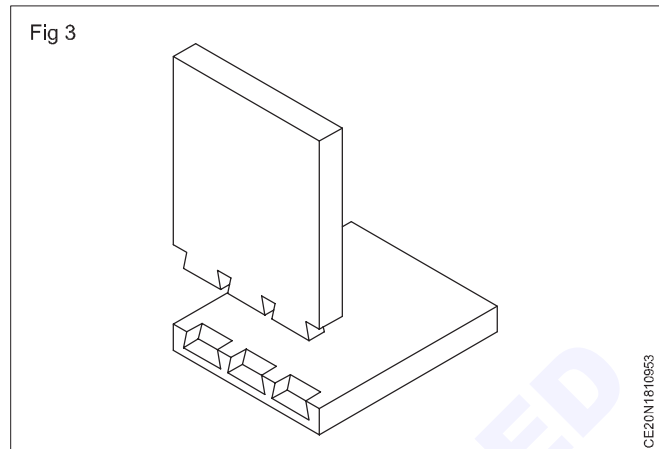
Common dovetail joint or through dovetail joint (Fig 2)

It is the strongest joint. It has two or more details. End grain is seen on both sides of the joint used in making strong boxes, rails of tea trays and in carcase construction etc.



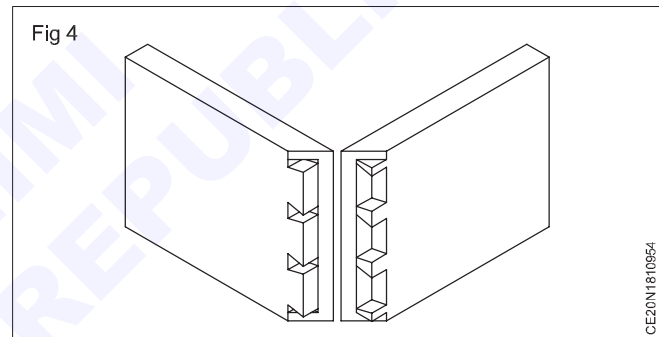
Lapped dovetail joint (Fig 3)

The lap is left on outside of the pins to cover the end grain of the dovetails. This joint used to join the front and sides of table drawers.



Secret dovetail joint (Fig 4)

In this dovetail joint there is a double lap on both sides of the joint, used in high class cabinet work and jewel boxes, where appearance and strength are required.



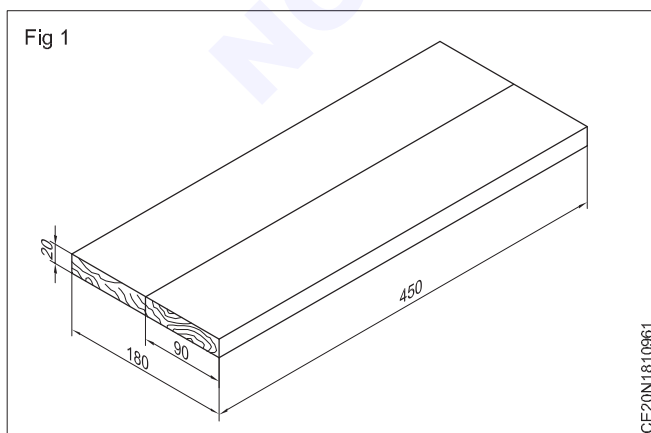
Broadening joint

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

- explain the various types of broadening joint and application.

These joints are used to produce wide boards from a number of narrow boards by joining them edge to edge.

Butt joints - In the simplest form of butt joint the edges are shot square butted together and held in place by means of glue or corrugated box fasteners. (Fig 1)

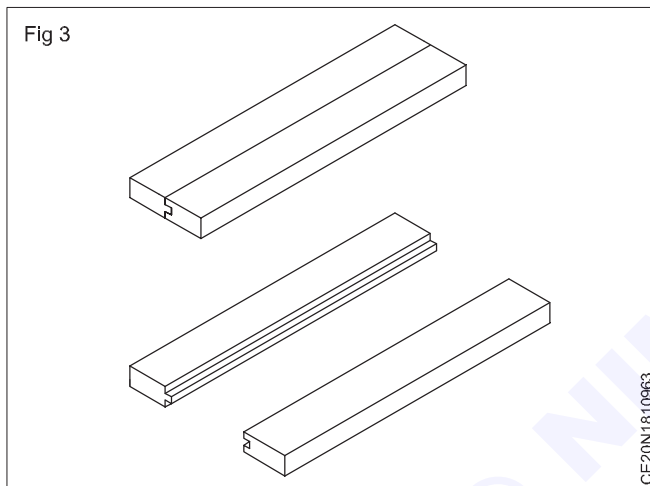
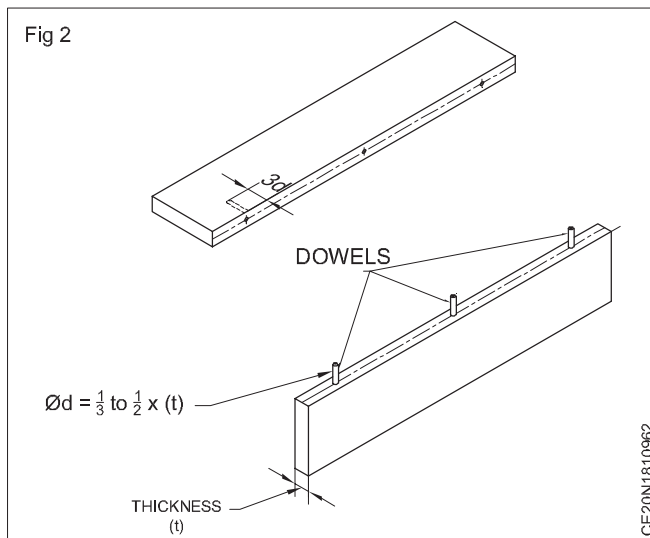


Cheap constructional work, such as packing cases, corrugated fasteners are often used to hold the pieces together and seldom used in cabinet work.

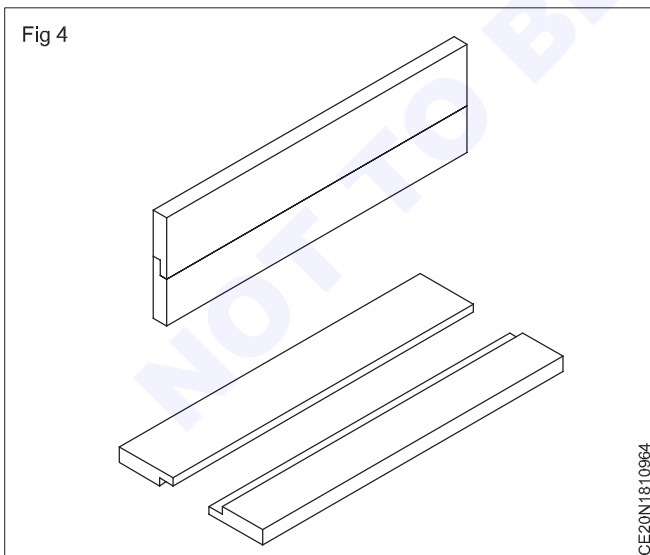
Dowelled joint (Fig 2): Similar to the butt joint, added strength being supplied by the addition of dowels glued and inserted into holes in each edge.

This is used for table tops, etc., where a stronger joint than the plain butt joints is required.

Tongued and grooved joint (Fig 3): A common form of widening joint used in flooring boards and better types of packing cases etc., It is joint is used for desk tops, etc., glue is necessary to make the joint permanent.

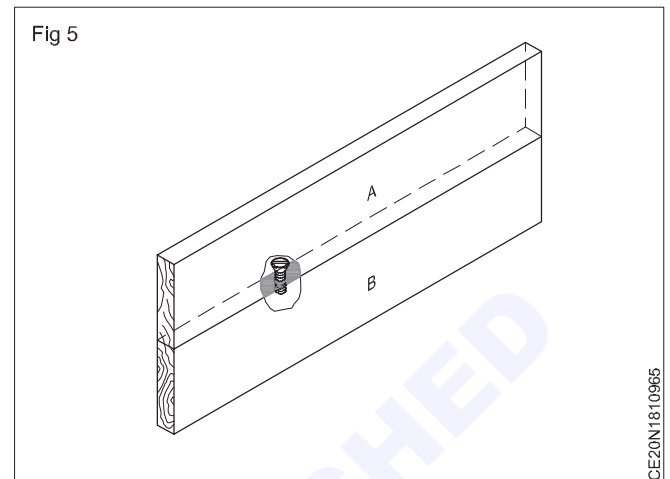


Rebated joint (Fig 4): This joint consists of rebating both pieces. The purpose of the rebates being to give extra gluing surface used for corner joints of boxes, cabinet carcasses, drawers etc.,



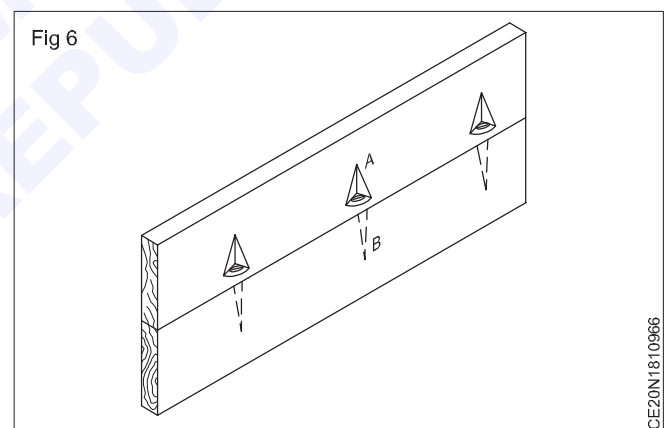
Secret screwed butt joint (Fig 5)

This joint are used to strengthen butt widening joints. Useful for joining greasy timbers which do not glue easily. The heads of the screws hold the members of the joint together mechanically and, if necessary, the job can be worked on immediately after assembling.



Pocket screw butt joint (Fig 6)

This joint is used in butt joint similar to secret screwed joint instead a pocket is chiseled as shown in Fig 6 in one of the joint piece and screw is driven through the pocket to other piece of joint.



Lengthening joints, types and applications

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

- state the various types of lengthening joints and uses.

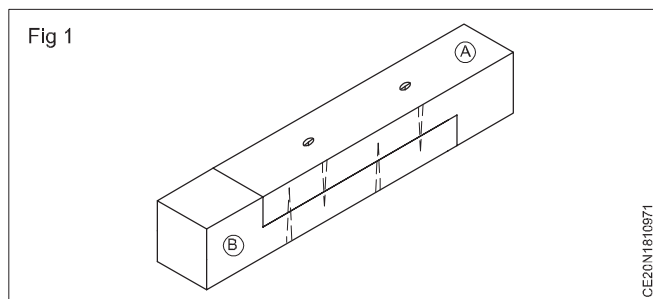
Lengthening joints

Description

These joints are also known as longitudinal joints or spliced joints. These joints are used for joining small lengths of wood pieces end to end to increase the length of wooden member. The method of lengthening depends upon the situation of a member in a framed structure.

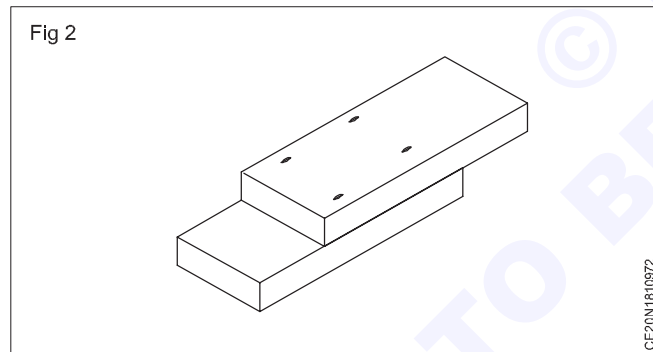
These joints are more useful in building works, such as beams.

1 End half lap joint (Fig 1)



Two pieces of wood are cut half lap and joined. Both sides of wood are joined with screws. This is particularly used where it supports the load on its bottom /top sides. (e.g.,) beam.

2 End over lap joint (Fig 2)



In this joint both wooden pieces are secured one over the other assuring the thick less 4 to 5 times as shown in the Fig no :1. Both pieces are joined with the keep of nail or screws. this joint can be made with less time but less strength can only be obtained. This joint is used only for banner frame.

3 End bevel lap joint (Fig 3)

In this joint wooden pieces secured one over the other like end over lap joint, but bevel is made for the joint screw in the Fig 2. This joint is stronger, than end half lap joint.

4 Table scarf joint (Fig 4)

This joint is also made in step by step and is cut and fixed with in metal plates. Since these are weak joints, there has to be supports provided at the bottom.

Fig 3

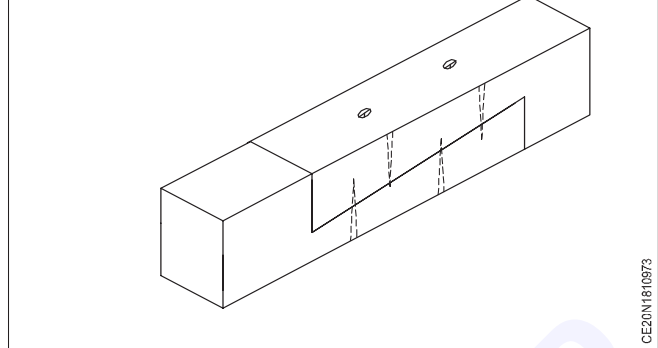
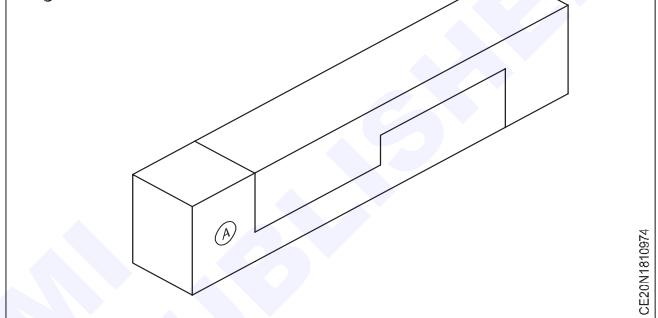
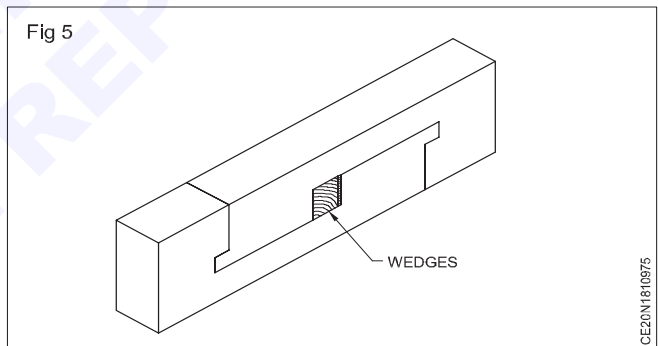


Fig 4



5 Table scarf joint with wedges (Fig 5)

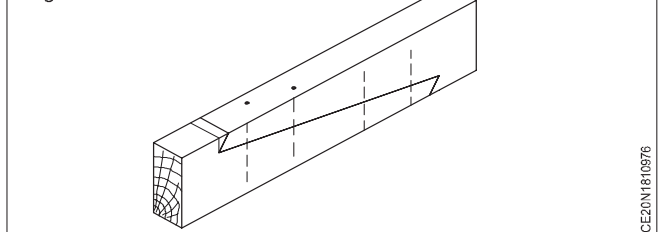


In this type of joint, the projections are made at the end of one piece and corresponding depressions are formed on the other piece. Two pieces are then secured together by means of two wedges. Such joints give good appearance since the uniform depth of the member, and can also be dismantled when required.

6 Bevel scarf joint (Fig 6)

This joint is used at the edges of thickness. Further additional strength glue can be applied between the joint. Generally this joint can be used on the beams.

Fig 6

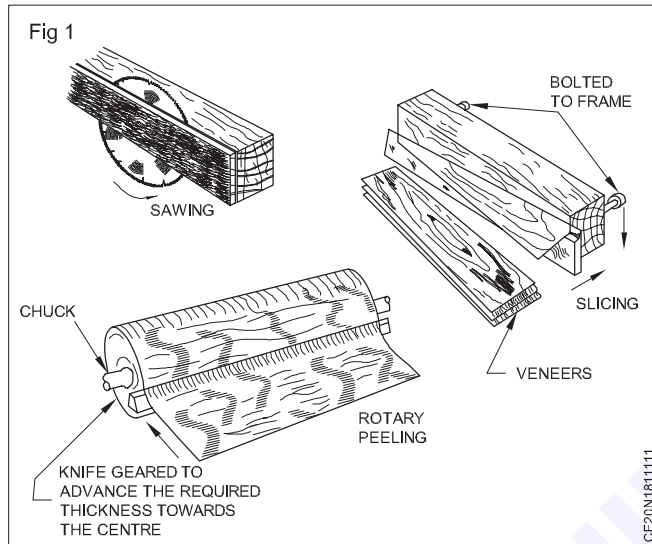


Wood products industrial forms of timber - veneer

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

- state the details of veneer
- state the advantage of veneer
- state the types of veneer.

A veneer is a thin sheet of wood obtained from logs or fitches by rotary peeling, slicing or fine sawing. (Fig 1)



Veneers are used for decorating furniture manufacturing plywood, making laminated bent and moulded shapes and for surfacing various types of composite boards.

Originally veneer was used for decorative purposes only, being glued to the solid wood of furniture.

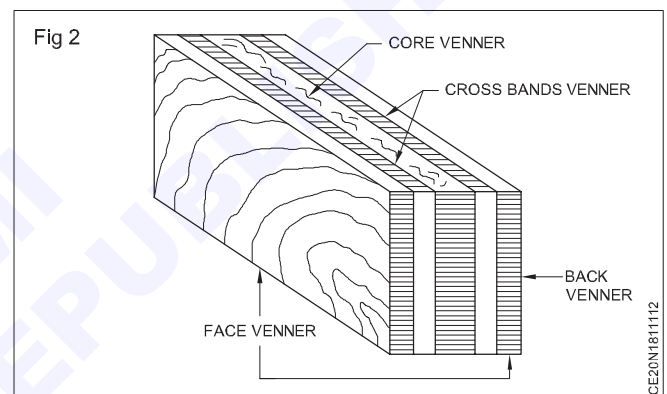
The figure veneer is glued to built up block board (core stock) plywood or particle board as a base or core.

Advantages of veneered construction

- 1 Decorative veneers are about 1mm thick and up to 25mm sheets have almost identical figure markings making it possible to produce a number of matched panels. Therefore, it is economical than expensive figured timber.
- 2 In ordinary circumstances figured timber could not be seasoned successfully, but veneer allow this and use of figured timber with unusual and beautiful effects.

- 3 Veneer panels are less likely to check and warp. They are more stable and stronger than solid timber.
- 4 The core of veneered panels are made to any width length and thickness and built up of soft, light, straight grained using cheap timber or composite materials.
- 5 Bent or curved panels can be readily made from veneers.

Types of veneers (Fig 2)



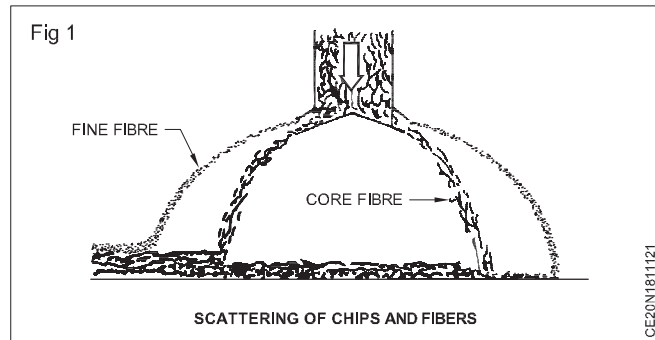
- 1 **Core veneers** : The core in ply wood is the central ply which form a base or ground to which the face or figured veneers are glued. The thickness of veneers size from 2-6 mm.
- 2 **Cross - band veneers** : The cross-band veneers strengthen the core and reduce shrinkage and warping. The thickness of veneers size from 1.3 - 1.6 mm.
- 3 **Back veneers** : The unfigured veneers glued to the back surface of panels. Back veneers should be the same thickness as the face veneers.
- 4 **Face veneers** : These veneers are glued to the front surface of the panels. The thickness of veneers size from 0.3 to 1.6mm.

Application of hard board, fibre board, laminated board and plywood

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

- identify the different types of boards
- explain the manufacturing process of different boards
- state the application of hard board, fibre board, laminated board and plywood.

Hard board (Fig 1)



Hard board, made by breaking wood chips, are reduced to fibres, and water is added to make a soupy pulp.

The pulp follows into a tracing mesh screen where water is drawn off to form a mat.

That mat is then pressed under heat to weld the wood to fibres back together by utilizing aligning the (natural adhesive is used) form them into hard thin, dry board sheets.

The sheet is cut into panels of various sizes as follows.

Thickness of the hard boards (mm)

Board	Thickness (mm)
Medium hard boards	6, 8, 10 and 12
Standard hard boards	3, 4, 5, 6 and 9
Tempered hard boards	3, 4, 5, 6, and 9

Width and length of hard boards (metres)

Width	1.2 metres
Length	1.2, 1.8, 2.4, 3.0, 3.6, 4.8 and 5.5 metres

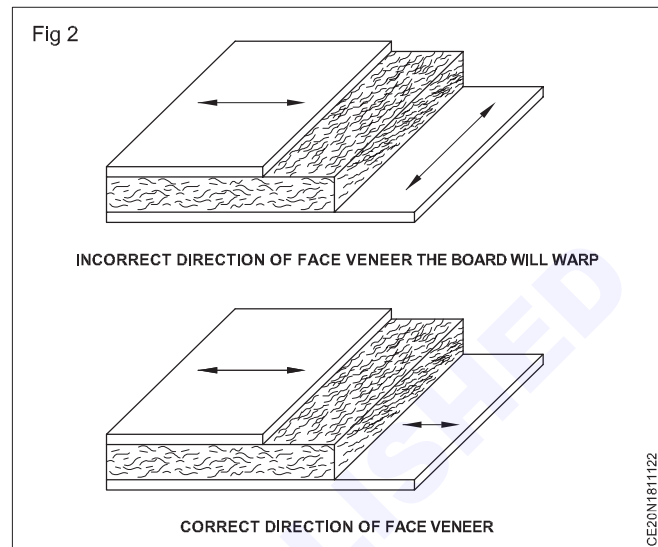
Uses

Interior work - wall sheeting ceiling, paneling, flush door, sheeting for covering frames furniture carcass drawer bottom and cabinet back.

Fiber board

Hard fiber board can be used as well slab, door board, floor, furniture and other decorations instead of wood. And the soft fiber board whose apparent density and porosity is high, often used as heat proof or acoustical materials.

Laminated board (Fig 2)

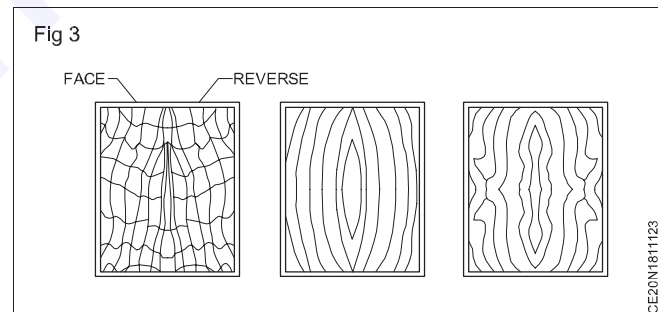


Laminated board are used for veneered furniture. The aim and purpose of laminated boards is to obtain a strong and light board which does not warp and twist and can be used for high class furniture production.

Uses

Generally used for high quality furniture and joinery.

Sunmica sheet (Fig 3)



It is a type of decorated plastic laminated sheet material and is manufactured in India by the Sunmica Institute and trade named as sunmica.

It is a beautiful, strong and durable material which is manufactured in sheets.

Sunmica can be fixed to the wooden or plywood surface or walls with the help of glue.

Plywood

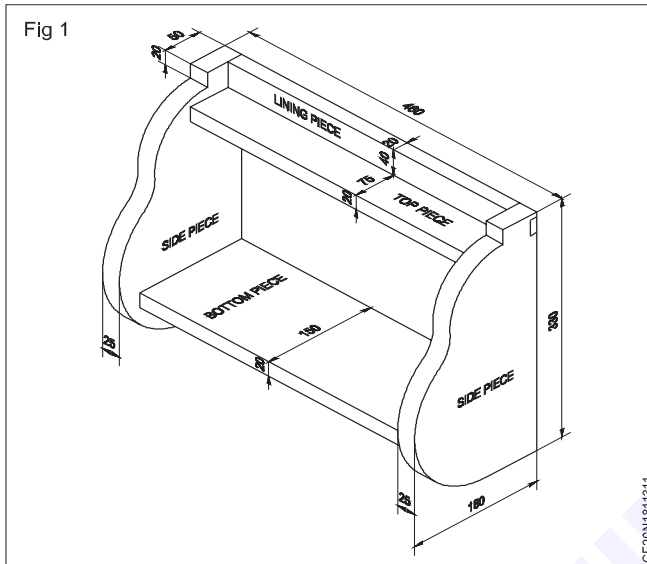
Refer to Exercise No - 1.3.21

Calculation of timber required for wall bracket and sequence of operation

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

- estimate the materials required for wall bracket, kind of wood : teak wood
- state the sequence of operation for wall bracket.

Raw material for wall bracket dimensions in mm.
(Fig 1)



Sl.No	Utilization to the wall bracket	W x T x L	No of pieces
1	side pieces	200x30x400	2
2	Top pieces	100x25x500	1
3	Bottom pieces	175x25x500	1
4	Lining piece	50x25x6mm	1
5	Back piece	430 x 220 x 6mm	1

Raw material for wall bracket dimensions in metres

Sl.No	WxTxL	No of pieces	Volume m ³
1	0.2x0.03x0.4	2	0.0048
2	0.1x0.025x0.5	1	0.00125
3	0.75x0.025x0.5	1	0.0021875
4	0.05x0.025x0.5	1	0.000625
	Total volume	-	0.008863m ³

Back piece plywood=430x220x6mm = 1 ½ Sq feet

Plywood rate/Sq feet = Rs 80/-

For 1.5 Sq feet = Rs 120/-

Cost of raw material [estimation of the cost approximately]

The total comes to = Cubicmetre

Teak wood rate/cubicmetre = Rs 90000/-

For 0.00886 m³ = 0.00886 x 90000

= 797.4

Rounded to = Rs 798/-

Plywood = Rs 120/-

Total = Rs 918/-

List out the sequence of operation

Planning to size

Side lining, to pond bottom piece with jack plane, try square, marking gauge.

Marking

Marking with foot rule, try square, marking gauge and marking knife.

Mortising

Stub mortise with mortise chisel firmer chisel and mallet.

Tenoning

Stub tenon with firmer chisel and mallet.

Gluing

Apply the joints

Assemble

Side Bottom and lining pieces

Clamping

Clamping with "T" bar clamp.

Drilling

Drilling with portable electrical drill machine.

Nailing

Nailing with wire nail.

Back piece assemble

Back piece assemble with wall bracket frame.

Finishing

Finishing with smoothing plane sand paper and polishing or painting

Door, window and ventilators parts, location, size and types

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

- state the constructional details of door frame, doors, size, location and types
- state the technical terms used in door and door shutter construction.

Types of doors

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 inside the building and to give a view from 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 as 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 2.00m
 - 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 $8 \times 100 = 800$ mm) and height=20 modules (is $20 \times 100 = 2000$ mm) with single shutter.

The letter 'D' denotes a door opening and letters stands for single shutter. Illrly the designation 10DT 21 of door opening denotes.

Width of opening = $10 \times 100 = 1000$ mm

Height of opening = $21 \times 100 = 2100$ 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.

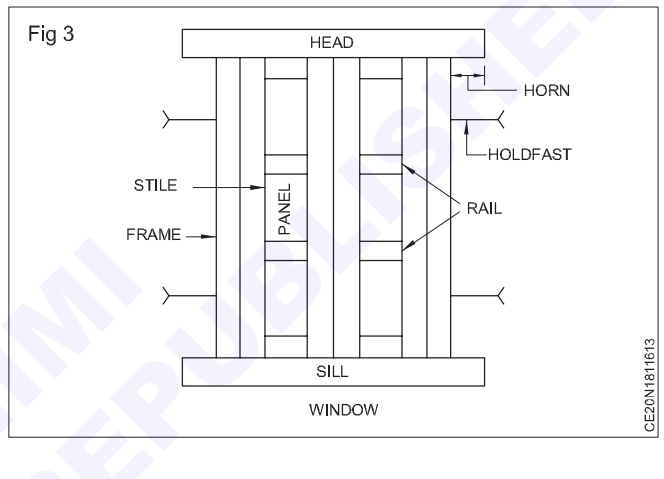
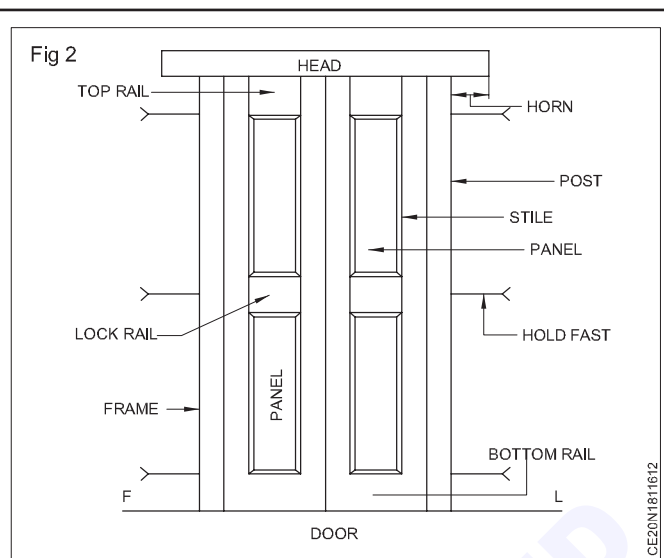
Classifications

According to arrangements of components	On the basis of method of manner of construction	On the basis working operation	Metal doors
Battened and ledged doors	Framed and paralleled 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	

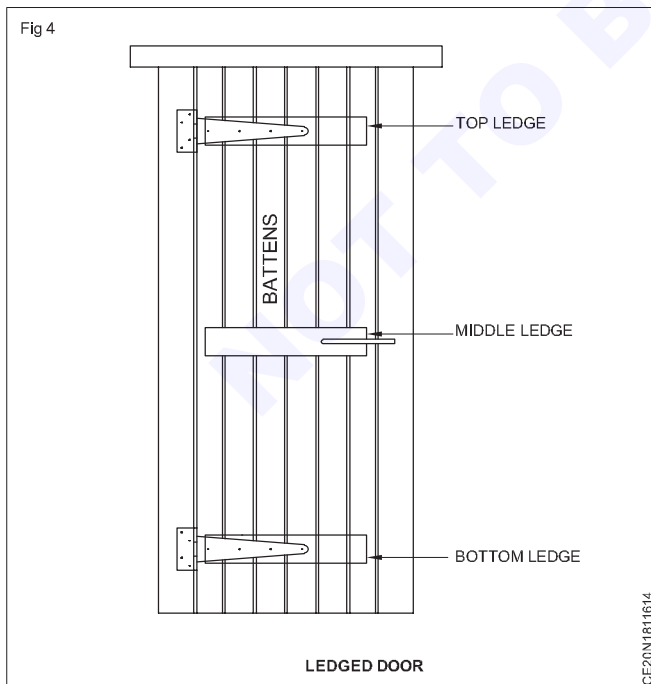
Technical terms

SI No.	Terms	Figure
1	Frame: It is an assembly of horizontal and vertical members forming an enclosure to which the shutters are fixed.	The diagram illustrates the components of a door frame and shutter. It shows a cross-section of a door opening with a frame. Labels include: INTEL (top horizontal member), DOOR OPENING, DOOR FRAME, HOLD FASTS, PANEL FRAME, GLASS PANEL, WOODEN PANEL, PANELS, HINGES, and DOORS. The diagram is labeled 'Fig 1' and 'DOORS'.
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.
15	Rebate: Depression or recess made inside the door frame, to receive the door shutter.
16	Sash: Special type of frame, made of light sections and designed to carry glass.
17	Louvers: A piece of timber which is fixed 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

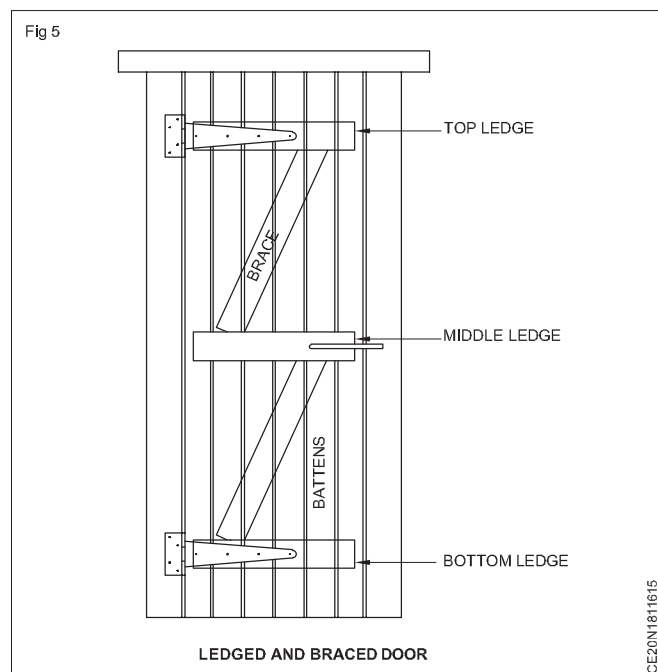


Battened ledged and framed doors: In this type of doors a frame work for shutters are provided to make the door stronger and better in appearance as shown in figure. (Fig 4)

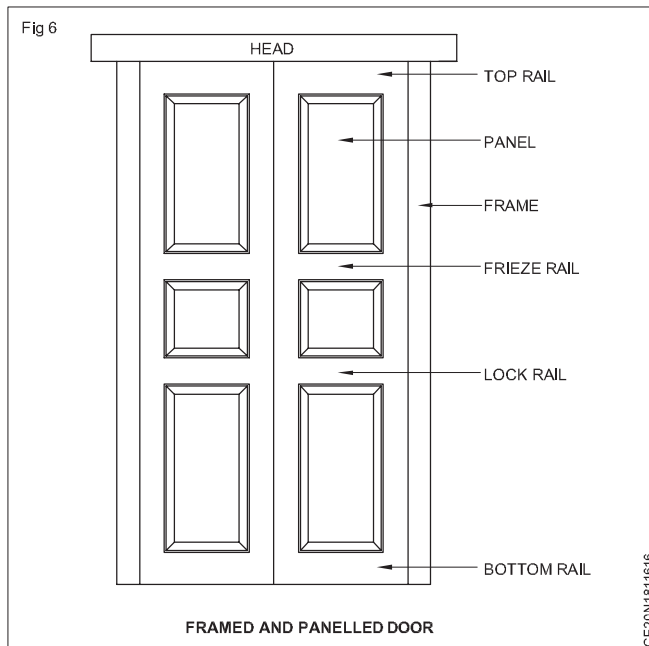


Battened ledged framed and braced doors

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. (Fig 5)



Framed and paneled door (Fig 6)



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. Paneled doors are of various types such as.

Single paneled doors

Two paneled doors

Three paneled doors

Multiple paneled doors

Features of framed and paneled 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 joined to the styles at both the ends.

The styles and rails are joined 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.

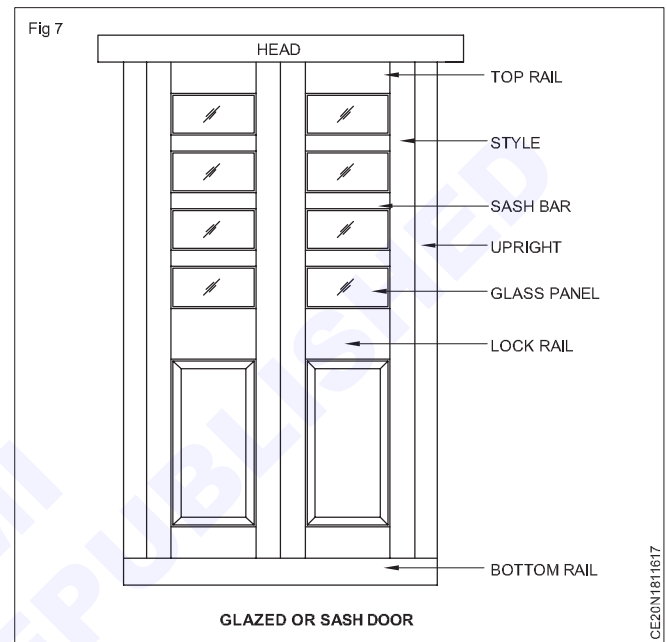
Additional timber beading is provided on one or both the sides to improve the elevation of the door.

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 of 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 0.5m². These restrictions do not apply to panel of plywood, particles boards on hard board.

Glazed or sash door (Fig 7)



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.

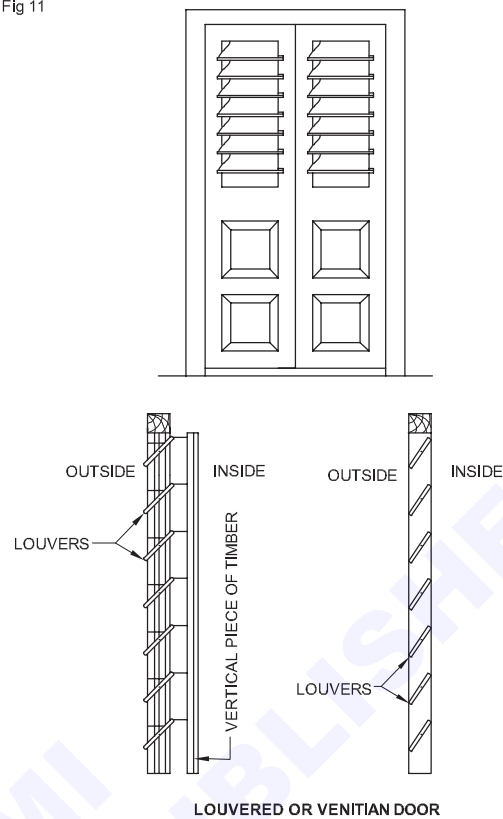
Flush Door: Flush doors are becoming popular these days because of their pleasing appearance, simplicity of construction, less cost, and greater durability. They are used both for residential as well as public and commercial buildings. These doors consist of solid or semi-solid skeleton or core covered both sides with plywood, or veneers etc. This door presents a flush and joint less surface which can be neatly polished.

Flush doors are of two types

- Solid core or laminated core flush door (Fig 8 & 9)
- Hollow core or cellular core flush door (framed) (Fig 10)

Louvered or Venetian Door (Fig 11)

Fig 11

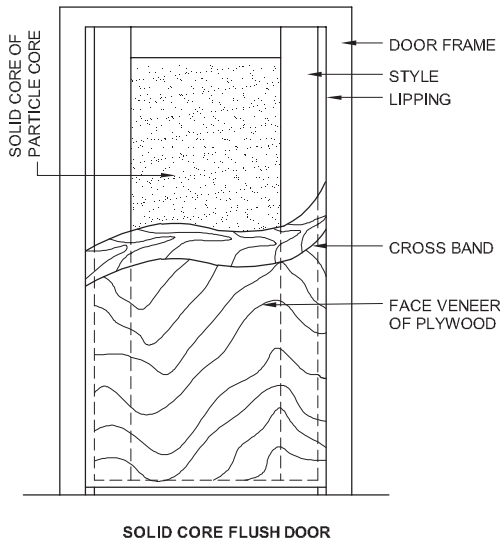


Louvered doors permit free circulation of air through them and at the same time maintain the privacy of the room. However, these doors catch dust which is very difficult to be cleaned. These doors are generally used for latrine and bathrooms of residential and public buildings. This is achieved by fixing 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 12) : 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 estates in sweet shops etc.

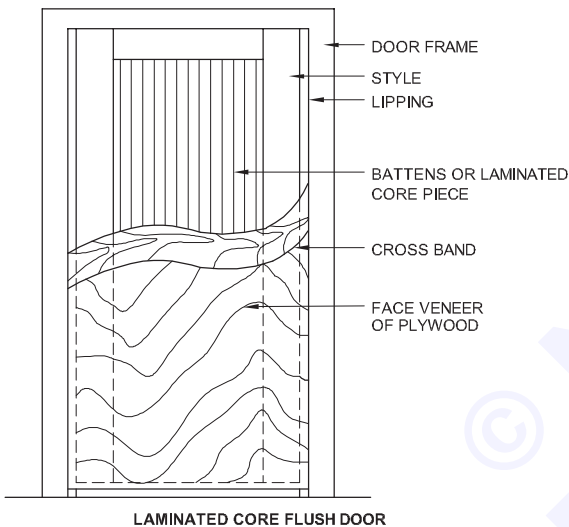
Revolving Doors (Fig 13) : Such doors are provided only in public buildings such as libraries, museums, and banks etc. where there are constant visitors. Such doors provide entrance to one person and exit another person simultaneously and close automatically when not in use.

Fig 8



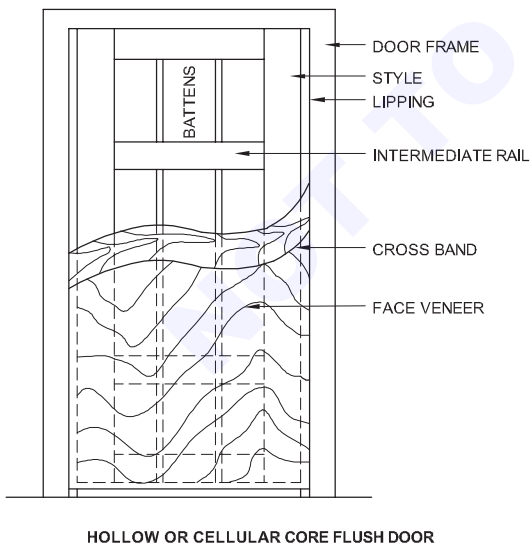
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Fig 9

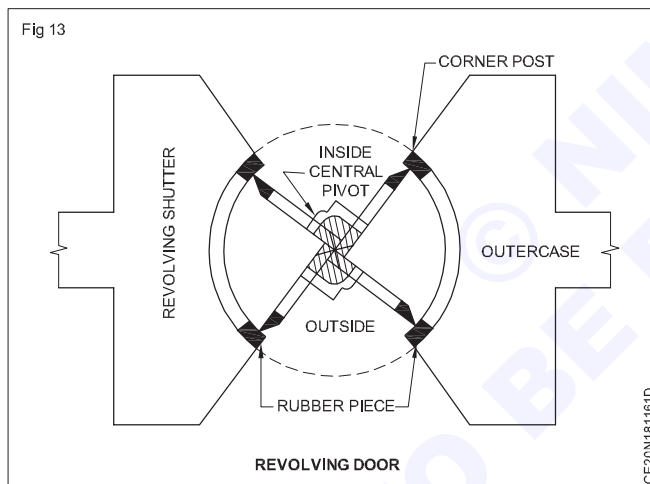
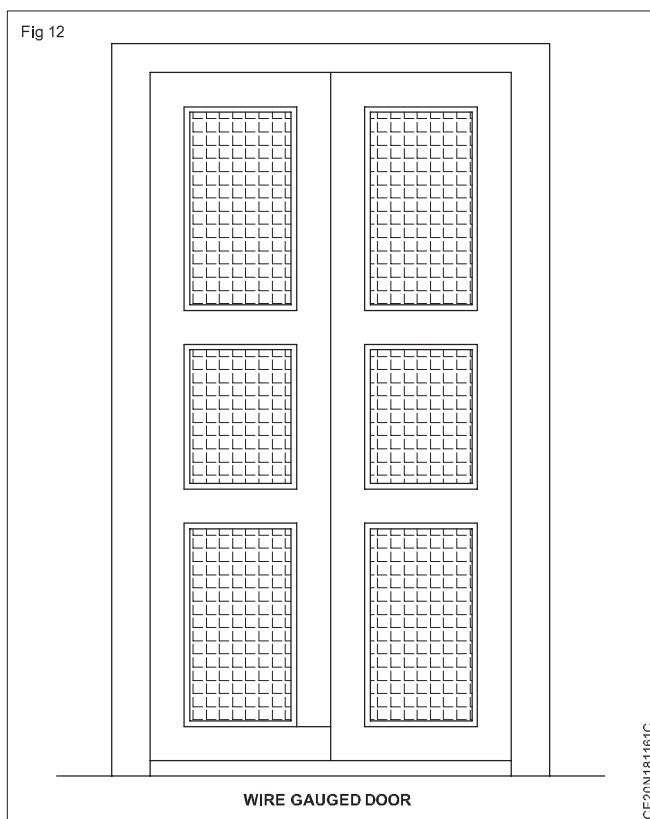


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Fig 10



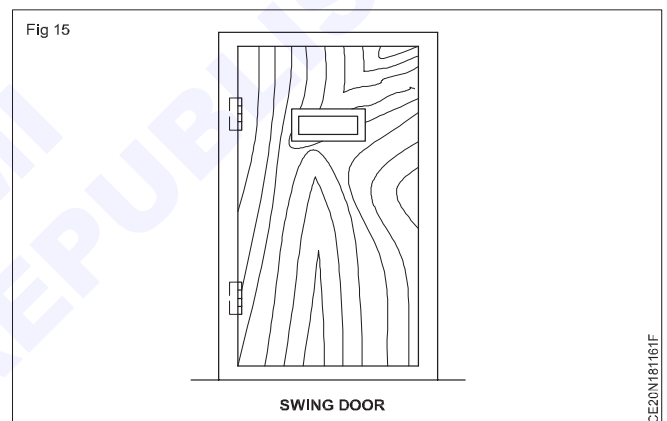
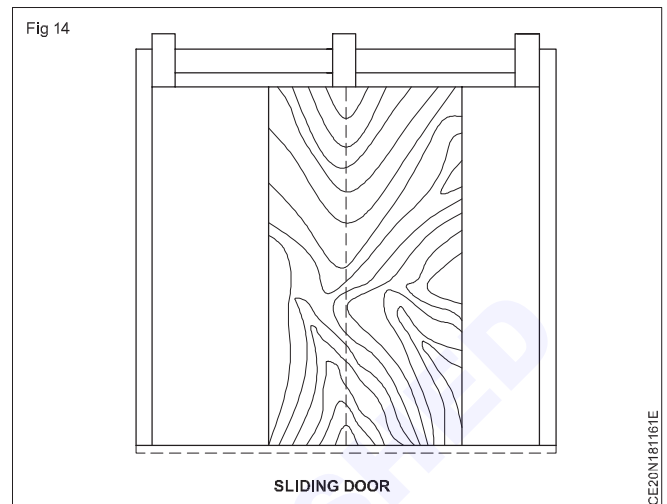
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Sliding Door (Fig 14) : In this type of door, the shutter slides on the side with help of runner and guide rails. The shutter may be of one or several leaves and can slide either on one side or both the sides. Cavities may be provided in the wall to 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, showrooms etc. It is provided with handles, locking arrangement, stopper etc.

Swing Door (Fig 15) : 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 slight 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 Fig 15.



Collapsible Steel Door (Fig 16) : A collapsible door may consist of a mild steel frame. The door can be opened or closed by a slight push or pull. A collapsible door thus works without hinges. It is used for compound gate, residential building, sheds, godown etc.

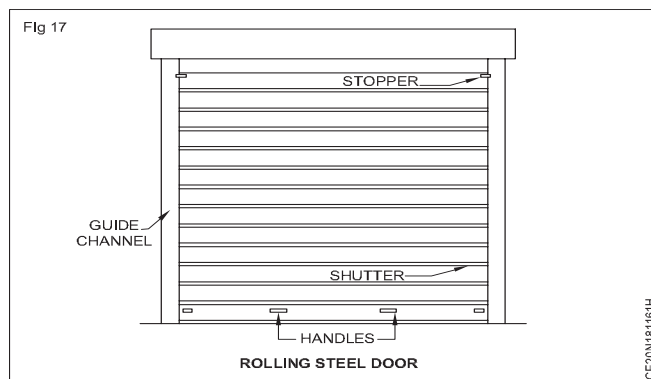
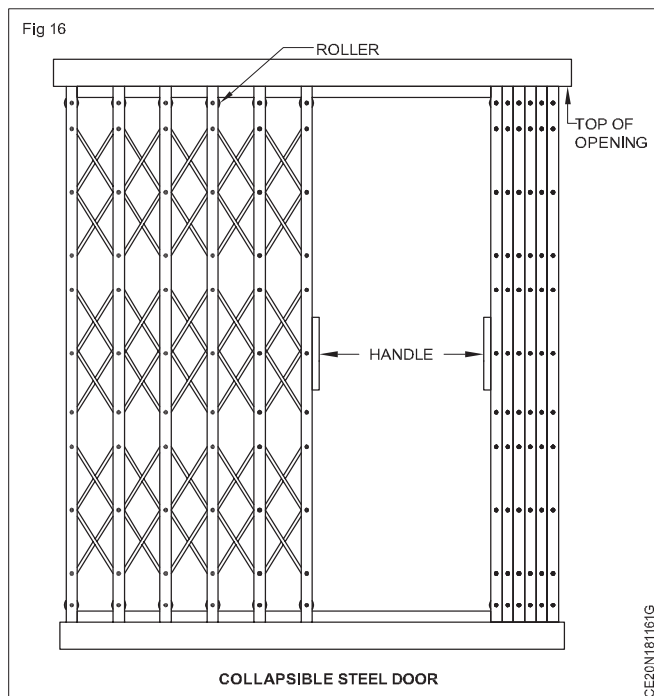
Rolling Steel Shutter (Fig 17)

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.

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:

- Pull push type rolling shutters provided for door opening area less than 10m^2
- Mechanical gear type rolling shutters provide for door opening are greater than 10m^2



PVC doors

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

- description the PVC door
- state use of PVC as substitute of wood.

Description

Polyvinyl chloride (PVC), a synthetic resin made from the polymerization of vinyl chloride. Polyethylene among the plastics in production and consumption, PVC is used in an enormous range of domestic and industrial products, from raincoats and shower curtains to window frames and door frame and doors, vinyl flooring, cable coatings, medical devices, plumbing and Automotive parts.

Uses of PVC as substitute of wood

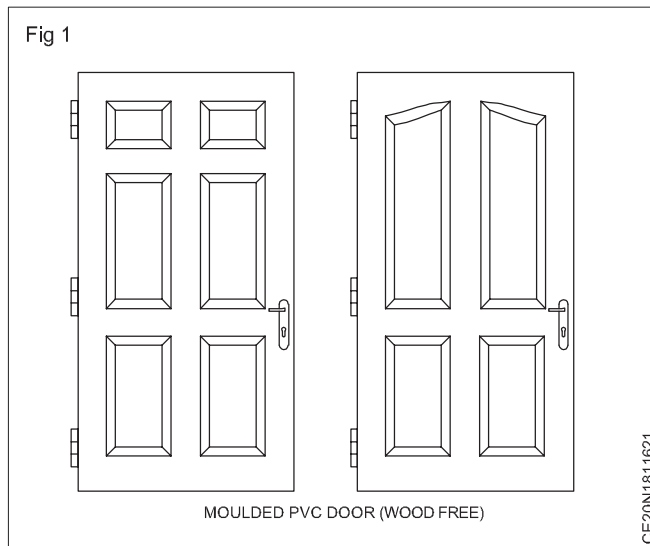
- PVC is a very durable material. It is strong and resilient to any conditions. The tough material can withstand any kind of weather and climate.
- They are very light in weight. Hence they are very easy to install and handle.
- PVC doors are resistant to rotting, rusting, flaking, fading and peeling. It is also not a corrosive material. All you have to do is to clean PVC door with slight soap water.
- PVC is a very low maintenance material that is time saving and bought by the people.
- PVC is very stable to pollution, salt water and chemicals. Wood often swells and rots if it comes in contact with water or chemicals. It is not the case with PVC.
- PVC is resistant to fire and flames. If there are any fire accidents, you will not have to worry about the safety of your doors.

- Unlike aluminium, PVC prevents condensation.
- It also keeps your home warm in winter and cool in summer. It promote cost efficient thermal insulation.
- They are sturdy and unbreakable.
- PVC is much cheaper than the wooden and aluminium doors.
- It is not just a good thermal insulator, but also a sound insulator. The rooms will remain sound proof once you cover them with PVC doors.
- They also need minimal maintenance in terms of cost. Wooden doors need to be polished every two to five years unlike PVC doors.
- They come practically in all colours. They can also be designed in the way you want and to suit the interiors of your home.
- PVC has more performance ratings than other materials used to make doors. This is because recent innovations have enhanced the structural performance of PVC changing the perception of people who neglected it until now.
- It is also an environmental friendly material as it is completely recyclable. Thus, it is a resource saving material that causes less pollution.
- It consume less energy even while manufacturing, thus it is an eco friendly material.

- They are pleasing to the eye and have an aesthetic appearance. It is the best choice for modern homes that are designed in nice patterns.

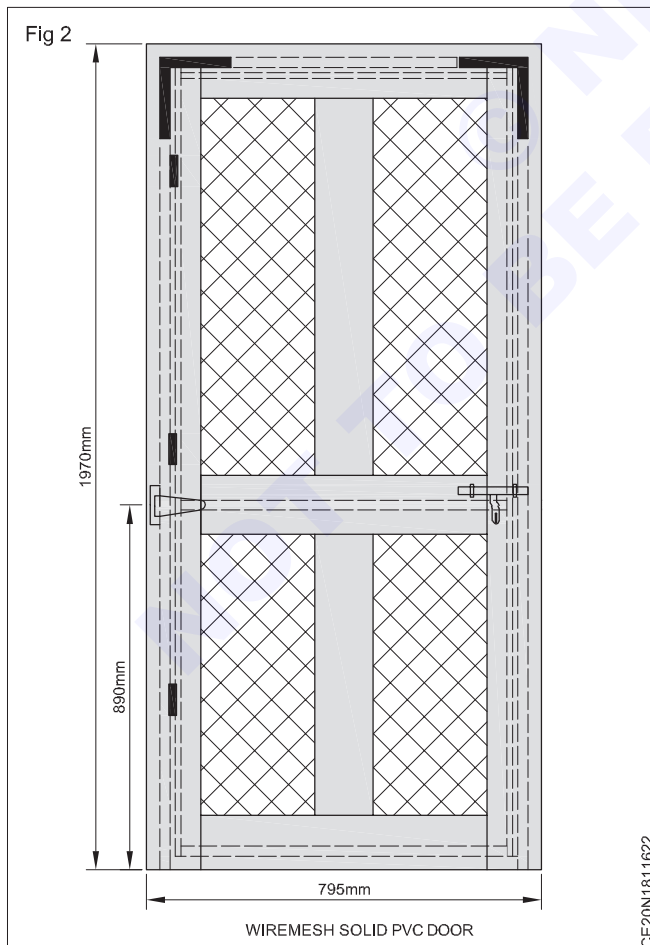
Types of PVC door

Moulded PVC door (Fig 1)



All the surface of moulded PVC door should be uniform smooth finish and free from crack and seam. Passing joints shall be finished ensuring that no gaps are visible.

Wire mesh solid PVC door (Fig 2)



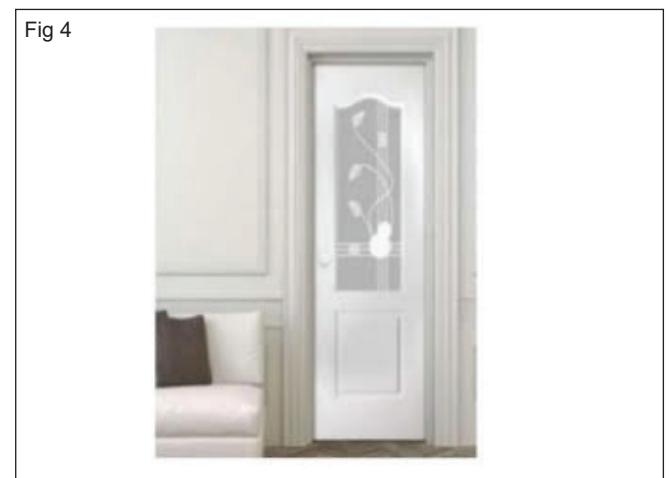
All the surface of wire mesh solid PVC door should be uniform smooth finish and free from crack and seam. The door should be finished ensuring that no gaps are visible. Size: Length: 1970 mm width: 795MM.

Kitchen and W.C bath PVC door (Fig 3)



All the surface of module PVC door should be uniform smooth finish size 28mm with solitaire pan, 'A' section 'H' section, plastic bracket, galvanized 'T' bar and galvanized tube.

New style PVC door (Fig 4)



When you begin creating the interiors of your house, you will discover that there are countless door types to pick to impart that space with the ideal appearance and still permit it to deal with its function.

If it is a vacation home, you will need to know how to protect a vacant property and a strong door would be a good idea.

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 to 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.

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 x 1190	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 Varieties of windows used in building construction are as follows:

Fixed 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

- 1 Breath of window = $\frac{1}{8}$ (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 the 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.

$$\text{It, } 6 \times 100 = 600 \text{ mm}$$

And height equal to 12 modules

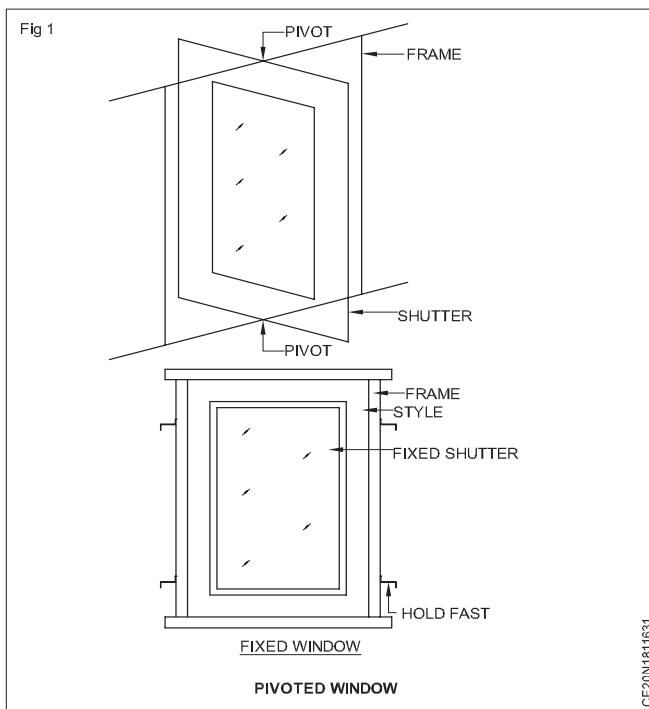
$$\text{It, } 12 \times 100 = 1200 \text{ mm}$$

Indian standard recommendations for size of opening size of frame and size of window shutters are given below:

shutters are fixed. No rebate is provided to the window frame. The shutters are fully glazed.

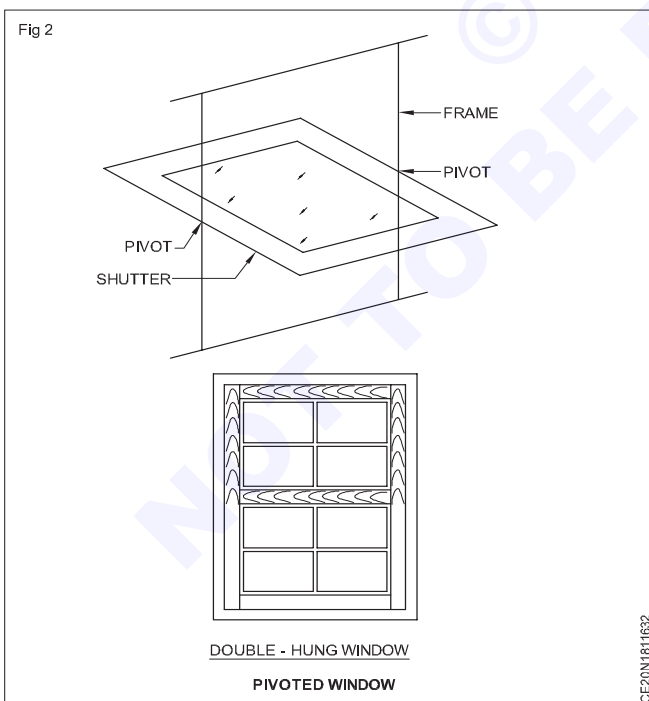
Pivoted window (Fig 1)

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)

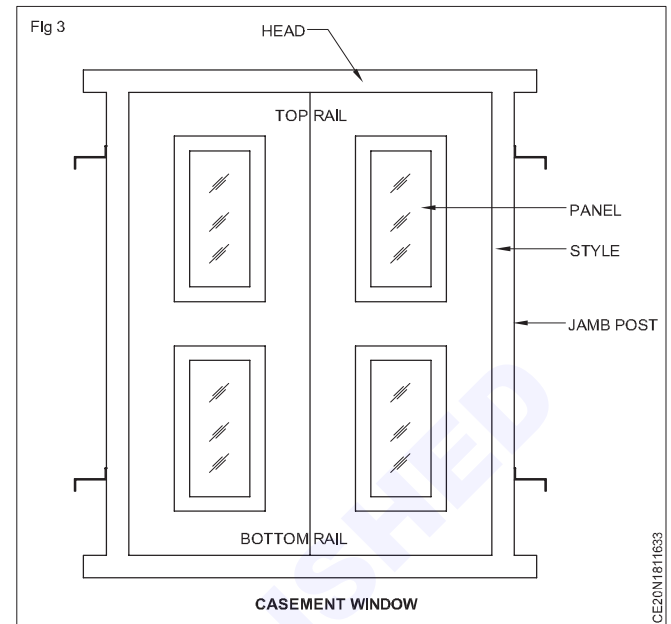
This type of window consists of a pair of shutters arranged one above the other which can slide vertically within the grooves provided in the frame. A pair of metal weights connected by chain passing over pulleys, is provided for each shutter. By this arrangement the window can be opened at top or bottom 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.



Casement window (Fig 3)

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.



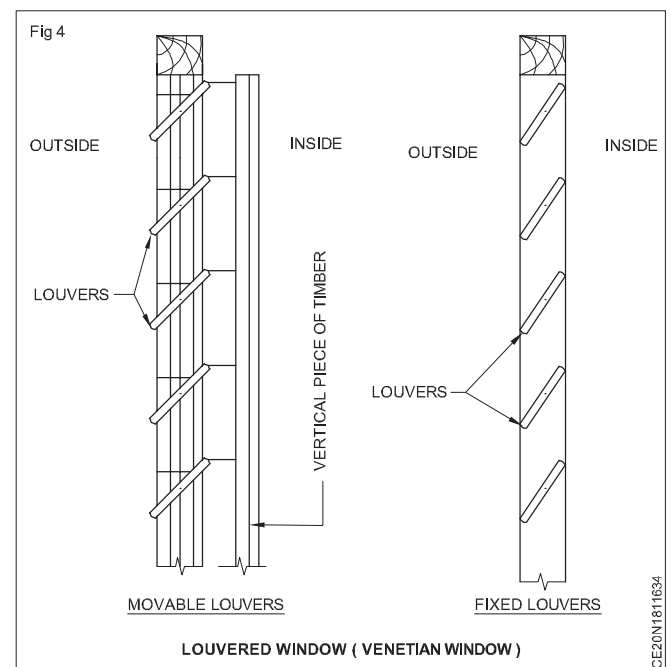
Sliding Window

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)



In this type of windows, the louvers are provided as in the case of louvered doors. They allow free passage of air when closed 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° 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, galvanised mild steel, aluminium, bronze, stainless steel etc. Bronze, aluminium and stainless steel are considered to be the best as they possess 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.

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 weather effects as in the case of wooden windows.

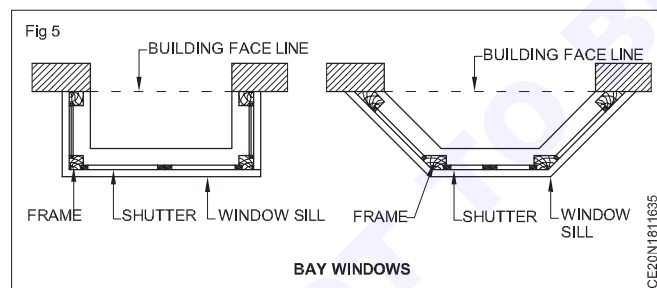
The steel windows exhibit elegant appearance.

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.

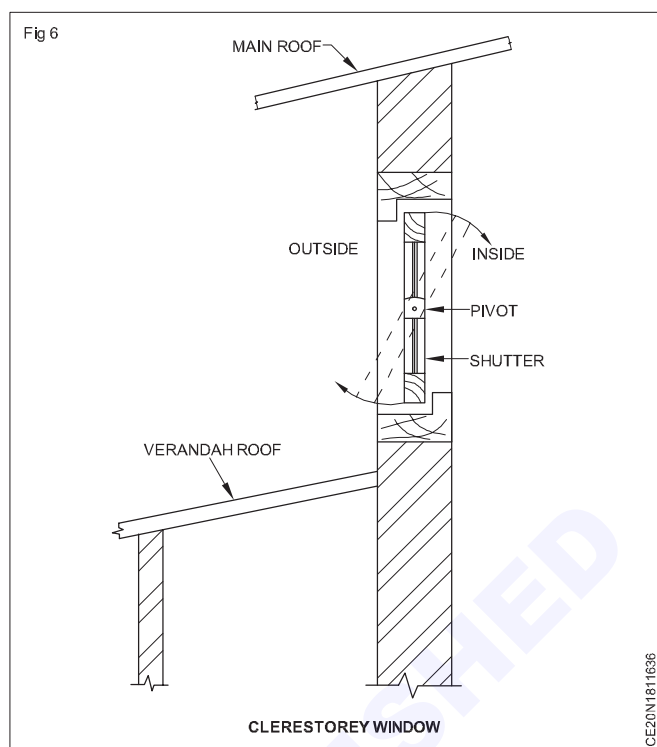
Bay windows (Fig 5)



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 improve the overall appearance of the building.

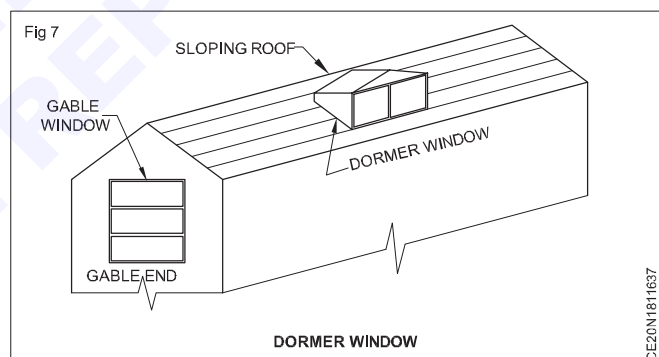
Clere – storey window (Fig 6)

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 improve 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 in the gable end of a pitched roof are known as a gable windows.

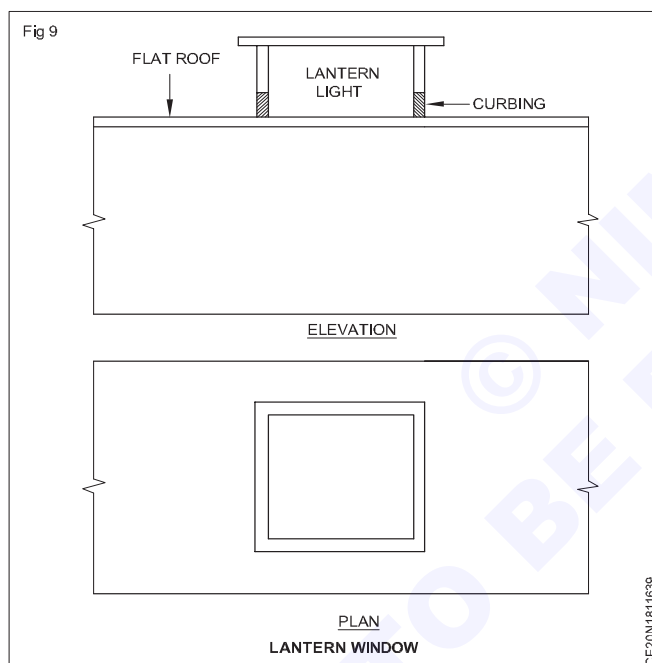
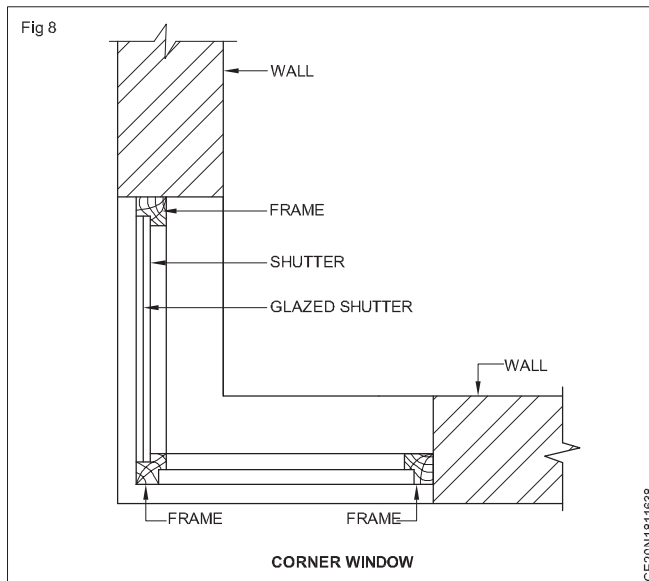
Corner window (Fig 8)

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.

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 insufficient. 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.



Type of channel window and uses

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

- state the types of channel window and use.

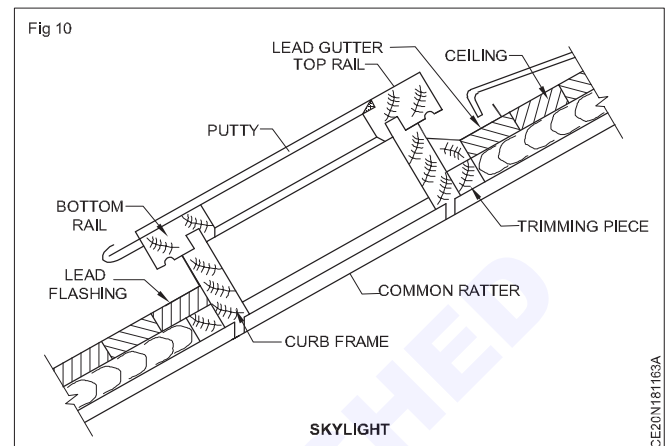
Aluminium Channel

Windows (frames and sashes) have the advantage over the timber of having low maintenance costs, and because of their narrow frames they provide maximum light and ventilation, but they must be treated with baked anti-corrosive paint, galvanized, sheradized or constructed with aluminium.

Types of windows is involved building construction named according to the type of frame (solid or box) or the way the sashes are hung.

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.



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 opens inside the bottom edge open outside so that rain water is excluded.

Ventilators combined with window or door

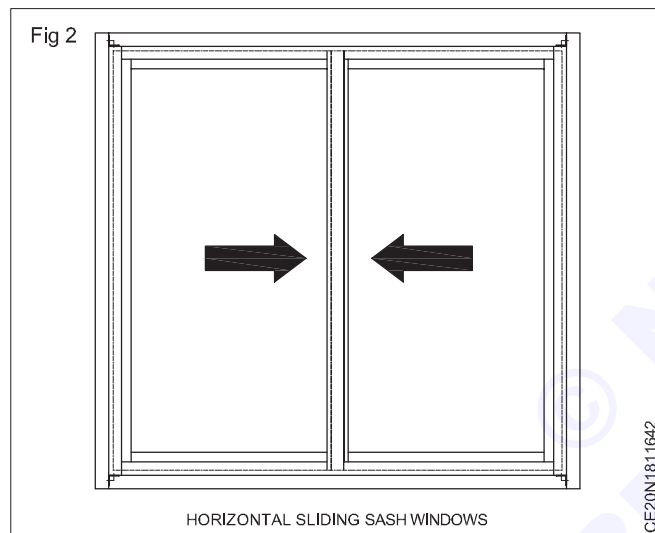
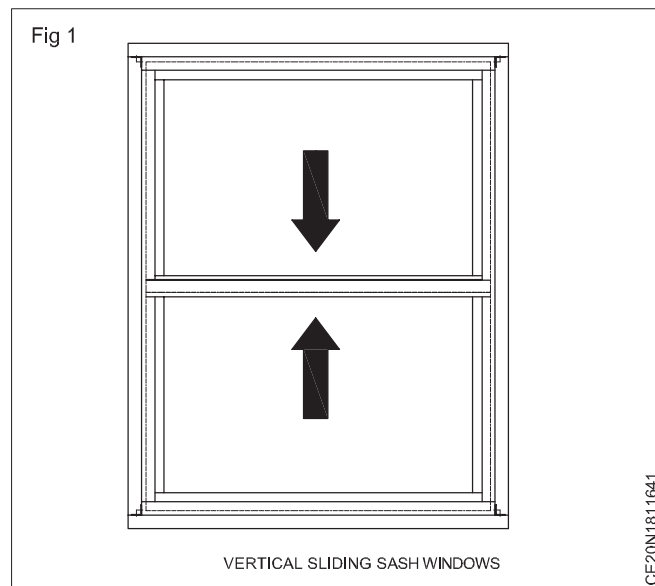
Ventilators may be provided in continuation of a door or a window at its top. Such a ventilator is known as Fan-light. The construction of a fan light is similar to sash window. Such a ventilator is usually hinged at top and can open out. Alternatively, the ventilator shutter can be hinged at the bottom.

Any type of window can be fitted into any types of wall, either into the outer skin or into the inner skin or cavity walls

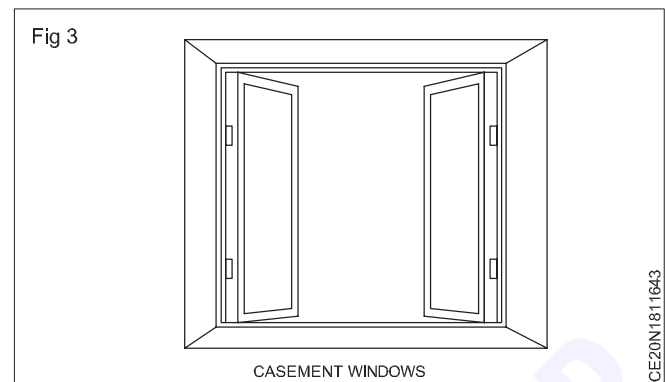
Vertical Sliding Sash Windows: Usually consist of pairs of sashes or double hung sashes, both of which open by sliding vertically in the channels of a box frame. The sashes are separated by a parting bead. (Fig 1)

Horizontal Sliding Sash Windows: Solid window frames are used. The sashes slide horizontally on metal tracks fixed to the sill and guided by tracks secured to

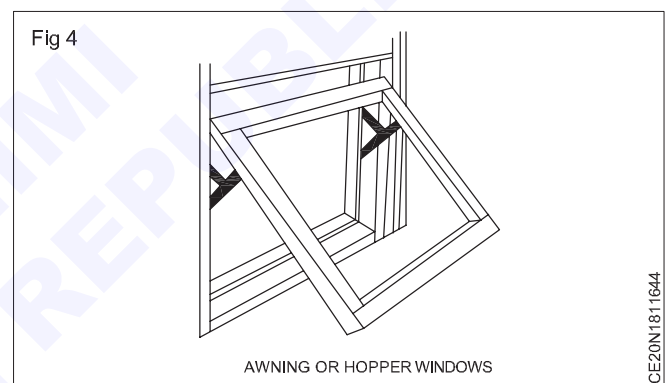
the head. Ball bearing sash roller sheaves are mortised into the bottom rails (Fig 2).



Casement Windows: The Sashes are hinged along one of their vertical edges to the stiles of solid window frames. They generally open outwards and any be held open with a casement stay or telescopic stay arms operated manually or by a hand winder. (Fig 3)



Awning or Hopper Windows: These are usually multiple sashes arranged in vertical tiers (some may be fixed) in a solid casement frame with mullions. Friction casement stays are attached to the sash stiles and jambs and mullions so that each sash opens outwards from the bottom. The sashes may be separated. (Fig 4)



Safety precaution, elementary first aid, artificial respiration and treatment for electrical shock

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

- explain the necessity of adopting the safety rules
- list the safety rules to be followed by the electrician
- explain how to treat a person for electric shock/injury.

Necessity of safety rules: Safety consciousness is one of the essential attitudes required for any job. A skilled electrician always should strive to form safe working habits. Safe working habits always save men, money and material. Unsafe working habits always end up in loss of production and profits, personal injury and even death. The safety hints given below should be followed by Electrician to avoid accidents and electrical shocks as his job involves a lot of occupational hazards.

The listed safety rules should be learnt, remembered and practiced by every electrician. Here a electrician should remember the famous proverb, **“Electricity is a good servant but a bad master”**.

Safety rules

- Only qualified persons should do electrical work.
- Do not work on live circuits
- Use wooden or PVC insulated handle screwdrivers when working on electrical circuits.
- When soldering, place the hot soldering irons in their stand.
- Replace or remove fuses only after switching off the circuit switches.
- Use extension cords with lamp guards to protect lamps against breakage and to avoid combustible material coming in contact with hot bulbs.
- Use accessories like sockets, plugs, switches and appliances only when they are in good condition and be sure they have the mark of BIS (ISI). Necessity of using BIS(ISI) marked accessories is explained under standardisation.
- Stand on rubber mats while working/operating switch panels, control gears etc.
- Position the ladder, on firm ground.
- Always use safety belts while working on poles or high rise points.
- Never place your hands on any moving part of rotating machine.
- Only after identifying the procedure of operation, operate any machine or apparatus.
- Use always earth connection for all electrical appliances along with 3-pin sockets and plugs.
- While working on dead circuits remove the fuse grips; keep them under safe custody and also display ‘Men on line’ board on the switchboard.
- Do not connect earthing to the water pipe lines.

- Discharge static voltage in HV lines/equipment and capacitors before working on them.

Safety practice - first aid

Electric shock

We are aware that the prime reasons for severity of shock are the magnitude of current and duration of contact. In addition, the other factors contribute to the severity of shock are:

- age of person
- body resistance
- not wearing insulating footwear or wearing wet footwear
- Weather condition
- Wet or dry floor
- Mains voltage etc.

If assistance is close at hand, send for medical aid, then carry on with emergency treatment.

If you are alone, proceed with the treatment immediately.

Make sure the victim is not in contact with the supply.

Effects of electric shock

The effect of current at very low levels may only be an unpleasant tingling sensation, but this itself may be sufficient to cause some persons to lose their balance and fall.

At higher levels of current the person receiving a shock may be thrown off his feet and will experience severe pain and possibly minor burns at the point of contact.

At an excessive shock can also cause burning of the skin at the point of contact.

Treatment of electric shock

Prompt treatment is essential.

Check for the victim's natural breathing and consciousness. Take steps to apply respiratory resuscitation if the victim is unconscious and not breathing.

In the case of burns/injury in the back, follow Nelson's method

In case the mouth is closed tightly, use Schafer's or Holger-Nelson method.

Treatment for electrical burns

A person receiving an electric shock may also sustain burns when the current passes through the body.

Do not waste time by rendering first aid to the victim until breathing has been restored and the patient can breathe normally unaided.

Burns are very painful. If a large area of the body is burnt, do not give treatment, except to exclude the air, eg. by covering with clean paper or a clean cloth, soaked in clean water. this relieves the pain.

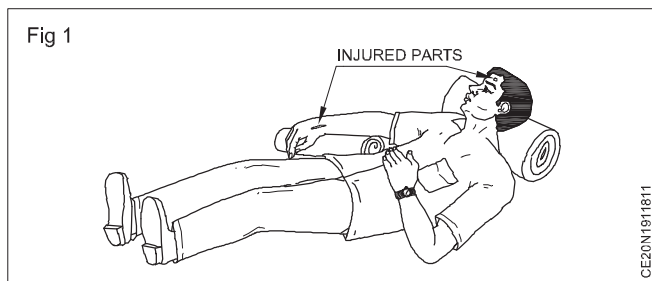
Severe bleeding

Any wound which is bleeding profusely, especially in the wrist, hand or fingers must be considered serious and must receive professional attention.

Immediate action

Always in cases of severe bleeding

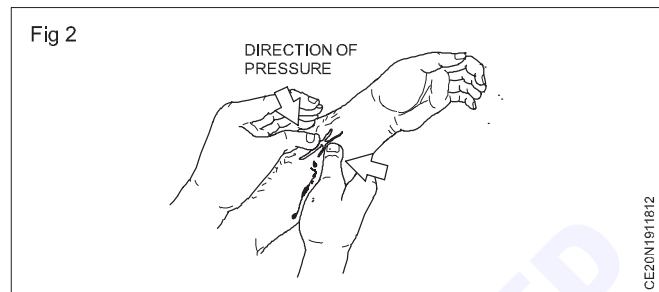
- make the patient to lie down and rest
- if possible, raise the injured part above the level of the body (Fig 1)
- apply pressure to the wound
- call for medical assistance



To control severe bleeding

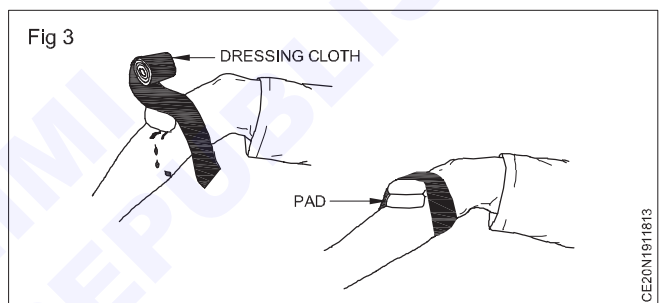
Squeeze together the sides of the wound. Apply pressure as long as it is necessary to stop the bleeding. When the bleeding has stopped, put a dressing over the wound and cover it with a pad of soft material. (Fig 2)

For an abdominal wound which may be caused by falling on a sharp tool, keep the patient bending over the wound to stop internal bleeding.



Large wound

Apply a clean pad and bandage firmly in place. If bleeding is very severe apply more than one dressing. (Fig 3)



Rescue operation - first aid treatment - Artificial respiration

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

- explain how to rescue a person who is in contact with a live wire
- state the first aid and its key aims
- explain ABC of the first aid
- brief how to give first aid treatment for a victim
- explain how to treat a person affected due to electric shock/injury.

The severity of an electric shock will depend on the level of current which passes through the body and the length of time of contact. Do not delay, act at once. Make sure that the electric current has been disconnected. If the victim is still in contact with the supply - break the contact either by switching off or by removing the plug or pulling the cable free.

If not, stand on some insulating material such as dry wood, rubber or plastic or newspaper and then pull his shirt sleeves. However, you have to insulate yourself and break the contact by pushing or pulling the person free. (Figs 1 & 2)

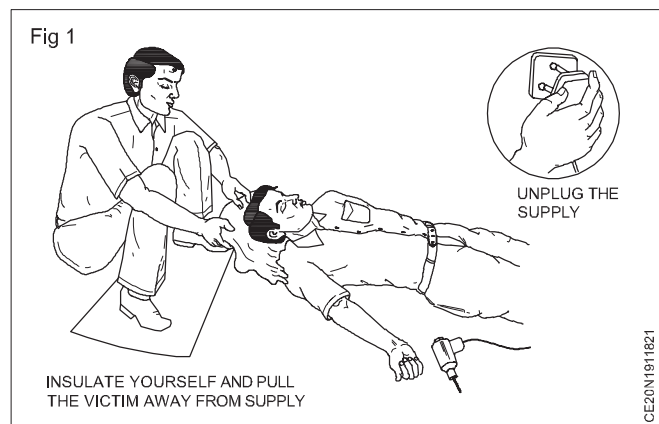


Fig 2



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In any case avoid direct contact with the victim. Wrap your hands in dry material if rubber gloves are not available.

If you remain un-insulated, do not touch the victim with your bare hands until the circuit is made dead or he is moved away from the equipment.

If the victim is at a height, efforts must be taken to prevent him from falling or to make him fall safe.

Electric burns on the victim may not cover a big area but may be deep seated. All you can do is to cover the area with a clean, sterile dressing and treat for shock. Get expert help as quickly as possible.

If the casualty is unconscious but is breathing, loosen the clothing about the neck, chest and waist (Fig 3) and place the casualty in the recovery position.

Fig 3



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Keep a constant check on the breathing and pulse rate.

Keep the casualty warm and comfortable in the recovery position. Send for help.

Do not give an unconscious person anything to eat or drink.

Do not leave an unconscious person unattended.

If the casualty is not breathing - Act at once to resuscitate the victim - do not waste time.

Basic first - aid treatment

Refer Exercise No 1.1.01-08

First aid

- Call EMERGENCY number.
- 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 (Fig 2). 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.

Treatment of electric shock

Prompt treatment is essential

If assistance is close at hand, send for medical aid, then carry on with emergency treatment.

If you are alone, proceed with treatment at once.

Switch off the supply, if this can be done without undue delay. Otherwise, remove the victim from contact with the live conductor, using dry non-conducting materials such as a wooden bar, rope, a scarf, the victim's coat-tails, any dry article of clothing, a belt, rolled-up newspaper, non-metallic hose, PVC tubing, bakelised paper, tube etc. (Fig 3)

Avoid direct contact with the victim. Wrap your hands in dry material if rubber gloves are not available.

Elementary electricity and its units and general ideas of supply system

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

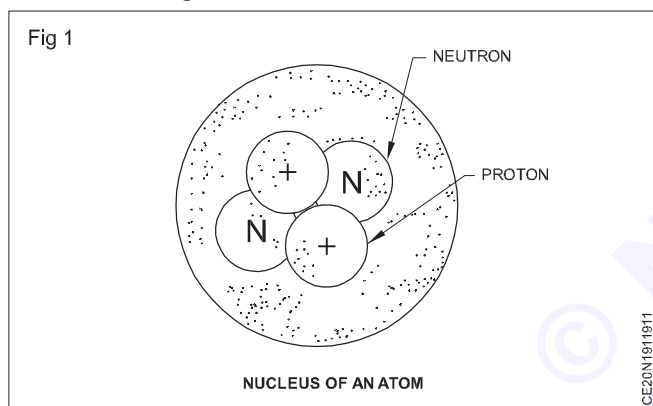
- explain about the atomic structure
- define the fundamental terms and definition of electricity
- state work, power and energy.

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.

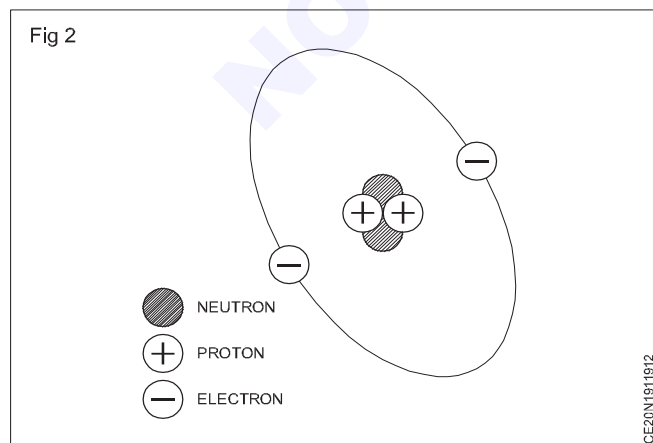
Atomic Structure

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.



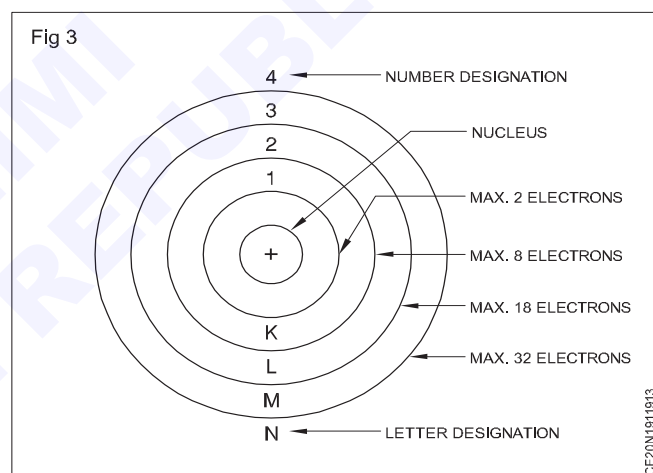
Protons: The proton has a positive electrical charge (Fig 1) it is almost 1840 times heavier than the electron and it is the permanent part of the nucleus; protons do not take an active part in the flow or transfer of electrical energy.

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.

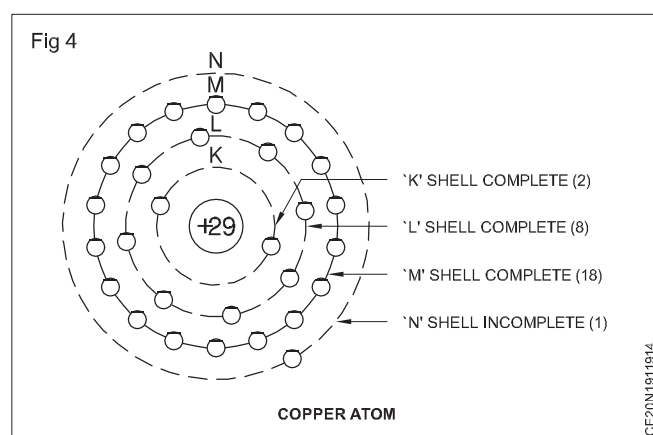


Neutron: A neutron is actually a particle by itself, and is electrically neutral. Since neutrons are electrically neutral they are not too important to the electrical nature of atoms.

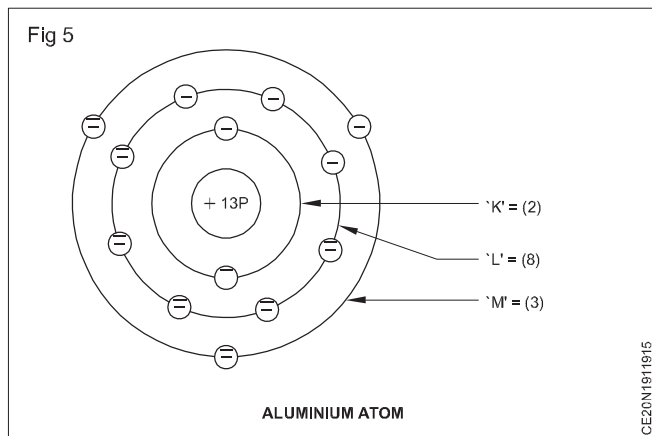
Energy shells: In an atom, electrons are arranged in shells around the nucleus. A shell is an orbiting layer or energy level of one or more electrons. The major shell layers are identified by numbers or by letters starting with 'K' nearest the nucleus and continuing alphabetically outwards. There is 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 be determined. Each shell layer, beginning with the first is filled 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 behaviour of atoms depends on how completely the various shells and sub-shells are filled.

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.

Conductors, insulators and semiconductors

Conductors : A conductor is a material that has many valence electrons permitting electrons to move through it easily. Generally, conductors have many valence shells of one, two or three electrons. Most metals are conductors.

Some common good conductors are Copper, Aluminium, Zinc, Lead, Tin, Eureka, Nichrome are conductors, where as silver and gold are very good conductors.

Insulators : An insulator is a material that has few, if any free 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.

Electrical units

Electrical Power (P) & Energy (E) : The product of voltage (V) and current (I) is called electrical power. Electrical power (P) = Voltage x Current $P = V \times I$

The unit of Electrical power is 'Watt' It is denoted by the letter 'P' It is measured by Watt meter. The following formulae can also be derived from formula of power (P) as

$$P = \frac{V^2}{R}$$

Electrical Energy (E)

The product of power (P) and time (t) is called as electrical energy (E)

Electrical Energy (E) = Power x time

$$E = V \times I \times t$$

The unit of electrical energy is "Watt hour" (Wh)

The commercial unit of Electrical energy is "Kilo watt hour" (KWH) or unit

Work, Power and Energy

Work is said to be done, when a force (F) displaces a body from one distance (s) to another (or)

$$\begin{aligned} \text{Work done} &= \text{Force} \times \text{distance moved} \\ w.d &= F \times S \end{aligned}$$

Power (P)

The rate of doing work is called as Power (P)

Power (P) = work done / time taken

$$P = \frac{F \times S}{t}$$

$$\text{Electrical Power} = VI \text{ Watt}$$

Energy

The capacity for doing work is called as electrical Energy

(or)

The product of power and time is known as Electrical energy

$$\begin{aligned} \text{(ie) Energy} &= \text{Power} \times \text{time} \\ &= VI \times t \end{aligned}$$

S.I unit of energy is "Joule"

$$\text{(ie) Energy} = (\text{Joule/sec}) \times \text{sec}$$

$$= \frac{\text{Joule}}{\text{Sec}} \times \text{Sec} = \text{joule}$$

General ideas of supply system of connection in 3-phase AC

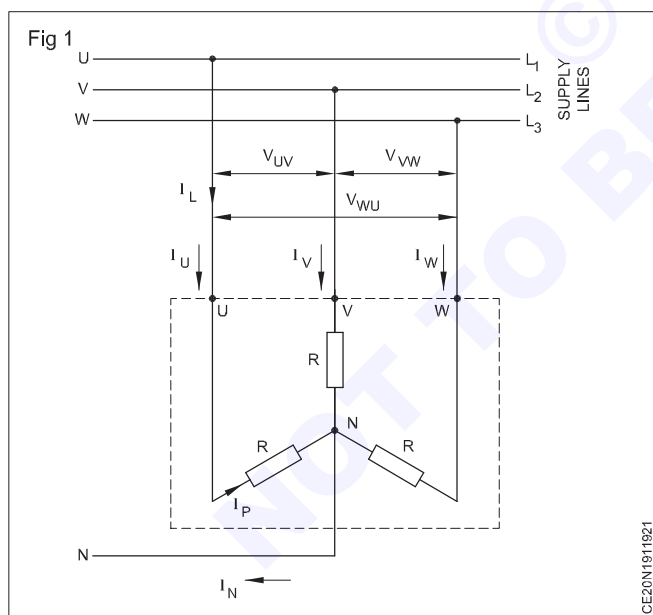
Objectives: At the end of this lesson you shall be able to

- explain the star and delta systems of connection
- state phase relationship between line and phase voltages and current in a star connection delta connection
- state the relationship between phase and the voltage and current in star and delta connection.

Methods of 3-phase connection: If a three-phase load is connected to a three-phase network, there are two basic possible configurations. One is 'star connection' (symbol Y) and the other is 'delta connection' (symbol D).

Star connection: In Fig 1 the three-phase load is shown as three equal magnitude resistances. From each phase, at any given time, there is a path to the terminal points U, V, W of the equipment, and then through the individual elements of the load resistance. All the elements are connected to one point N: the 'star point'. This star point is connected to the neutral conductor N. The phase currents i_U , i_V , and i_W flow through the individual elements, and the same current flows through the supply lines, i.e. in a star connected system, the supply line current (I_L) = phase current (I_P).

The potential difference for each phase, i.e. from a line to the star point, is called the phase voltage and designated as V_P . The potential difference across any two lines is called the line voltage V_L . Therefore, the voltage across each impedance of a star connection is the phase voltage V_P . The line voltage V_L appears across the load terminals U-V, V-W and W-U and designated as V_{UV} , V_{VW} and V_{WU} in the Fig 1.

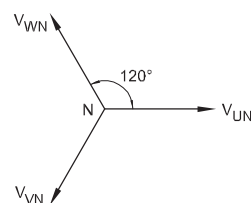


The line voltage in a star-connected system will be equal to the phasor sum of the positive value of one phase voltage and the negative value of the other phase voltage that exist across the two lines. (Fig 2)

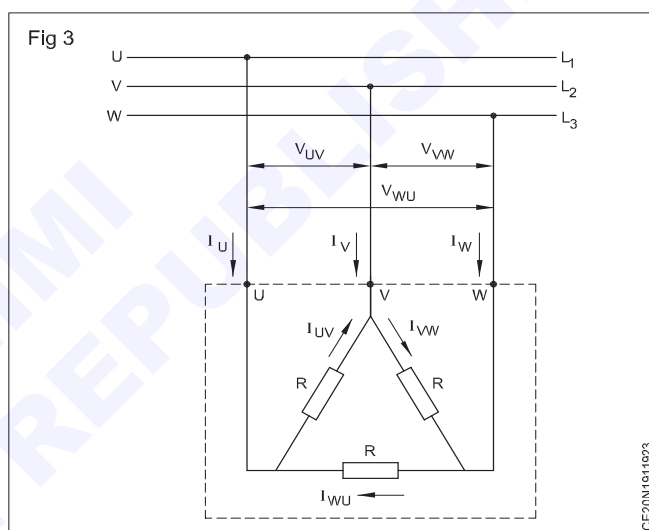
Thus

$$\begin{aligned} V_L &= V_{UV} = (\text{phasor } V_{UN}) - (\text{phasor } V_{VN}) \\ &= \text{phasor } V_{UN} + V_{VN} \end{aligned}$$

Fig 2



Delta connection: There is a second possible arrangement for connecting a three-phase load in a three-phase network. This is the delta or mesh connection (D). (Fig 3)



The load impedances form the sides of a triangle. The terminals U, V and W are connected to the supply lines of the L_1 , L_2 and L_3 .

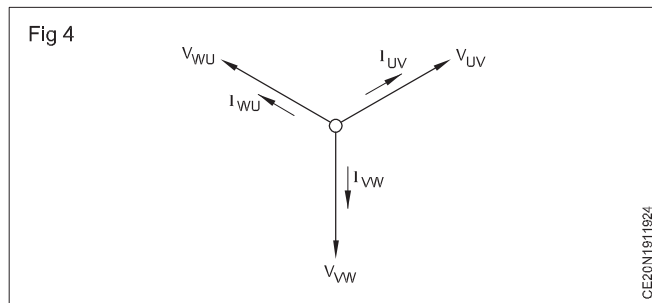
In contrast to a star connection, in a delta connection the line voltage appears across each of the load phases.

The voltages, with symbols V_{UV} , V_{VW} and V_{WU} are, therefore, the line voltages.

The phase currents through the elements in a delta arrangement are composed of I_{UV} , I_{VW} and I_{WU} . The currents from the supply lines are I_U , I_V and I_W , and one line current divides at the point of connection to produce two phase currents.

The voltage and current relationships of the delta connection can be explained with the aid of an illustration. The line voltages V_{UV} , V_{VW} and V_{WU} are directly across the load resistors, and in this case, the phase voltage is the same as the line voltage. The phasors V_{UV} , V_{VW} and V_{WU} are the line voltages. This arrangement has already been seen in relation to the delta connection.

Because of the purely resistive load, the corresponding phase currents are in phase with the line voltages. (Fig 4)



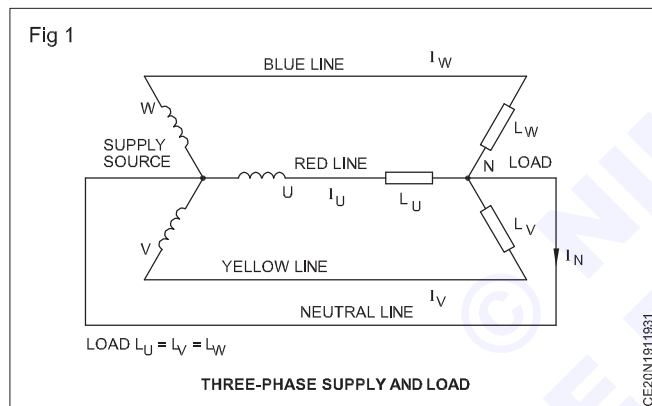
Their magnitudes are determined by the ratio of the line voltage to the resistance R .

Neutral in 3-phase system

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

- explain the current in neutral of a 3-phase star connection
- state the earthing the neutral.

Neutral: In a three-phase star connection, the star point is known as neutral point, and the conductor connected to the neutral point is referred as neutral conductor (Fig 1).



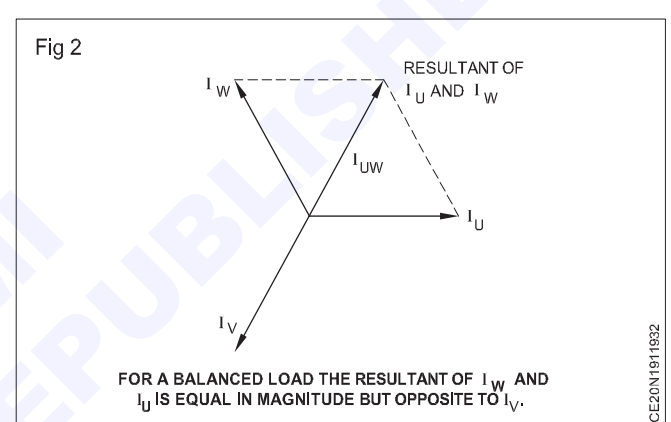
Current in the neutral conductor: In a star-connector, four-wire system, the neutral conductor N must carry the sum of the currents I_U , I_V and I_W . One may, therefore, get the impression that the conductor must have sufficient area to carry a particularly high current. However, this is not the case, because this conductor is required to carry only the I_N = phasor sum of I_U , I_V and I_W .

Fig 2 shows this phasor addition for a situation where the loads are balanced and the currents are equal. The result is that the current in the neutral line I_N is zero.

Therefore, for a balanced load the neutral conductor carries no current.

Earthing of neutral conductor: Supply of electrical energy to commercial and domestic consumers is an important application of three-phase electricity. For 'low voltage distribution' - in the simplest case, i.e. supply of light and power to buildings - there are two requirements.

- 1 It is desirable to use conductors operating at the highest possible voltage but with low current in order to save on expensive conductor material.



- 2 For safety reasons, the voltage between the conductor and earth must not exceed 250V.

A voltage distribution system according to criterion 2, only possible with a low line voltage below 250 V. However, this is contrary to criterion 1. On the other hand, with a star connection, a line voltage of 415V is available. In this case, there is only 240V between the supply line and the neutral conductor. Criterion 1 is satisfied and, to comply with 2, the neutral conductor is earthed.

Indian Electricity Rules: I.E. Rules insist that the neutral conductor must be earthed by two separate and distinct connections to earth. Rule No.61(1)(a), Rule No.67(1)(a) and Rule No.32 insist on the identification of neutral at the point of commencement of supply at the consumer's premises, and also prevent the use of cut outs or links in the neutral conductor. BIS stipulate the method of earthing the neutral. (Code No.17.4 of IS 3043-1966)

Cross-sectional area of neutral conductor: The neutral conductor in a 3-phase, 4-wire system should have a smaller cross-section. (half of the cross-section of the supply lines).

Wireman's tools kit, portable power machines and wiring materials

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

- list the tools and portable power machines necessary for a wireman
- specify the tools and state the use of each tool.

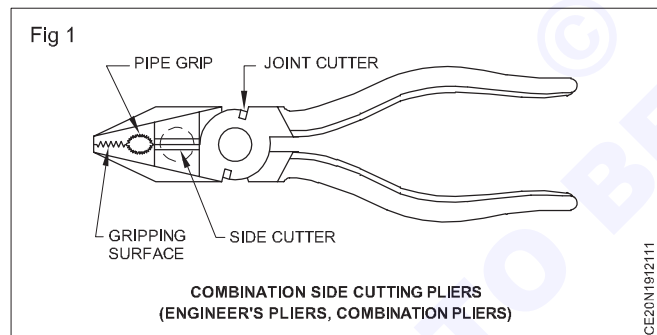
Listed below are the most commonly used tools and portable power machines by wireman.

- Try square
- Firmer chisel
- mallet
- Tenon saw
- Measuring steel tape
- Pincers
- Portable electric drill light duty
- Portable power heavy duty hammer drill machine
- Portable electric screw driver

Refer Exercise No 1.8.100-101

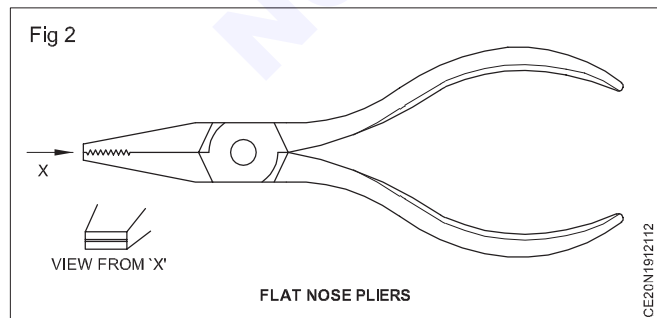
Pliers: They are specified with their overall dimensions of length in mm. The pliers used for electrical work will be of insulated grip.

1 Combination pliers with pipe grip, side cutter and insulated handle. BIS 3650 (Fig 1)



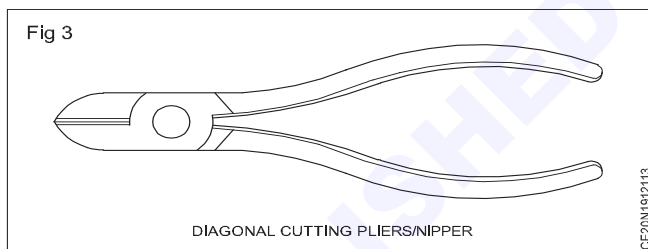
It is made of forged steel. It is used for cutting, twisting, pulling, holding and gripping small jobs in wiring assembly and repairing work.

2 Flat nose pliers BIS 3552 (Fig 2)

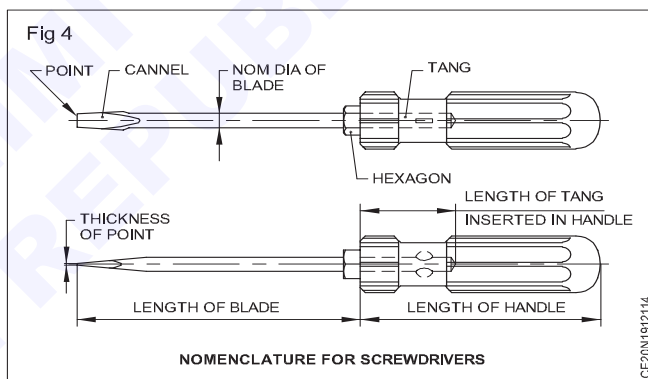


Flat nose pliers are used for holding flat objects like thin plates etc.

3 Side cutting pliers (Diagonal cutting pliers) BIS 4378 (Fig 3) It is used for cutting copper and aluminium wires of smaller diameter (less than 4mm dia).



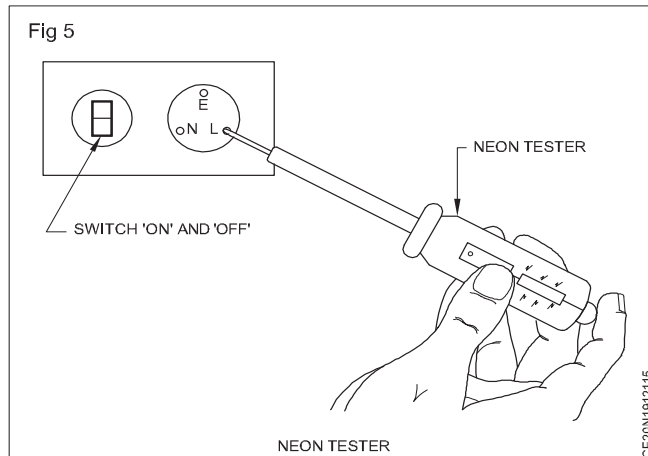
4 Screwdriver BIS 844 (Fig 4)



The screwdrivers used for electrical works generally have plastic handles and the stem is covered with insulating sleeves.

Star-head screw driver: It is used for driving star headed screws.

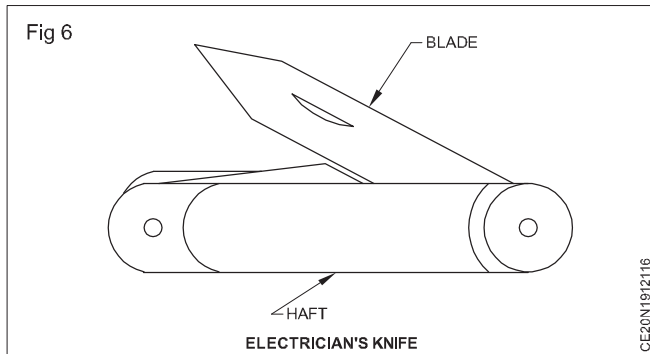
5 Neon tester BIS 5579 - 1985 (Fig 5)



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 electrodes. It may have a tip like a probe or screw-driver at one end.

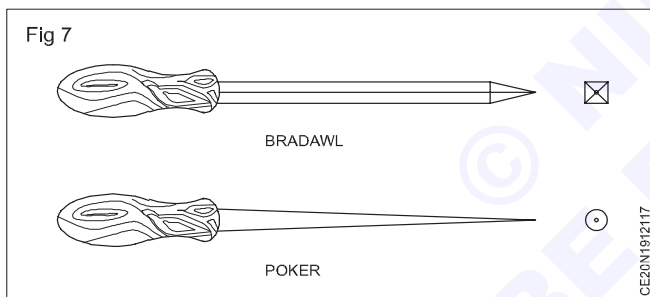
6 Electrician's knife (Double blade) (Fig 6)



The size of the knife is specified by its largest blade length eg. 50 mm, 75 mm.

It is used for skinning the insulation of cables and cleaning the wire surface.

7 Bradawl square pointed (or poker) (Fig 7)

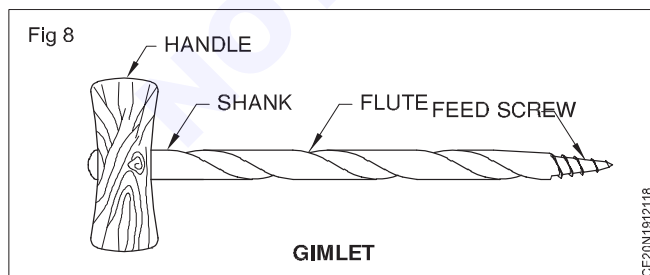


Bradawl square pointed (or poker) BIS 10375 - 1982

It is specified by its length and diameter eg. 150 mm x 6 mm.

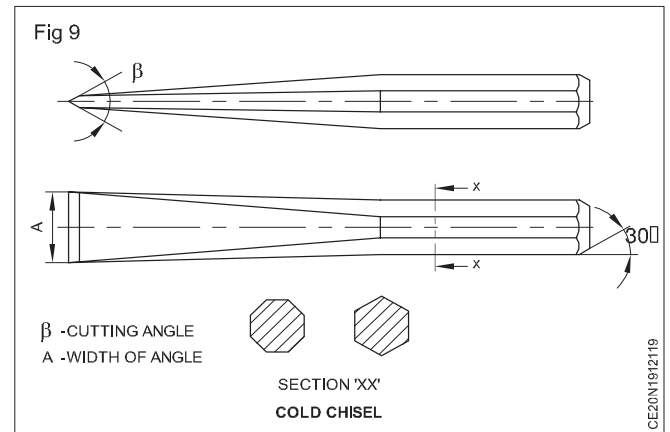
It is a long sharp tool used for making pilot holes on wooden articles to fix screws.

8 Gimlet (Fig 8)



It is used for boring small holes on wooden articles. It has a wooden handle and a boring screwed edge. The size of it depends upon its diameter. Eg. 3 mm, 4 mm, 5 mm, 6 mm.

9 Flat cold chisel BIS 402 (Fig 9)

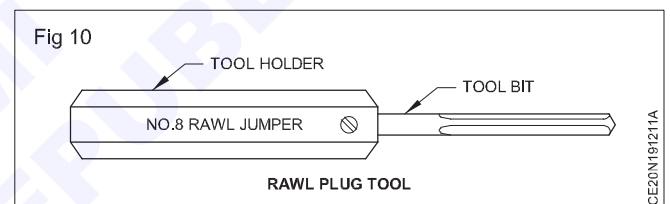


Its size is given by the nominal width and length.

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. (Fig 8)

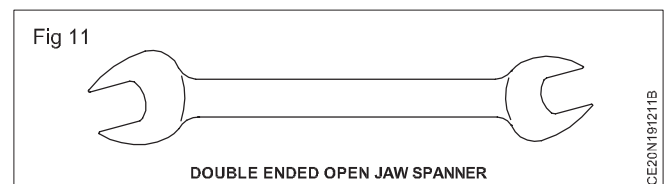
10 Rawl plug tool and bit (Fig 10)



Its size depends upon the number. As the number increases, the thickness of the bit as well as the plug also increases. Eg. 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.

11 Spanner: double ended (Fig 11) BIS 2028



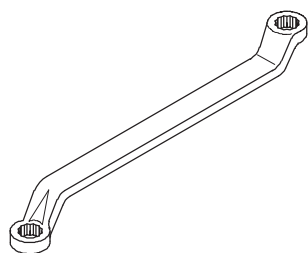
The size of a spanner is indicated so as to fit on the nuts. They are available in many sizes and shapes.

The sizes, indicated in double-ended spanners are the distance between two jaws of a side.

12 Ring spanner set (Fig 12) BIS 2029

The ring spanner is used in places where the space is restricted and where high leverage is required.

Fig 12



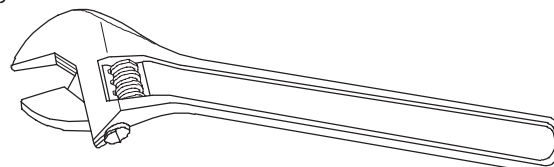
RING SPANNER

CE20N191211C

13 Single ended open jaw adjustable spanner (Fig 13) 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, 250mm etc.

Fig 13



ADJUSTABLE SPANNER

CE20N191211D

Various types of electrical Wire

S.No	Materials	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.

Electrical Fittings

- 1 Tube light fittings
 - a single tube
 - b Durable tube
- 2 Sodium vapour lamp fittings
- 3 Mercury vapour lamp fittings
- 4 Hallowgen lamp fittings
- 5 Spot light fittings

System of wirings, wiring installation for domestic lightings

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

- state the types wiring used in domestic installations.

Introduction

The type of wiring to be adopted is dependent on various factors viz. location durability, safety, appearance, cost and consumer's budget etc.

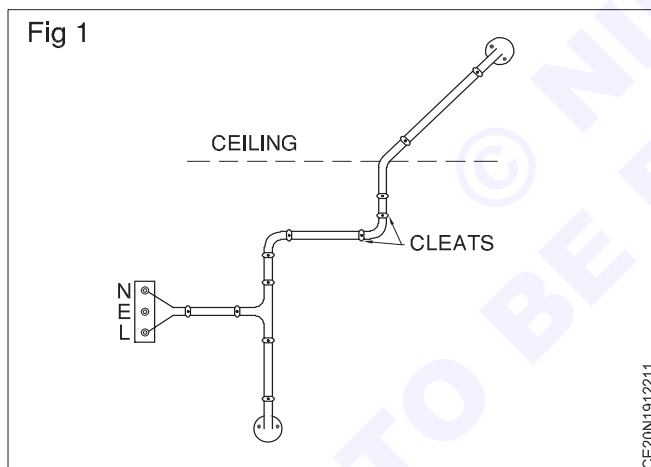
Types of wiring

The following are the types of internal wiring used in domestic installations.

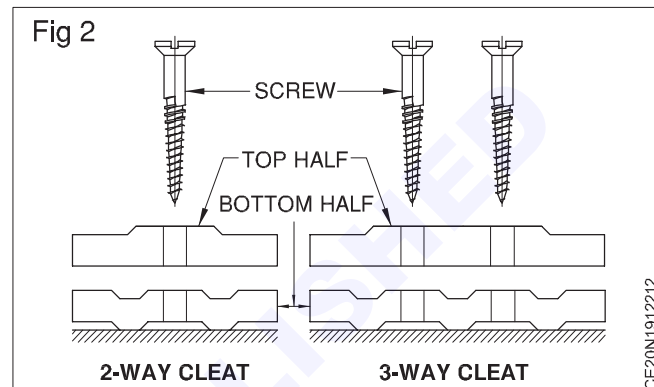
- Cleat wiring (for temporary wiring only)
- CTS/TRS (batten) wiring
- Metal/PVC conduit wiring, either on surface or concealed in the wall.
- PVC casing & capping wiring

Cleat wiring

This system uses insulated cables supported in porcelain cleats (Fig 1).



Cleat wiring is recommended only for temporary installations. These cleats are made in pairs having bottom and top halves (Fig 2). Bottom half is grooved to receive the wire and the top half is for cable grip.



Initially the bottom and top cleats are fixed on the wall loosely according to the layout. Then the cable is drawn through the cleat grooves, and it is tensioned by pulling and the cleats are tightened by the screw.

The cleats are of three types, having one, two or three grooves, so as to receive one, two or three wires.

Cleat wiring is one of the cheapest wirings considering the initial cost and labour, and is most suitable for temporary wiring. This wiring can be quickly installed, easily inspected and altered. When not required this wiring could be dismantled without damage to the cables, cleats and accessories. This type of wiring may be done by semi-skilled persons.

Types of power wiring

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

- explain the types of electrical wiring and their application
- state the advantages and disadvantages of each types.

Types of wiring system

Tree system: In this system, copper or aluminium strips in the form of bus bars are used to connect the main supply to the raising mains (Fig1). This system is suitable for multi-story buildings.

Advantages

- 1 The length of the cables required for installation will become less. Hence, the cost is less.

- 2 This system is suitable for high rise buildings.

Ring main system: This system consists of two pairs of cables of size 4 or 6sq.mm which run through the rooms and are brought back to the main or sub-board (Fig 2 & 3). Tappings are taken for sockets or ceiling roses from the pair of cables through fuses and controlling switches. There may be saving of copper used because the current can be fed from both sides. As this system requires special sockets or plugs with fuses it becomes costly; and hence rarely used in India.

Fig 1

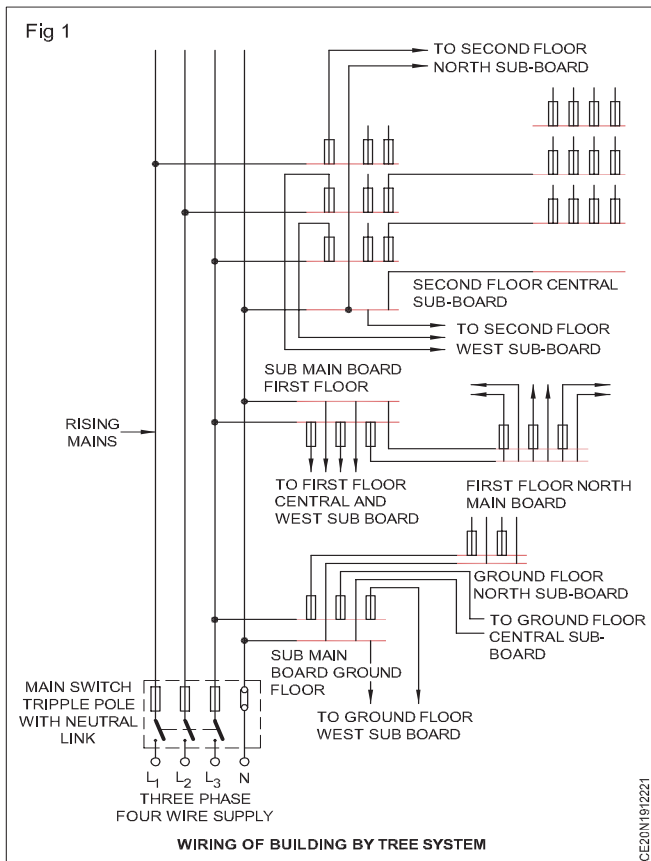


Fig 2

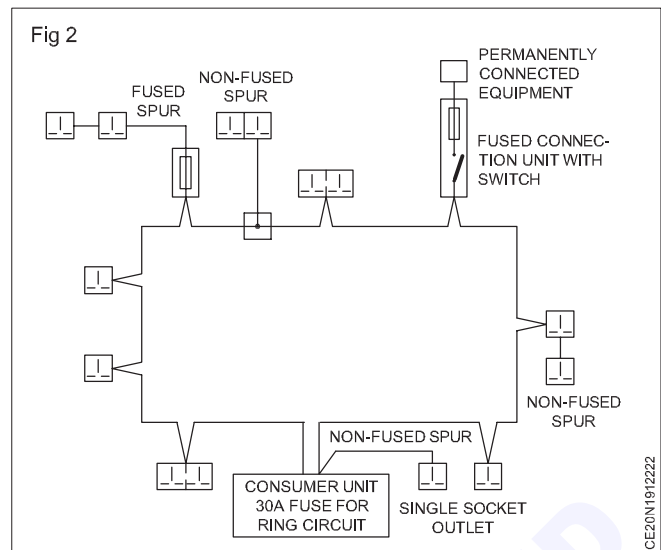
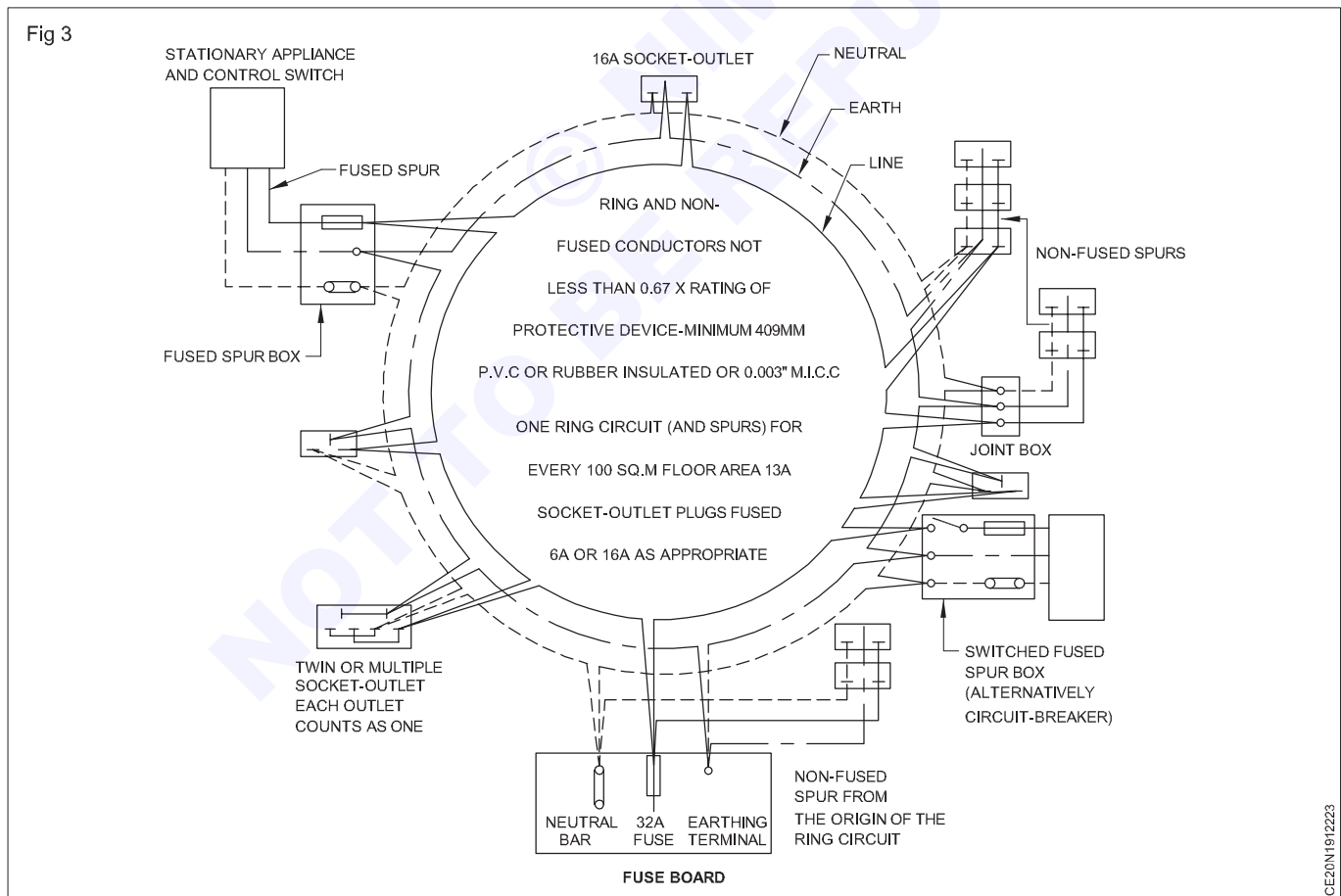
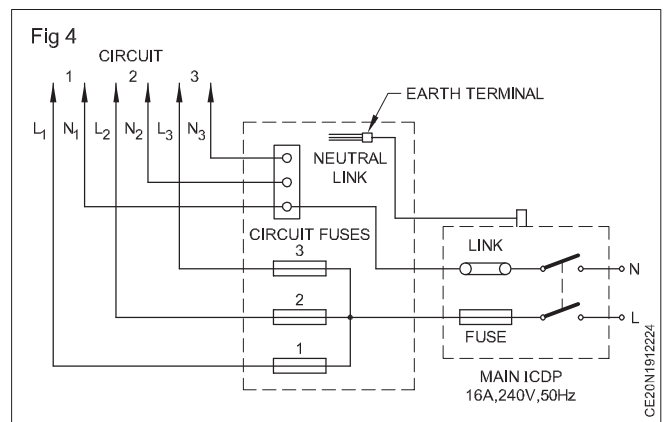


Fig 3



Distribution board system: This is the most commonly used system. This system enables the appliances connected to the system to have the same voltage. The main switch is connected to the distribution board through suitable cables. The distribution board has a number of fuses depending upon the number of circuits required in the installation, and the phase and neutral cable of each phase are taken from the distribution board (Fig 4).



Installation for domestic lightings, fittings

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

- name the types of bulbs for illumination
- explain direct and indirect lighting.

Types of lamps used for illumination: The lamps used are:

- incandescent lamps
- tube lights

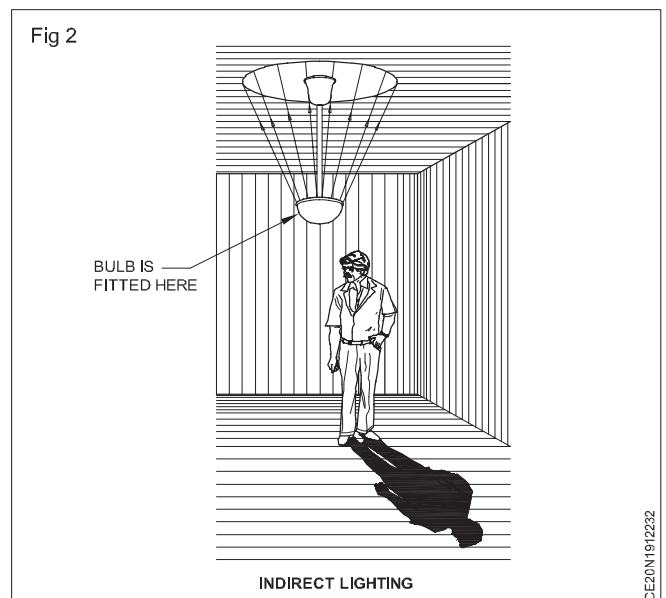
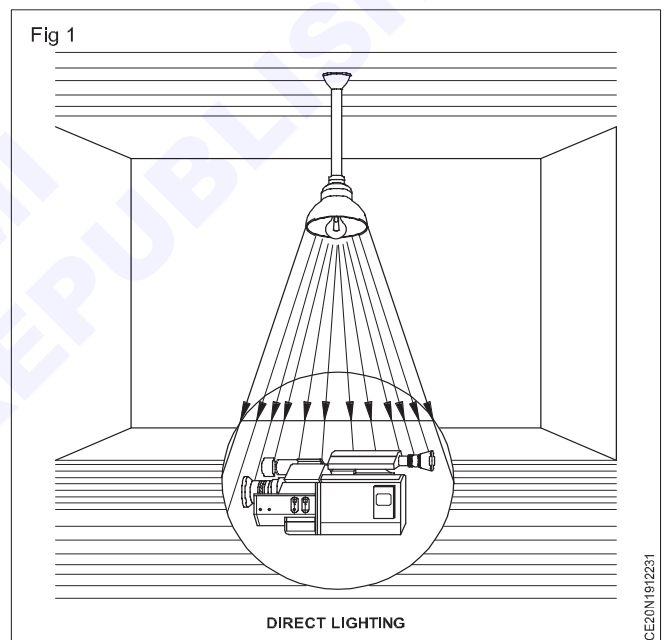
Types of bulbs/incandescent lamps

- Glow lamps
- Moonlight lamps
- Luminous lamps
- Daylight lamps
- Tree light lamps
- Photo flood lamps
- Movie flood lamps
- Photo flash lamps
- Silvered bowl lamps
- Projector lamps
- Reflector lamps
- Halogen lamps.

Points to remember while designing illumination direct lighting and indirect lighting: Lighting for commercial purposes is divided into many parts such as built in direct lighting (Fig 1), indirect lighting (Fig 2), core lighting, spot lighting etc.

To achieve the above lighting there are ceiling fixtures, side wall fixtures, portable fixtures and other luminaries available.

The number of lumens required for the working place is 150 lumens/m². The lumens provided by the lamp must however be greater than this figure to allow for depreciation of the installation owing to dust and dirt on the lamps and their fittings.

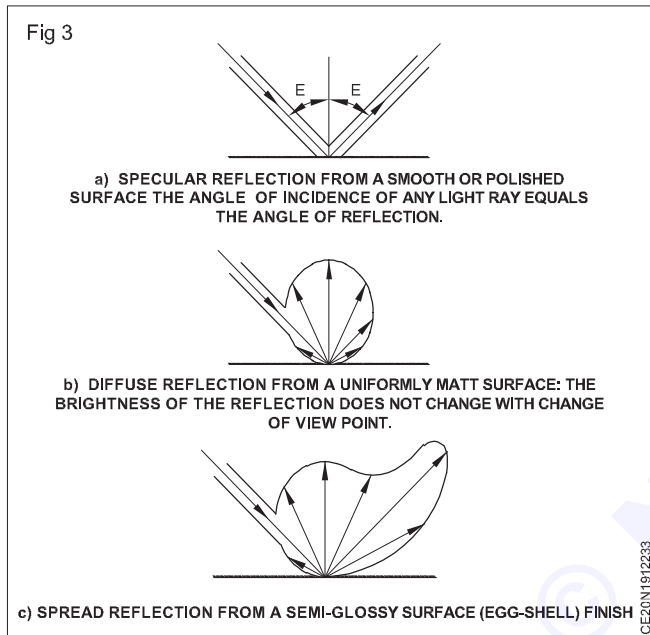


Atleast 150 lumens per square metre should be provided for adequate visual performance on rough or unskilled work. Up to 1500 lumens per square metre should be provided for difficult or fine works.

Most sources radiate light in all direction and are too bright to be viewed comfortably. The light must therefore be controlled to direct it where it is required and to soften its brilliance.

Reflection of light may be of three kinds.

- Specular reflection Fig 3(a)
- Diffuse reflection Fig 3(b)
- Spread reflection Fig 3(c)



Specular reflection: When light strikes a mirror like surface it is reflected at the same angle and in the same plane as it strikes, for example a car lamp.

Diffuse reflection: Diffuse reflection is useless for the precise control of light, but it can be used to reflect light in a general direction.

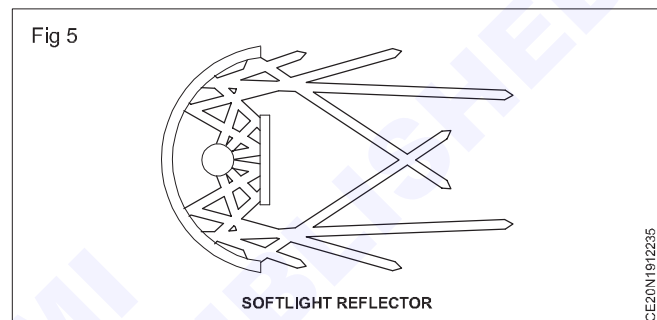
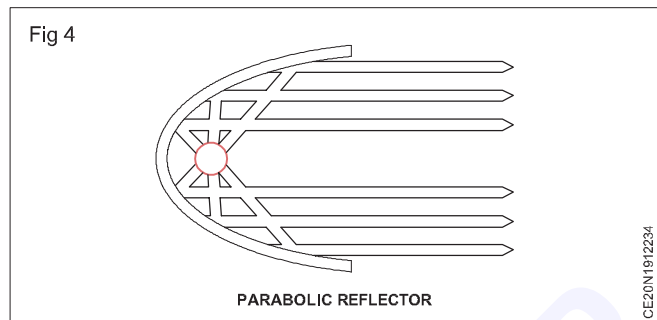
Spread reflection: Unpolished metals and satin-finish mirrored surfaces have reflection characteristics between specular and diffuse. Vitreous and synthetic enamels are widely used for reflecting surfaces of light fittings. Vitreous enamels is the more hard working.

Types of reflectors: A lamp without any kind of reflector will radiate light in every direction. By placing the lamp within a reflector, you can control the light and direct it where you want it.

Dispersive type: The reflecting surface is either white enamelled or vitreous enamelled. The Vitreous enamelled type is more expensive and less efficient optically but are more suitable for use in damp and corrosive atmosphere.

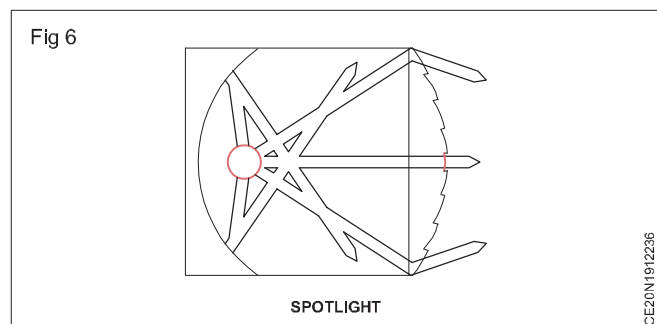
Mirror type reflector: These have highly polished surface for specular reflection. Silvered glass, Chromium plated; copper sheet anodized aluminium shades are typical example of this. This type is used in yard lighting.

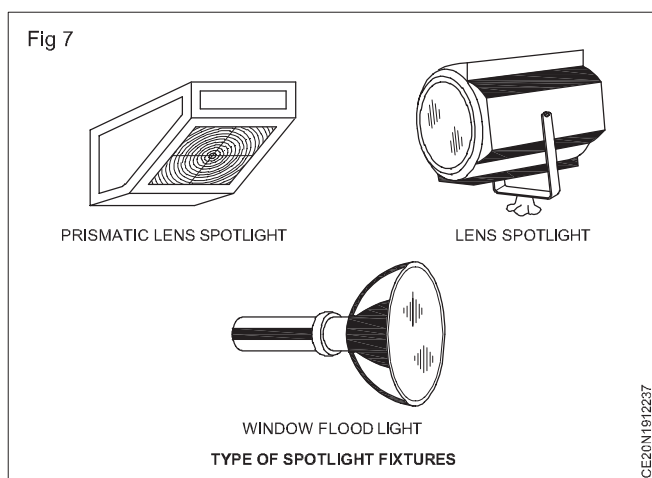
Parabolic and soft light reflector (Fig 4 & Fig 5)



A parabolic reflector produces a hard light and is most commonly used with tungsten lamps. A soft light reflector has shield in front of the bulb and so produces a diffused light. A spotlight enables you to vary the light beam. In each case, the light will be softer if the reflector surface is matted or dimpled rather than highly polished.

Spotlighting (Figs 6 & 7): Spotlighting is one way lighting, usually employed projectors with lenses but sometimes with reflectors only, and is used to give special illumination to a limited area as in theatre practice. The spotlights must be so located as to be out of the direct line of vision and produce no trouble some reflections or glare.





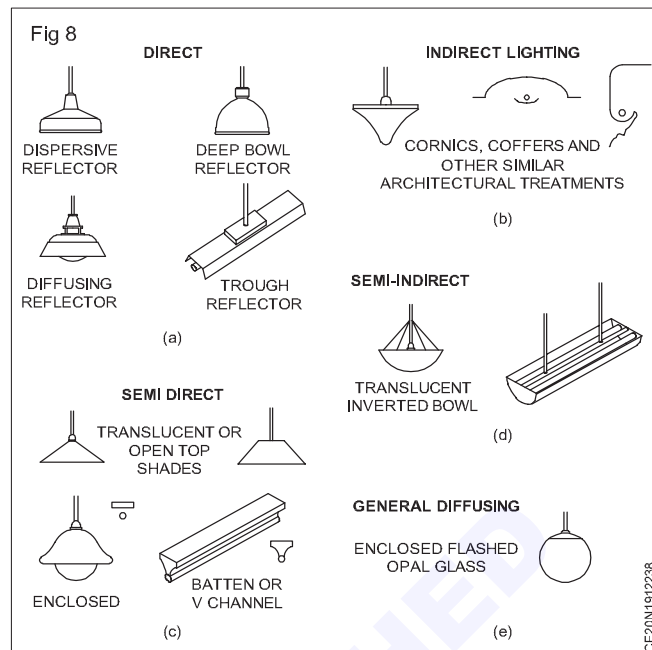
Supplementary lighting: Supplementary lighting as the name implies, should be employed in conjunction with a general lighting system, when necessary or desirable.

Light fitting, types and performance (Fig 8)

Direct lighting type has largest efficiency from energy utilization point of view but glare is always present. Such systems are used for flood and Industrial lighting. (Fig 8a)

Indirect lighting type designed to avoid glare and recommended for specific purposes. (Fig 8b)

Semi direct type designed to avoid glare and recommended for offices and other specific purposes. (Fig 8c)



Semi indirect type designed to avoid glare and recommended for specific purposes. (Fig 8d)

General diffusing type system has got low efficiency but are free from glare and has got uniform distribution of light.

Details of reflector's and their %age of light distribution is given in Table 1 for your reference.

Table 1
Lighting systems

Types of system	Amount of emergent light	
	Downward	Upward
Shaded or reflector system		
1 Direct	90 to 100%	0 to 10%
2 Semi direct	60 to 90%	10 to 40%
3 Semi indirect	10 to 40%	60 to 90%
4 Indirect	0 to 10%	90 to 100%
Diffused system		
1 General diffused	50%	50%

Above table is in line with CIE classification of general indoor lighting luminaries

Conductor: Insulator, semi conductor, cable joints, measurement of cable

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

- state the cable jointing method.

UG cables laying method

The reliability of the underground cable (UG) installation depends upon the proper laying and attachment of fittings (i.e) cable and boxes, joints, branch connectors etc.

Methods of laying of UG cables

The following are the methods of laying underground cables

- 1 Laying direct in ground
- 2 Laying in ducts
- 3 Laying on racks in air.
- 4 Laying on racks inside a cable tunnel.
- 5 Laying along buildings or structures.

Precautions while handling cables

- 1 Prevent the cable from dragging on the floor.
- 2 Prevent kinking of the cable.
- 3 After laying the cable in the ducts it should be immediately covered or suspended.

Cable jointing methods: This process consists of the following steps.

- a Exact measurement of the cable for insulation removal.
- b Removal of insulation.
- c Replacing of the original insulation with high grade tapes and sleeves.
- d Dressing the cable ends and conductor joints through sleeves/split sleeves.
- e Providing separators between cables.
- f Fixing a cast iron or any other protective shell around the joint and filling the joint boxes with molten bitumen compound.
- g Plumbing metallic sleeves or brass glands to the lead sheath of the cable to prevent moisture from entering the joint in case of cast iron joint boxes or tape insulation in case of cast resin kit joint boxes.

Straight through joints

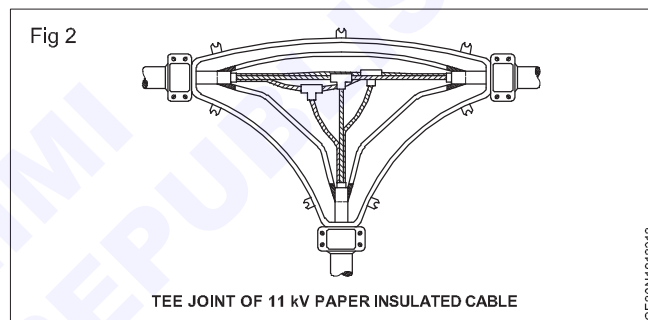
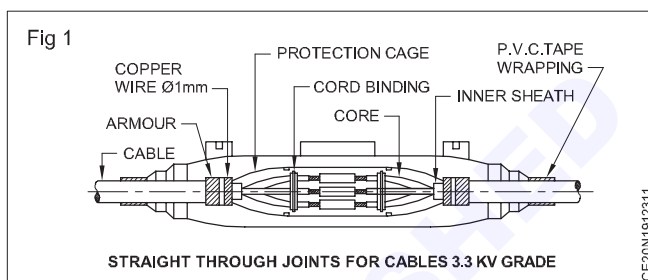
The emphasis should be laid on quality and selection of proper cable, cable accessories, proper jointing techniques.

For PILC cable: For paper insulated lead sheathed cables, straight joints are made either by using sleeve joints or crimping joints up to voltage grade 11 KV. Above 11 KV, compound filled copper or brass sleeves, along with cast iron, fibre glass protection boxes are used.

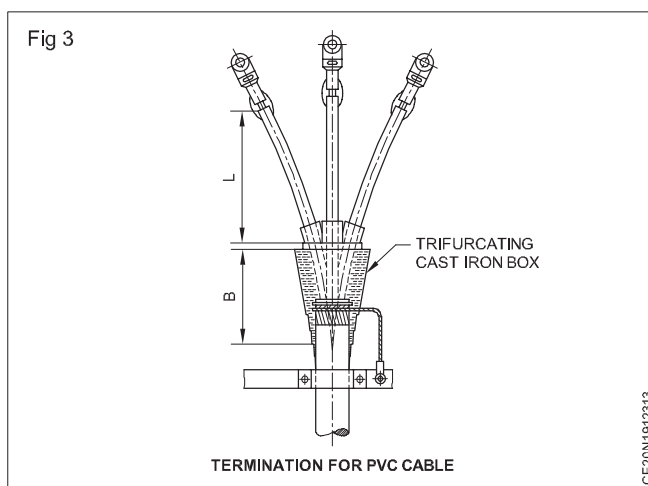
Fig 1 shows such a joint.

Tee joint: These joints are to be restricted up to 11 KV.

These joints are made either using cast resin kits or C.I. boxes with or without sleeves for PILC cables and cast resin kits for PVC and XLPE cables. (Fig 2)



Tri-furcating end connections: In order to connect UG cables to the air break switches etc. tri-furcating boxes are used. They can be either cast resin type up to 1.1 KV or cast iron type for 11 KV and above. This type of box is shown in Fig 3.



Method of preparing and filling compounds

- Hot pouring
- Cold pouring

Hot pouring compounds: A bituminous compound of melting temperature 90°C and pouring temperature 180°C - 190°C is used for hot pouring.

Cold pouring compound: Cold pouring is used by using cast resin system for PVC cable jointing. This has been developed for application up to 11 KV grade cables. The compound consists of a resin base and a polyamine hardener. The two component liquids are mixed at the site in accordance with the recommendation of the manufacturer.

Measurement of resistance

Let the value of S for balance be S₁. The four arms of the Wheatstone bridge are P, Q, R + X, S₁ at balance:

$$\frac{R+X}{S_1} = \frac{P}{Q}$$

This determines R + X i.e. the total loop resistance as P, Q and S₁ are known.

The switch K is then thrown to position '2' and the bridge is rebalanced. Let the new value of S for balance be S₂. The four arms of the bridge now are P, Q, R, X + S₂.

At balance

$$\frac{R}{X+S_2} = \frac{P}{Q}$$

$$\frac{R+X+S_2}{X+S_2} = \frac{P+Q}{Q} \text{ or } X = \frac{(R+X)Q - S_2 P}{P+Q}$$

Hence, X is known from the known value of P, Q, S₂ from this equation and R+X (the total resistance of 2 cables) as determined from Eqn. knowing the value of X, the position of the fault is determined.

$$\text{Now } \frac{X}{R+X} = \frac{l}{2l} \text{ or } l = \frac{X}{R+X} 2l$$

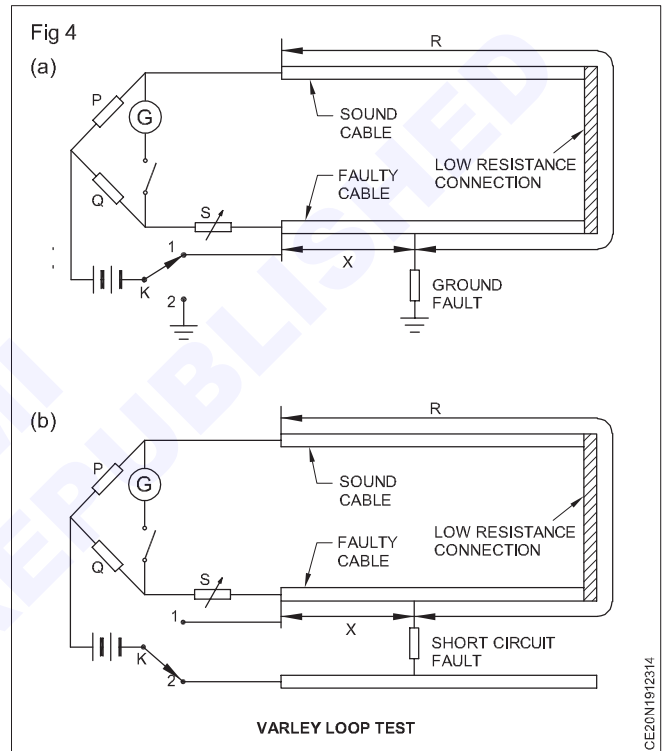
Where

l = length of fault from the test end and

l = total length of conductor.

Equations for murray loop test and varley loop test are valid only when the cable sections are uniform throughout the loop. Corrections must be applied in case the cross-sections of faulty and sound cables are different or when the cross-section of the faulty cable is not uniform over its entire length.

Since temperature affects the value of resistance, corrections must be applied on this account if the temperatures of the two cables are different. Corrections may also have to be applied in case the cables have a large number of joints. (Fig 4)



Properties of conductors - insulators and semi-conductors

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

- state the differentiate between conducting and insulating materials
- state the types and properties of insulating materials.

Conductors, insulators and semiconductors

Conductors: A conductor is a material that has many valance electrons permitting electrons to move through it easily. Generally, conductors have many valance shells of one, two or three electrons. Most metals are conductors.

Some common good conductors are Copper, Aluminium, Zinc, Lead, Tin, Eureka, Nichrome, are conductors, where as silver and gold are very good conductors.

Insulators: An insulator is a material that has few, if any, free 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 semiconductors are used to produce modern electronic components such as diodes, transistors and integrated circuit chips.

Types of fuses, MCB, ELCB, RCCB, ABCB, MCCB, AC and DC/ AC fundamentals and poly phase and soldering

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

- explain the types, working principle and parts of a miniature circuit breaker
- state the advantages and disadvantages of MCB
- state the categories and applications of MCBs
- state the application, advantage and disadvantage of MCCBs.

Circuit breaker

A circuit breaker is a mechanical switching device capable of making, carrying and breaking the currents under normal condition and breaking the currents under abnormal conditions like a short circuit.

Miniature circuit breaker (MCB)

A miniature circuit breaker is a compact mechanical device for making and breaking a circuit both in normal condition and in abnormal conditions such as those of over current and short circuit.

Types of MCB's

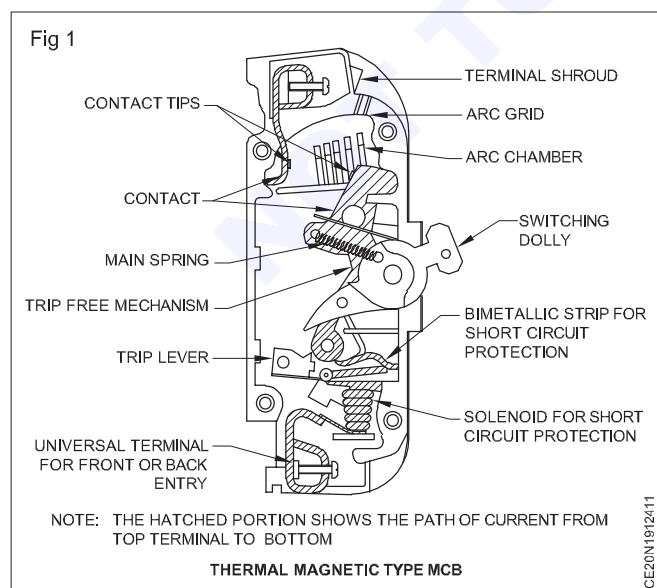
MCBs are manufactured with three different principles of operation namely

- a Thermal Magnetic
- b Magnetic hydraulic and
- c Assisted bimetallic

Out of three MCB's thermal magnetic MCB is discussed below

Thermal magnetic MCB

The switching mechanism is housed in a moulded housing with phenolic moulded high mechanically strong switching dolly. This type of MCB is also provided with bimetallic overload release (Fig 1).



The electric current gets through two contact tips one each on moving and fixed contact of silver graphite.

An arcing chamber incorporating de-ionising arc chutes for control and quick suppression of the arc is provided in the gap between two contacts. It has a ribbed opening closed by metal grid which allows ventilation and escape of gases.

For protection against over-load and short circuit, MCB's have thermal magnetic release unit. The overload is taken care of by bimetallic strip, short circuit currents and over loads of more than 100% are taken care by solenoid.

Categories of MCBs

Certain manufacturers like Indo Kopp manufacture the MCBs in three different categories namely 'L' series, 'G' series, and 'DC' series.

'L' series MCBs

'L' series MCBs are designed to protect circuits with resistive loads. They are ideal for protection of equipment like Geysers, ovens and general lighting systems.

'G' series MCBs

'G' series MCBs are designed to protect circuits with inductive loads. G series MCBs are suitable for protection of motors, air conditioners, hand tools, halogen lamps etc.,

'DC' series MCBs

'DC' series MCBs are suitable for voltage upto 220V DC and have a breaking capacity up to 6kA.

The tripping characteristics are similar to 'L' and 'G' series. They find extensive application in DC controls, locomotives, diesel generator sets etc.,

Advantages of MCB

- 1 Tripping characteristic setting can be done during manufacture and it cannot be altered.
- 2 They will trip for a sustained overload but not for transient overload.
- 3 Faulty circuit is easily identified.
- 4 Supply can be quickly restored.
- 5 Tamper proof.

6 Multiple units are available.

Disadvantages

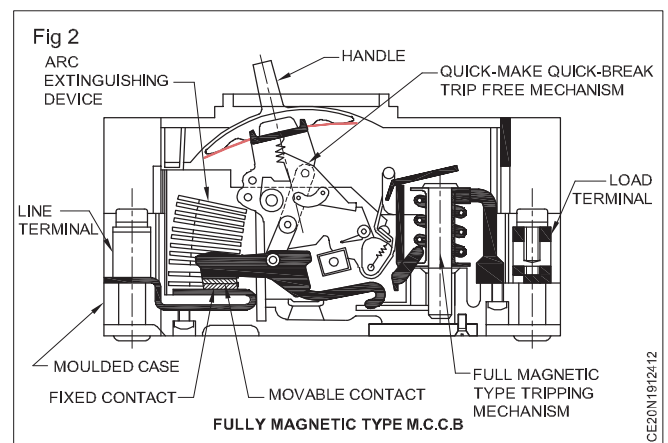
- 1 Expensive.
- 2 More mechanically moving parts.
- 3 They require regular testing to ensure satisfactory operation.
- 4 Their characteristics are affected by the ambient temperature.

Moulded Case Circuit Breakers (MCCB)

Moulded case circuit breakers are similar to thermo magnetic type MCBs except that these are available in higher ratings of 100 to 800amp at 500V 3-phase.

In MCCB, thermal and magnetic releases are adjustable. A shunt release is also incorporated for remote tripping and interlocking at MCCB. MCCBs are provided with under voltages release. There are two types of MCCB.

- 1 Thermal magnetic type.
- 2 Fully magnetic type (Fig 2).



Advantages of MCCB

- 1 MCCBs occupy much less space in comparison to fuse switch units.
- 2 MCCBs provide equal amount of protection against high faults as switch gears having HRC fuses.

Disadvantages

- 1 MCCBs are much costlier.
- 2 Leak proof situation required.
- 3 Sensitivity to insulation resistance low.

ELCB - types - working principle - specification

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

- explain the working principle, different types and construction of an earth leakage circuit breaker (ELCB).

Introduction

The sensation of electric shock is caused by the flow of electric current through the human body to earth. When a person comes in contact with electrically live objects like water heaters, washing machines electric iron etc., the extent of damages caused by this current depends on its magnitude and duration.

This kind of current is called the leakage current which comes in milli-amperes. These leakage currents being very small in magnitude, hence undetected by the fuses/MCBs are the major cause for the fires due to electricity.

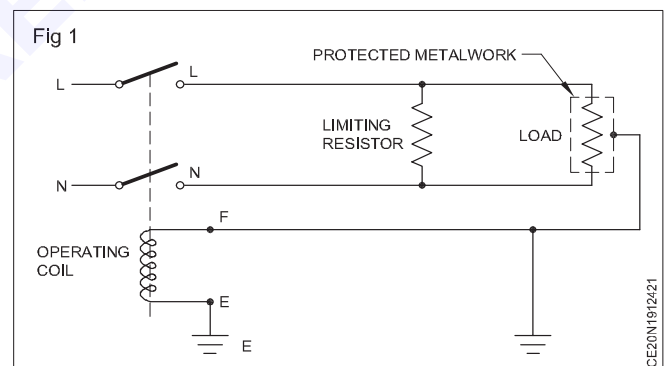
The leakage current to earth also results in the wastage of energy and excessive billing for electricity not actually used.

These residual current circuit breakers (RCCB) are popularly called as Earth leakage circuit breakers (ELCB).

Basically ELCBs are of two types namely voltage operated ELCBs and the current operated ELCBs.

Voltage operated ELCB

This device is used for making and breaking a circuit. It automatically trips or breaks the circuit when the potential difference between the protected metal work of the installation and the general mass of earth exceeds 24V. This voltage signal will cause the relay to operate (Fig 1).



Voltage operated ELCBs are meant to be used where it is not practicable to meet the requirements of IEE wiring regulation by direct earthing or where additional protection is desirable.

Current operated ELCB

This device is used for making and breaking a circuit and for breaking a circuit automatically when the vector sum of current in all conductors differs from zero by a predetermined amount. Current operated ELCBs are much more reliable in operation, easier to install and maintain.

Construction of current operated ELCB

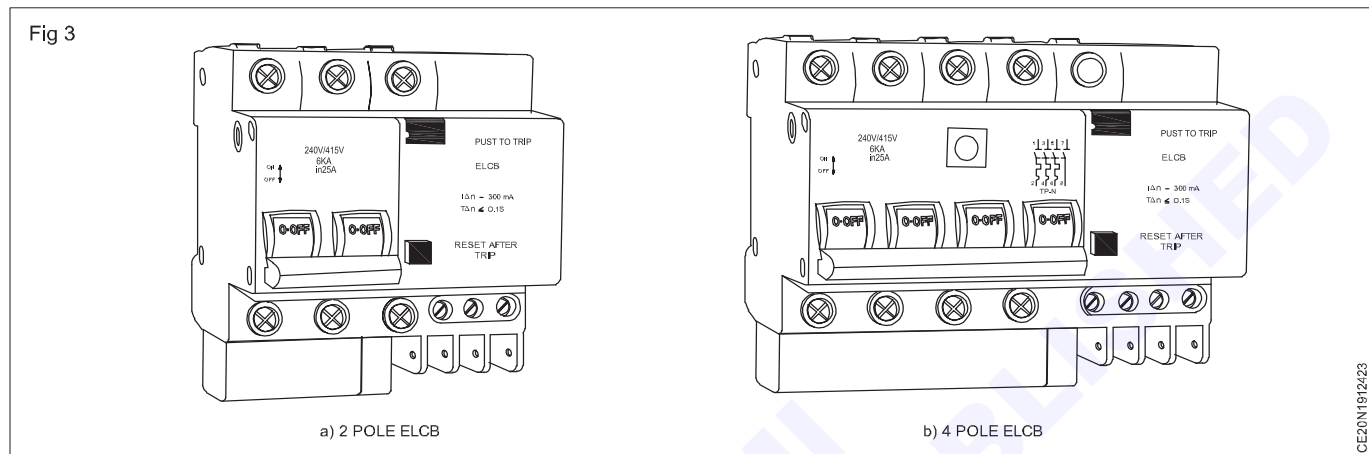
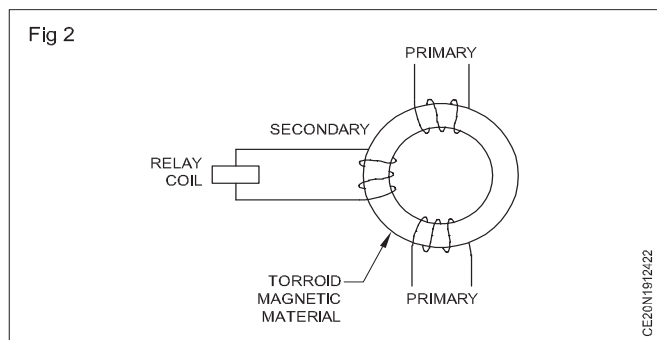
It consists of a Torroid ring made of high permeability magnetic material. It has two primary windings each carrying the current flowing through phase and neutral of the installation. The secondary winding is connected

to a highly sensitive electro - magnetic trip relay which operates the trip mechanism.

Working principle

The residual current device (RCD) is a circuit breaker which continuously compares the current in the phase with that in the neutral. The difference between the two is called as the residual current which is flowing to earth.

The purpose of the residual current device is to monitor the residual current and to switch off the circuit if it rises from a preset level (Fig 2&3).



Fuses

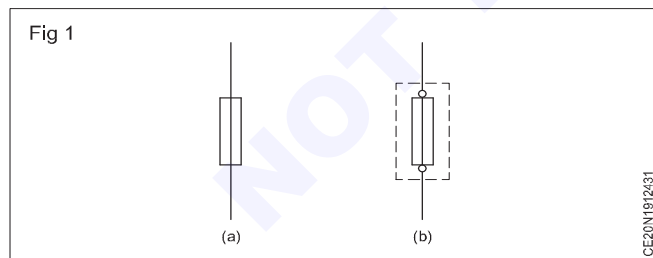
Objectives: At the end of this lesson you shall be able to

- explain the purpose of the fuse in a circuit
- classify the different types of fuses and their uses.

Purpose of fuses: A fuse is a safety device used for the purpose of protecting a circuit against excess current. In the event of excessive current, the fuse element melts and opens up the circuit thereby protecting it from damage.

Symbols: These are the graphical symbols used to illustrate an electrical fuse in electro-technical diagrams.

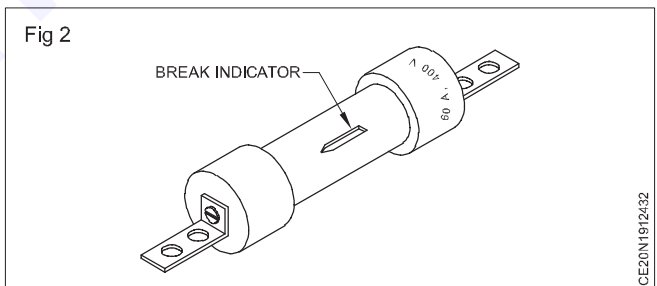
General symbols of a fuse (Fig 1)



Types of fuses used in domestic wiring

- Re-wirable type (up to 200A)
- Cartridge type (up to 1250A)

Rewirable type fuse (Fig 2): The fuse element in this type of fuse consists of a wire which may be replaced when necessary. These fuses are simple in construction and the initial cost as well as the renewal cost is very low.

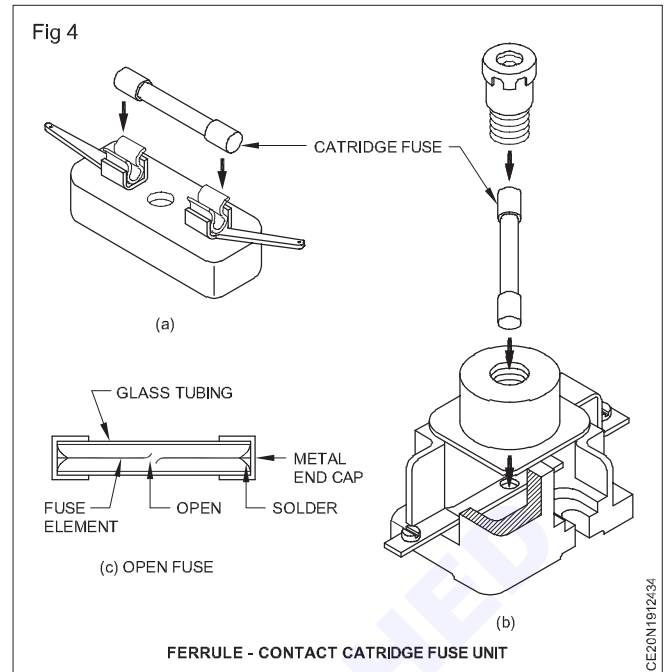
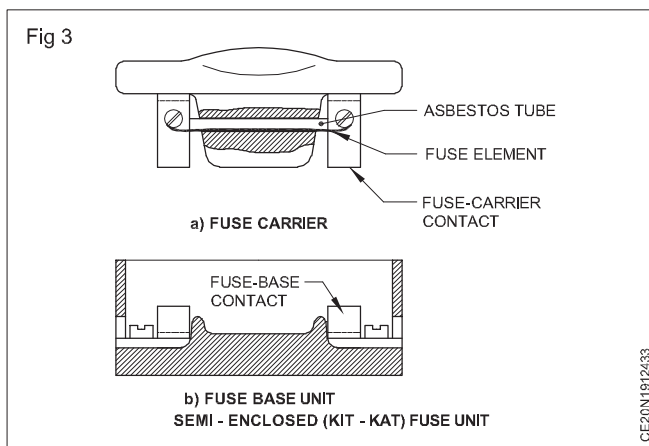


The fuse elements used in this type are tinned copper wires lead and tin alloy or aluminium wire.

Cartridge fuses: Cartridge fuses are developed to overcome the disadvantages of the rewirable fuses. As cartridge fuse elements are enclosed in an air tight chamber, deterioration does not take place. Further the rating of a cartridge fuse could be accurately determined from its marking. However, the cost of replacement of cartridge fuses is more than that of rewirable fuses.

Ferrule-contact cartridge fuses (Fig 3)

High rupturing capacity (HRC) fuses (Fig 4): They are cylindrical in shape and are made of a ceramic body filled in with a chemically treated filling powder or silica to quench the arcing quickly without any fire hazard.



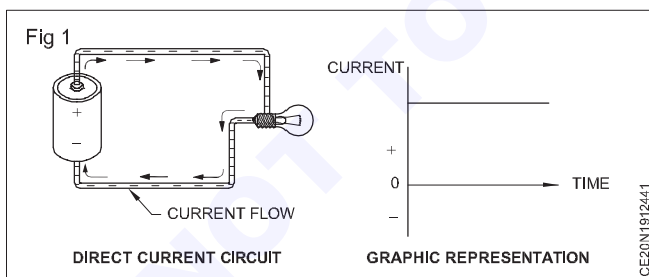
Alternating current - terms & definitions - vector diagrams

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

- state the features of direct current
- list out the advantages of DC over AC
- explain the generation of alternating current and terms used
- state the advantages of AC over DC.

Direct current (DC): Electric current can be defined as the flow of electrons in a circuit. Based on the electron theory, electrons flow from the negative (-) polarity to the positive (+) polarity of a voltage source.

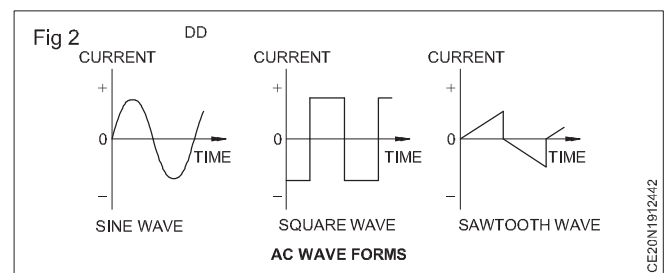
Direct current (DC) is the current that flows only in one direction in a circuit. The current in this type of circuit is supplied from a DC voltage source. Since the polarity of a DC source remains fixed, the current produced by it flows in one direction only. (Fig 1)



Advantages of DC over AC

- 1 DC needs only two wires of transmission, while a 3 phase AC may need upto 4 wires.
- 2 The corona loss associated with DC is negligible while for AC it increases with its frequency.
- 3 The skin effect is also observed in AC leading to problems in transmission conductor designs.
- 4 No inductive and capacitive losses.

Alternating current (AC): An alternating current (AC) circuit is one in which the direction and amplitude of the current flow change at regular intervals. The current in this type of circuit is supplied from an AC voltage source. The polarity of an AC source changes at regular intervals resulting in a reversal of the circuit current flow. (Fig 2)

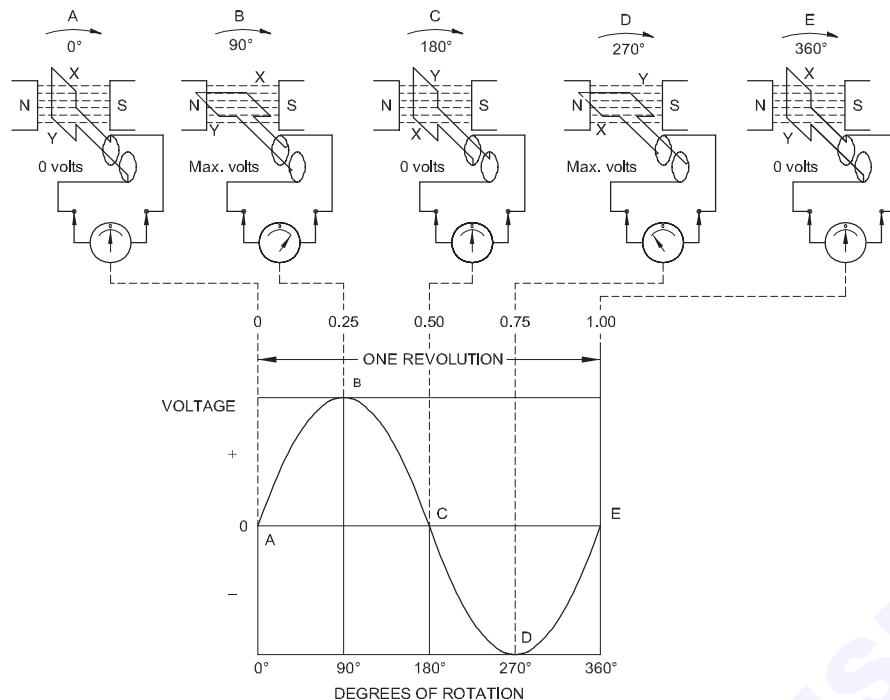


The sine wave: The shape of the voltage wave-form generated by a coil rotating in a magnetic field is called a sine wave. The generated sine wave voltage varies in both voltage value and polarity.

If the coil is rotated at a constant speed, the number of magnetic lines of force cut per second varies with the position of the coil. When the coil is moving parallel to the magnetic field, it cuts no lines of force.

The coil is shown in five specific positions in Fig 3. These are intermediate positions which occur during one complete revolution of the coil position. The graph shows how the voltage increases and decreases in amount during one rotation of the loop.

Fig 3



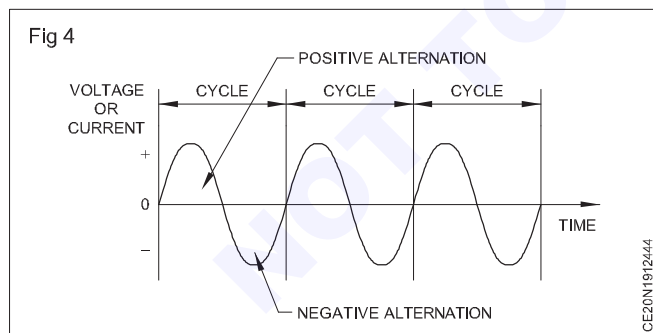
GENERATION OF AN ALTERNATING VOLTAGE: AS THE LOOP ROTATES THROUGH THE MAGNETIC FIELD, THE AMOUNT AND POLARITY OF THE VOLTAGE CHANGES WITH ANGLE AND DIRECTION OF MOTION.

CE20N19124/3

The sine wave is the most basic and widely used AC wave-form. The standard AC generator (alternator) produces a voltage of sine wave-form. Some of the important electrical characteristics and terms used when referring to AC sine wave voltage or current are as follows.

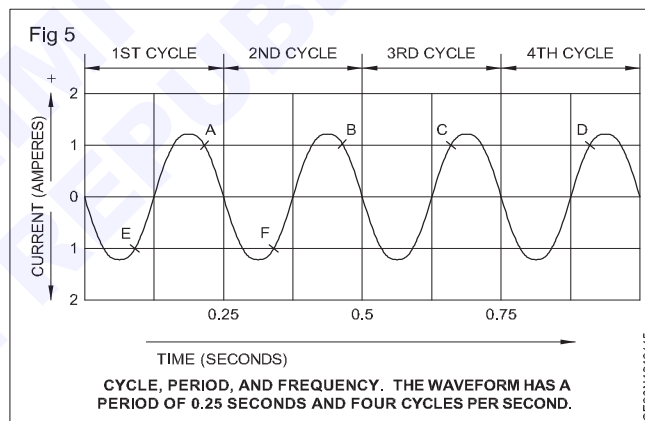
Cycle: One cycle is one complete wave of alternating voltage or current. During the generation of one cycle of output voltage, there are two changes in the polarity of the voltage.

These equal but opposite halves of a complete cycle are referred to as alternations. The terms positive and negative are used to distinguish one alternation from the other. (Fig 4)

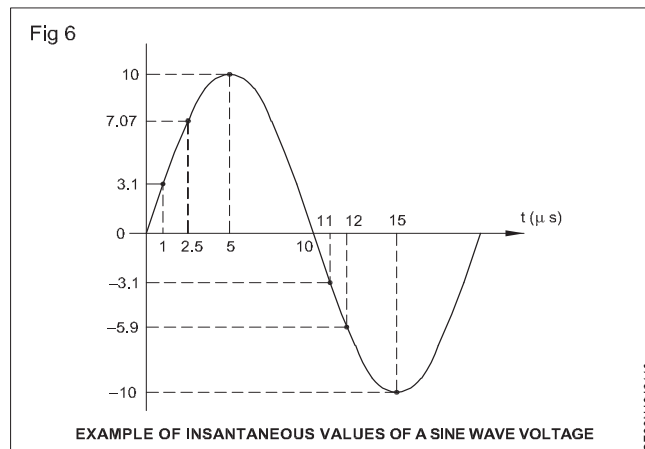


Period: The time required to produce one complete cycle is called the period of the wave-form. In Fig 6, it takes 0.25 seconds to complete one cycle. Therefore, the period (T) of that wave-form is 0.25 seconds.

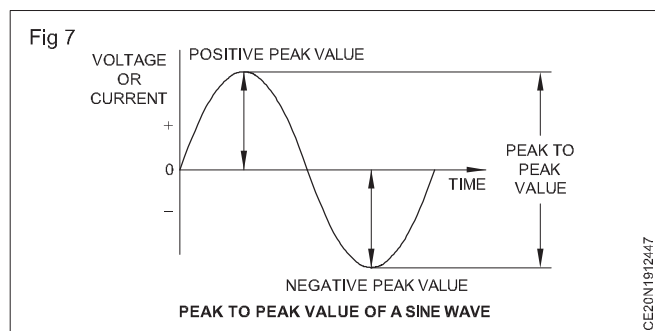
Frequency: The frequency of an AC sine wave is the number of cycles produced per second. (Fig 5) The unit of frequency is the hertz (Hz). For example, the 240V AC at your home has a frequency of 50 Hz.



Instantaneous value: The value of an alternating quantity at any particular instant is called instantaneous value. The instantaneous values of a sine wave voltage is shown in Fig 6. It is 3.1 volts at $1\mu s$, 7.07 V at $2.5\mu s$, 10V at $5\mu s$, 0V at $10\mu s$, -3.1 volt at $11\mu s$ and so on.



Peak value or maximum value: Each alternation of the sine wave is made up of a number of instantaneous values. These values are plotted at various heights above and below the horizontal line to form a continuous wave-form. (Fig 7)



The peak value of a sine wave refers to the maximum voltage or current value. Note that two equal peak values occur during one cycle.

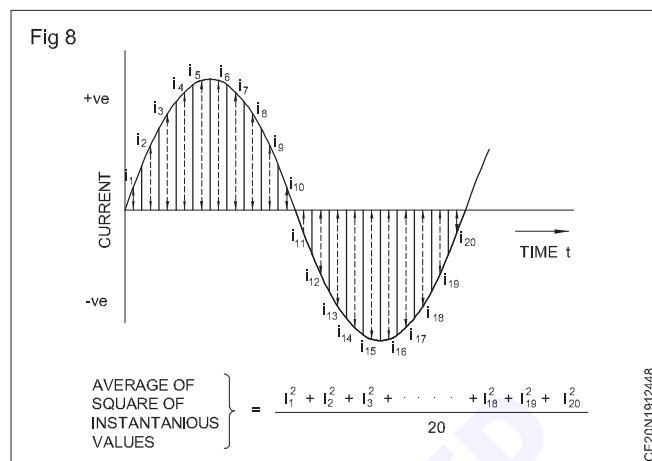
Peak-to-peak value: The peak-to-peak value of a sine wave refers to its total overall value from one peak to the other. (Fig 8) It is equal to two times the peak value.

Effective value: The effective value of an alternating current is that value which will produce the same heating effect as a specific value of a steady direct current. In other words, an alternating current has an effective value of 1 ampere, if it produces heat at the same rate as the heat produced by 1 ampere of direct current, both flowing in the same value of resistance.

Another name for the effective value of an alternating current / voltage is the **rootmean square (rms) value**. This term was derived from a method used to compute the value. The rms is calculated as follows.

The instantaneous values for one cycle are selected for equal periods of time. Each value is squared, and the average of the squares is calculated (values are

squared because the heating effect varies as square of the current or voltage). The square root of this is the rms value. (Fig 8)



By using this method, it can be proved that the effective value of a sine wave of current is always equal to 0.707 times its peak value. A simple equation for calculating the effective value of sine wave is:

for voltage, $V = 0.707 V_m$

for current, $I = 0.707 I_m$

where subscript m refers to the maximum value.

When an alternating current or voltage is specified, it is always the effective value OR rms value that is meant, unless otherwise stated. Standard AC meters indicate effective values only.

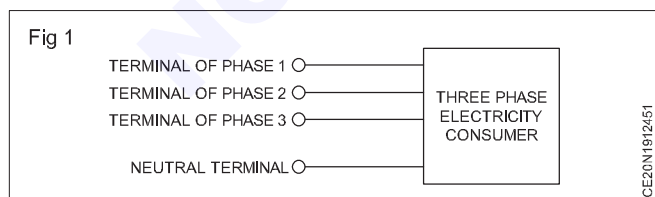
Form factor (K_f) Form factor is defined as the ratio of effective value to average value of half cycle for sinusoidal AC $K_f = \frac{0.7071 I_m}{0.6371 I_m} = 1.1$

Poly phase 3-Phase AC fundamentals

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

- state and describe the generation of 3-phase system with single loops
- state the advantages of the 3-phase system over a single phase system
- state and explain the 3-phase, 3-wire and 4-wire system

A three-phase power consumer is provided with the terminals of three phases. (Fig 1)



One great advantage of a three-phase AC supply is that it can produce a rotating magnetic field when a set of stationary three-phase coils is energized from the supply. This is the basic operating principle for most modern rotating machines and, in particular, the three-phase induction motor.

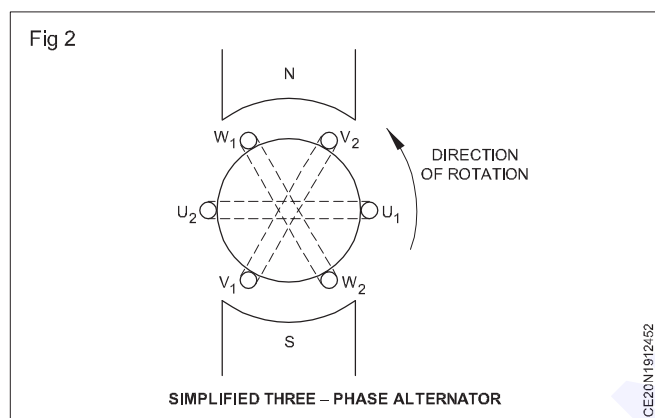
Further, lighting loads can be connected between any one of the three phases and neutral.

Review: Further to the above two advantages the following are the advantages of poly phase system over single phase system.

- 3-phase motors develop uniform torque whereas single phase motors produce pulsating torque only
- Most of the 3-phase motors are self starting whereas single phase motors are not
- Power factor of 3-phase motors are reasonably high when compared to single phase motors

- For a given size the power out put is high in 3-phase motors whereas in single phase motors the power output is low.
- Copper required for 3-phase transmission for a given power and distance is low when compared to single phase system.
- 3-phase motor like squirrel cage induction motor is robust in construction and more are less maintenance free.

Three-phase generation: To generate three-phase voltages, a similar method to that used for generating single-phase voltages is employed but with the difference that, this time, three wire loops U1, U2, V1, V2 and W1, W2 rotate at a constant angular speed about the same axis in the uniform magnetic field. U1, U2, V1, V2 and W1, W2, are displaced 120° in position with respect to each other, permanently. (Fig 2)



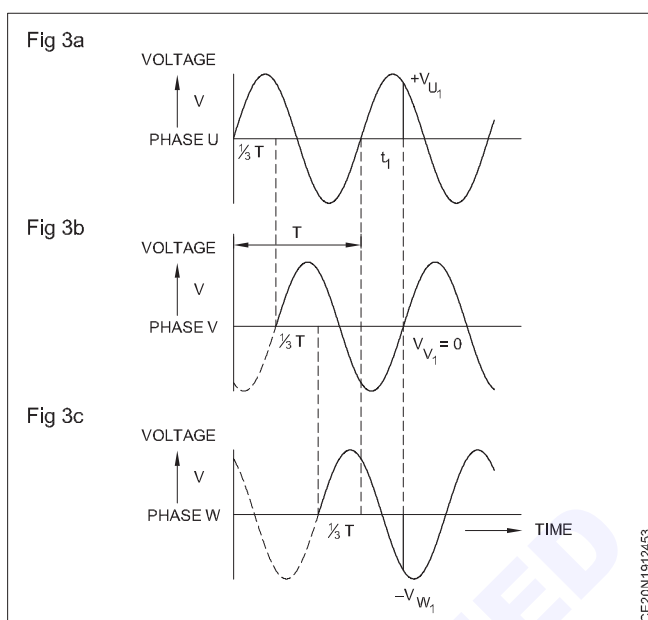
For each wire loop, the same result is obtained as for the alternating voltage generator. This means that an alternating voltage is induced in each wire loop. However, since the wire loops are displaced by 120° from each other, and a complete revolution (360°), takes one period, the three induced alternating voltages are delayed in time by a third of a period with respect to each other.

Because of the spatial displacement of the three wire loops by 120°, three alternating phase voltages result, which are displaced by one third of a period, T, with respect to each other. (Fig 3)

To distinguish between the three phases, it is a common practice in (heavy current) electrical engineering to designate them by the capital letters U, V and W or by a colour code red, yellow and blue. At a time 0, U is passing through zero volts with positively increasing voltage. (Fig 3a) V follows with its zero crossing 1/3 of the period later (Fig 3b), and the same applies to W with respect to V. (Fig 3c)

In three-phase networks, the following statements can be made about the three-phase voltages.

- The three-phase voltages have the same frequency.
- The three-phase voltages have the same peak value.



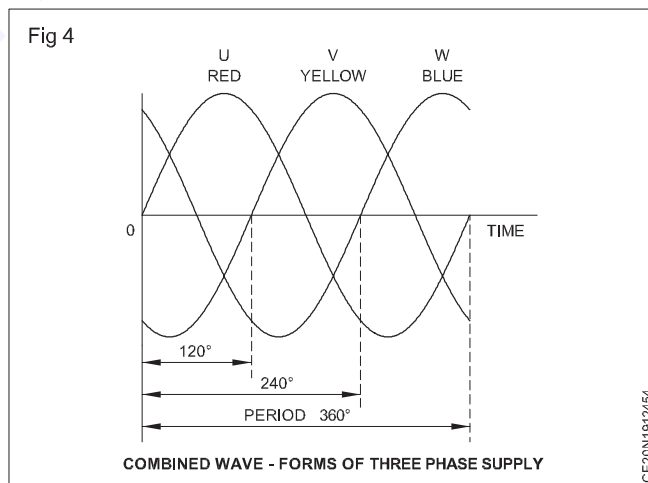
- The three-phase voltages are displaced by one third of a period in time with respect to each other.
- At every instant in time, the instantaneous sum of the three voltages

$$V_U + V_V + V_W = 0.$$

The fact that the sum of the instantaneous voltages is zero. At time t1, U has the instantaneous value V_U. At the same time, V_V = 0, and the instantaneous value for W is V_W. Because V_U and V_W have the same value but are opposite in sign, it follows that

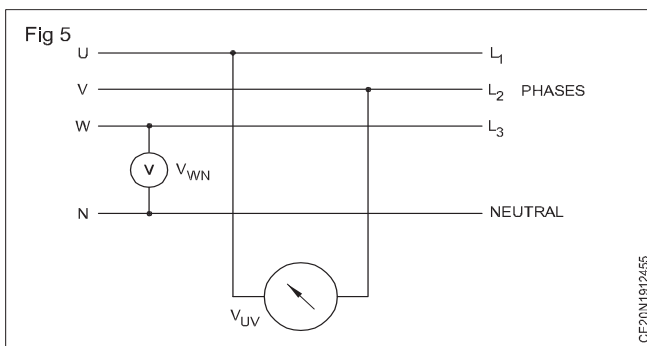
$$V_{U1} + V_{V1} + V_{W1} = 0.$$

The three voltages of the same amplitude and frequency are shown together in Fig 4.



Three-phase network: A three-phase network consists of three lines or phases. In Fig 5, these are indicated by the capital letters U, V and W.

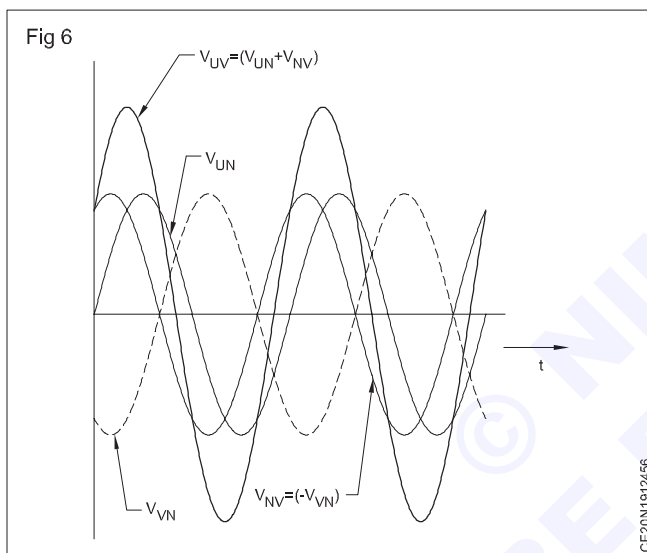
The return lead of the individual phases consists of a common neutral conductor N, which is described later in more detail. Voltmeters are connected between each of the lines U, V and W, and the neutral line N.



They indicate the RMS (effective) values of the voltages between each of the three phases and neutral.

These voltages are designated as phase voltages V_{UN} , V_{VN} and V_{WN} .

The individual, phase voltages all have the same magnitude. They are simply displaced from each other by one third of a period in time. (Fig 6)



The individual instantaneous, peak and RMS values are the same as for a single-phase alternating voltage.

Line and phase voltage: If a voltmeter is connected directly between line U and line V, the RMS value of the voltage V_{UV} is measured, and this is different from any of the three phase voltages.

Its magnitude is directly proportional to the phase voltage. The relationship is where the time variation wave-forms of V_{UV} and the phase voltages V_{UN} and V_{VN} are drawn.

V_{UV} has a sinusoidal wave-form and the same frequency as the phase voltages. However, V_{uv} has a higher peak value since it is computed from the phase voltages V_{UN} and V_{VN} . The varying positive and negative instantaneous values of V_{UN} and V_{VN} at a particular time produce the instantaneous value of V_{UV} . V_{UV} is the phasor sum of the two phase voltages V_{UN} and V_{VN} .

This combination of phase-displaced alternating voltages is called phasor addition.

The voltage across phase-to-phase is called the line voltage.

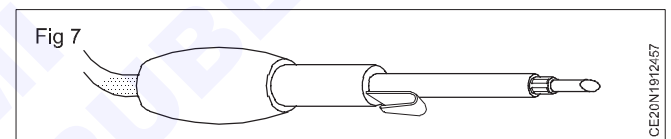
Soldering - types of solders, flux and methods of soldering

Soldering: Soldering is the process of joining two metal plates or conductors without melting them, with an alloy called solder whose melting point is lower than that of the metals to be soldered. The molten solder is added to the two surfaces to be joined so that they are linked by a thin film of the solder which has penetrated into the surfaces.

Necessity of soldering: Wire and cable joints should have the same electrical conductivity and mechanical strength as that of the parent conductor. This cannot be achieved by a mere mechanical joint. As such cable joints are soldered to have good mechanical strength, electrical conductivity and also to avoid corrosion.

Soldering methods

Soldering with a soldering iron: The most common method of soldering is with a soldering iron as shown in Fig 7. This is widely used for most kinds of soft soldering work.



Designation	Composition	Working temp.	Uses
Electrician's solder	Tin-60% Lead-40%	185°C. or 365°F.	Tinning and soldering electrical joints etc.

Solders : The following are the general proportions of tin and lead used in the solders.

Solder used for copper: The metal alloy used as a bonding agent in soldering is called a solder. The solders used for soft soldering consist of an alloy (mixture) of mostly tin and lead.

Factors influencing the choice of a solder

The factors that influence the choice of a solder are:

- melting point
- solidification range
- strength
- hardness
- seal ability
- price.

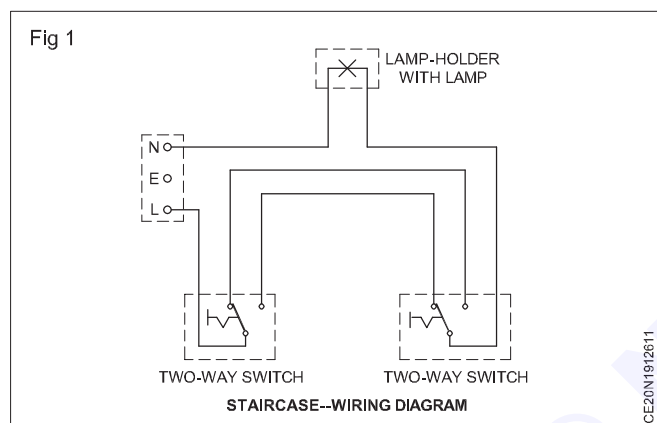
Flux: Flux is a substance used to dissolve oxides on the surface of conductors and to protect against de-oxidisation during the soldering process.

Types of electrical wiring, different electrical wiring accessories, IE rules of wiring, illumination

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

- state the difference between godown, tunnel and corridor, bank/hostel wirings
- draw the tunnel lighting / corridor / bank / hostel circuits
- prepare the mode chart for the above circuits.

Staircase wiring: In wiring one lamp controlled with one switch in a simple wiring circuit to begin with. However, one lamp controlled with two switches from two different places, known as staircase wiring in the very basic wiring. Fig 1 shows such a wiring where two double pole switches are used to control one lamp individually.



In the case of **godown wiring** we have seen that as you move inside the godown, you can switch on a lamp ahead of you while the light behind you is put off. The same process in the reverse order takes place while moving out of the godown.

But one light will not be sufficient to give enough illumination in the case of **tunnels** where darkness is more. Hence, the wiring circuit for a tunnel needs at least two lights to be 'ON' at a time while a person moves inside a tunnel and goes out.

Whereas in the case of **corridor wiring** the corridor may have a number of rooms occupied by different persons. When one moves toward his room, he needs a forward light to do so. The moment he finds the room and opens it, he may not need the corridor light. Then there should be an arrangement to switch off the light left behind the forward moving person and at the same time there should be a provision to switch off the light in front of his room. Such an arrangement is incorporated in corridor wiring.

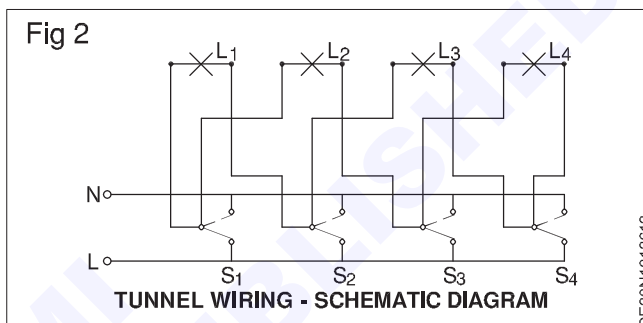
Tunnel lighting circuit (Fig 2)

In tunnel wiring a person walking along the tunnel can successively light behind two lamps ahead and put off a lamp behind with one switch.

All switches are two-way switches.

Caution: This circuit is not in accordance with IE rules as the phase and neutral come in the same switch. So care should be taken while connecting the wires.

Fig 2



The mode of operation of the switches and the consequent lighting position are shown below.

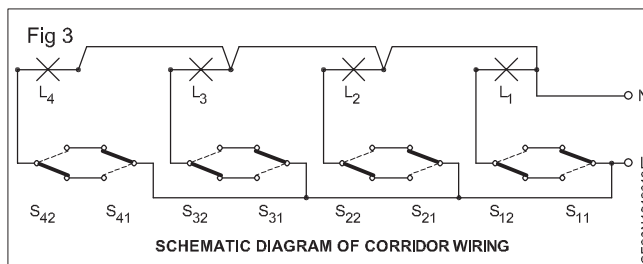
Mode chart for tunnel wiring

SWITCHES				LIGHTS			
S ₁	S ₂	S ₃	S ₄	L ₁	L ₂	L ₃	L ₄
✓	✗	✗	✗	✓	✓	✗	✗
✓	✓	✗	✗	✗	✓	✓	✗
✓	✓	✓	✗	✗	✗	✓	✓
✓	✓	✓	✓	✗	✗	✗	✗

MODE CHART FOR TUNNEL WIRING

Corridor wiring (Fig 3)

In this circuit, operating the first switch in one set makes the first light to switch on while operating the 2nd switch in the first set switches off the first light. This sequence goes on as explained in the mode chart.



Switch lamps chart

SWITCHES								LAMPS			
1st SET	2nd SET	3rd SET	4th SET					L ₁	L ₂	L ₃	L ₄
S ₁₁	S ₁₂	S ₂₁	S ₂₂	S ₃₁	S ₃₂	S ₄₁	S ₄₂				
ON	-	-	-	-	-	-	-	✓	×	×	×
ON	OFF	-	-	-	-	-	-	×	×	×	×
ON	OFF	ON	-	-	-	-	-	×	✓	×	×
ON	OFF	ON	OFF	-	-	-	-	×	×	×	×
ON	OFF	ON	OFF	ON	-	-	-	×	×	✓	×
ON	OFF	ON	OFF	ON	OFF	-	-	×	×	×	×
ON	OFF	ON	OFF	ON	OFF	ON	-	×	×	×	✓
ON	OFF	ON	OFF	ON	OFF	ON	OFF	×	×	×	×

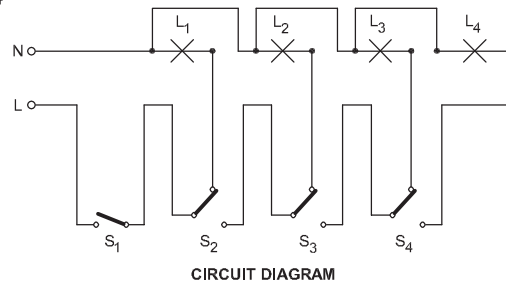
MODE CHART FOR CORRIDOR WIRING

Godown lighting circuit

Let us consider a godown lighting circuit having four lamps L₁, L₂, L₃ and L₄ which are to be controlled such that if one moves in a godown in either direction he can switch ON one light after the other in the forward direction while the lamp which was lighted earlier gets switched OFF. In an arrangement. S₁ is a one way switch, S₂, S₃ and S₄ are two-way switches.

While coming back from the godown when the person switches off the light 4, then the light 3 will be on and give light for his return movement. When he leaves the godown all the lights could be switched 'off' by operating switch S₁. (Fig 4)

Fig 4



The following chart gives the mode of operation of the switches and lights. Trainees are advised to make the return mode chart.

Mode chart for godown wiring

Switches				Lights			
S1	S2	S3	S4	L1	L2	L3	L4
ON	OFF	OFF	OFF	ON	-	-	-
ON	ON	OFF	OFF	-	ON	-	-
ON	ON	ON	OFF	-	-	ON	-
ON	ON	ON	ON	-	-	-	ON

Different electrical wiring accessories, and IE rules of wiring

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

- classify, specify, identify and state the uses of the accessories employed in domestic wiring
- state the IE rules related to safety and electric supply.

Electrical accessories: An electrical domestic accessory is a basic part used in wiring either for protection and adjustment or for the control of the electrical circuits or for a combination of these functions.

Rating of accessories: The standard current ratings of the accessories are 6, 16 and 32 amps. The voltage rating is 240V AC as per B.I.S. 1293-1988.

Mounting of accessories: The accessories are designed to mount either on the surface or concealed (flush type).

Surface mounting type: Accessories are provided with a seating so that when mounted they project wholly above the surface on which they are mounted.

Flush-mounting type: These accessories are designed to mount behind or incorporated with a switch plate, the back of the plate being flush with the surface of the wall or switch box.

The electrical accessories used in wiring installation, are classified according to their uses.

- Controlling accessories
- Holding accessories

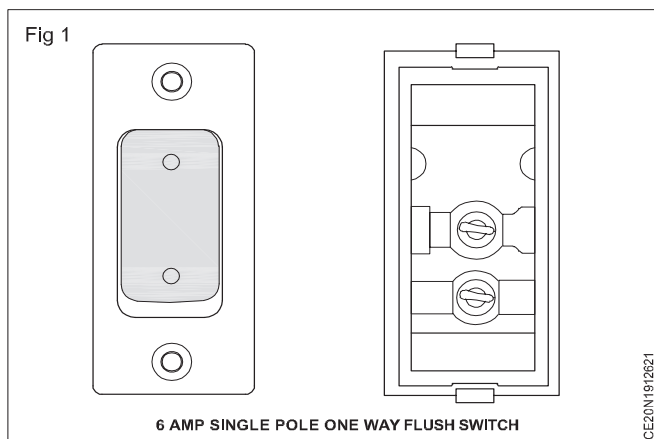
- Safety accessories
- Outlet accessories
- General accessories

Types of switches according to their function and place of use

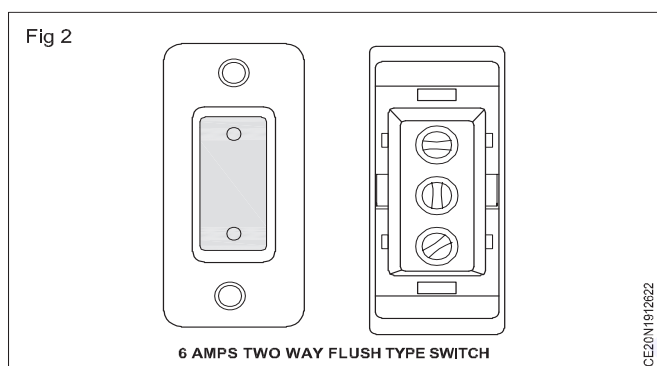
- 1 Single pole, one-way switch
- 2 Single pole, two-way switch
- 3 Bell-push or push-button switch
- 4 Pull or ceiling switch
- 5 Double pole switch (DP switches)
- 6 Iron clad double pole, (ICDP) switch.
- 7 Iron clad triple - pole (ICTP) switch.

Of the above 1,2,3,4 and 6 may be either surface mounting type or flush-mounting type.

Single pole, one-way switch: This is a two terminal device, capable of making and breaking a single circuit only. It is used for controlling light or fan or 6 amps socket. (Fig 1)



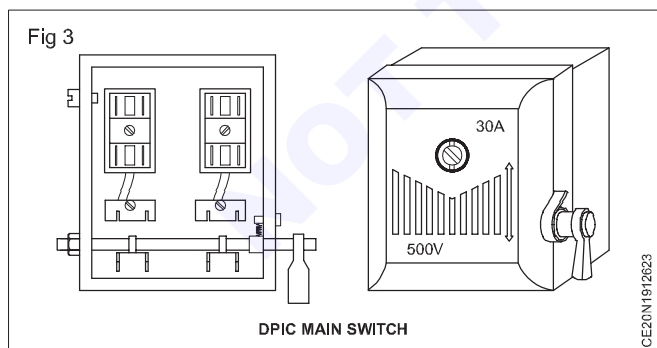
Two-way switch: This is a three terminal device capable of making or breaking two connections from a single position (Fig 2). These switches are used in staircase lighting where one lamp is controlled from two different places.



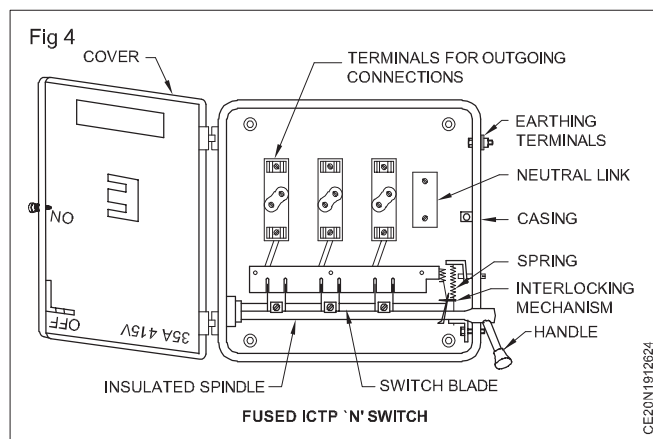
Bell-push or push-button switch: This is a two-terminal device having a spring-loaded button. When pushed it 'makes' the circuit temporarily and attains 'break' position when released.

Iron - Clad Double pole (ICDP) main switch : This switch is also referred to as DPIC switch and is mainly used for single phase domestic installations, to control the main supply. It controls phase and neutral of the supply simultaneously (Fig 3).

The current rating of the switch varies from 16 amps to 32 amperes.



Iron - Clad Triple pole (ICTP) main switch: This is also referred to as TPIC switch and is used in large domestic installation and also in 3-phase power circuits, the switch consists of 3 fuse carriers, one for each phase. Neutral connection is also possible as some switches are provided with a neutral link inside the casing (Fig 4).



The current rating of the switch varies from 16 to 400 amps.

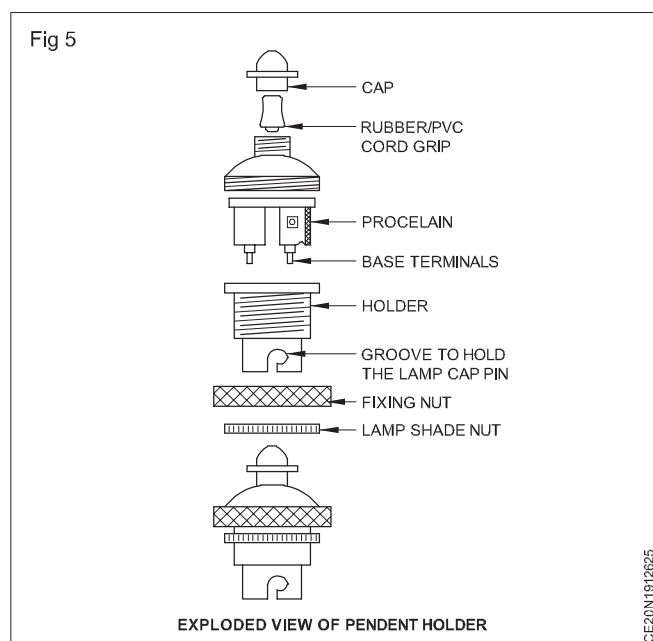
Holding accessories

Lamp-holders : A lamp-holder is used to hold a lamp. Earlier, brass holders were most commonly used but nowadays these have been replaced by bakelite holders. These may contain solid or hollow spring contact terminals. Four types of lamp-holders are mainly available.

- Bayonet cap lamp-holders
- Screw type holders
- Edison screw type lamp-holders
- Goliath Edison screw type lamp-holders

Bayonet cap (BC) lamp-holders: In this type, the bulb is fitted into the slot, and is held in position by means of two pins in the lamp cap. It has solid or hollow spring contact terminals, and the supply mains through the switch are connected to these contacts. In BC types there are two grooves on the circular construction of all types of holders.

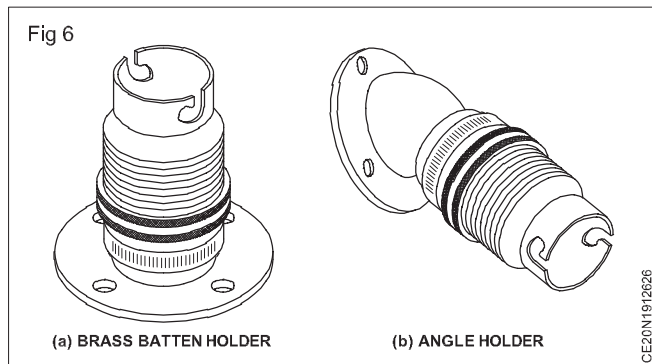
Pendent lamp-holders (Fig 5)



This holder is used in places where the lamps are required in a hanging position. These holders are made of either brass or bakelite. An exploded view of this holder shows the parts of the holder. These holders are used along with ceiling roses for suspending the lamps from the ceiling.

Batten lamp-holders: The straight batten holder (Fig 6a) is used on a flat surface on the round block, wooden board etc. These holders are made of either brass or bakelite.

Angle holders: The angle bottom holder, (Fig 6b) is to hold the lamp in a particular angle. These are made of either brass or bakelite. These are used for advertising boards, window display, kitchens etc.



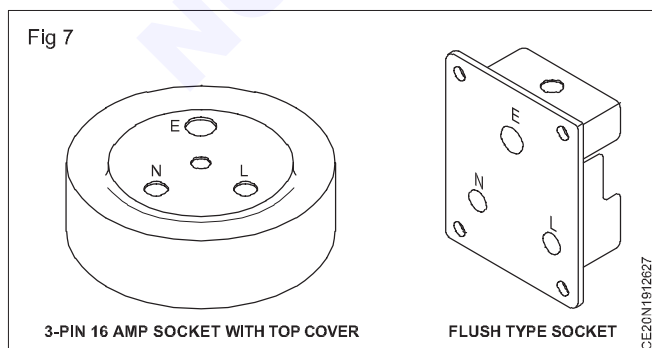
Specification of a lamp-holder: While specifying the lamp-holders, the type of material used for construction, type of gripping, type of mounting, working current and voltages should also be specified.

Socket outlet current rating: The standard ratings shall be 6, 16 and 32 amperes and 240 volts.

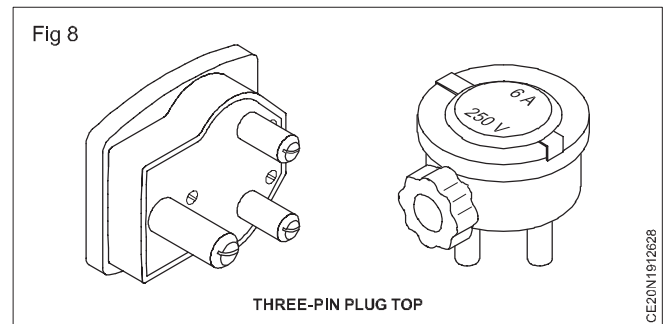
Two-pin socket: This socket is rated as 6A, 250V, having only two pins without earth connection. These are suitable only for double insulated appliances (having PVC or insulated body).

Two-pin plug top: It is used for taking the supply from the socket. It has got two pins of the same size.

Three-pin socket: This type of socket is suitable for light and power circuits. These sockets are rated as 6A, 250V or 16A, 250V, and are available as surface-mounting type and flush type (Fig 7). There are three terminals marked as Line (L) Neutral (N) and Earth (E).



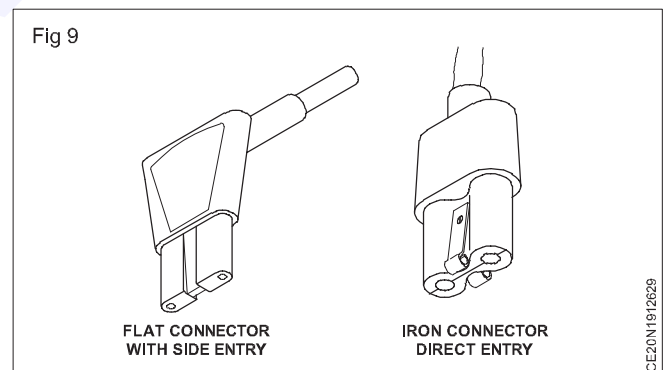
Three-pin plug top : It is used for taking the supply from the socket. It has three pins. Two are similar in size and the third one is bigger and longer which is for earth (Fig 8). These are also rated as 6A, 250V or 16A, 250V. These are made of bakelite, PVC materials.



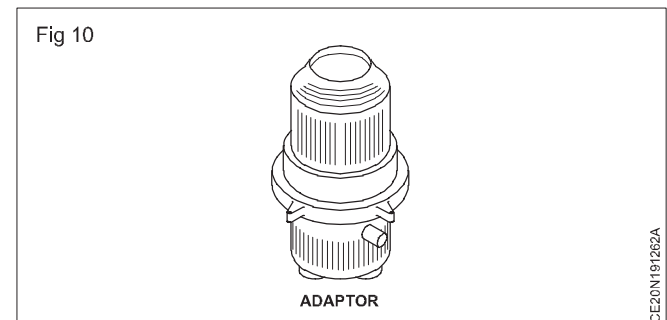
General accessories : Some accessories are used for general and special purposes such as:

- appliance connectors (or) iron connectors
- adapters
- ceiling roses
 - a two-plate
 - b three-plate
- connectors
- distribution board
- neutral links.

Appliance connectors or iron connectors : These are used as female connectors to supply current to electric kettles, electric iron, hotplate, heaters etc. It is made of bakelite or porcelain. These are rated as 16A, 250V (Fig 9).

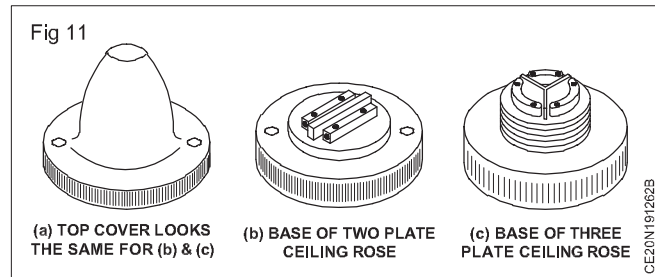


Adaptor (Fig 10): They are used for taking supply from a lamp holder for small appliances. They are made out of bakelite. They are available in ratings up to 6 A 250 V.



Ceiling roses: Ceiling roses are used to provide tapping points from the wiring for supplying power to fans, pendent-holders, tube lights etc. Normally flexible wires are used for tapping from the ceiling roses.

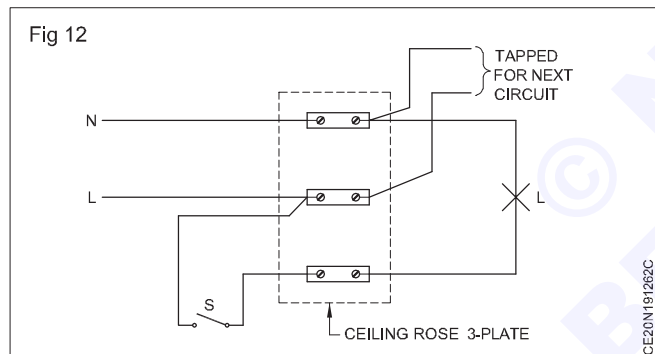
Two-plate ceiling rose (Fig 11a & b): This is made of bakelite and it has 2 terminals (phase & neutral) which are separated from each other by a bakelite bridge. The two-plate ceiling rose is used for 6A, 250V current capacity.



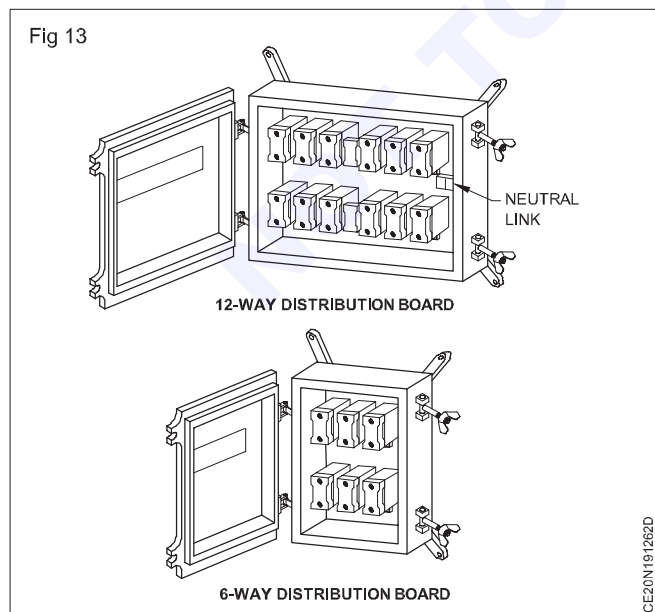
Three-plate ceiling rose: This type of ceiling rose has 3 terminals which are separated from each other by a bakelite bridge. It can be used for two purposes. (Fig 14c)

- Bunch light control
- To provide tapping for phase wire (Fig 12).

These ceiling roses are available in the rating of 6A, 250V

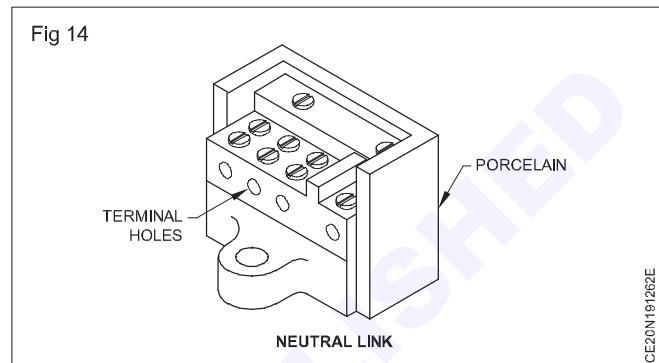


Distribution board (Fig 13)



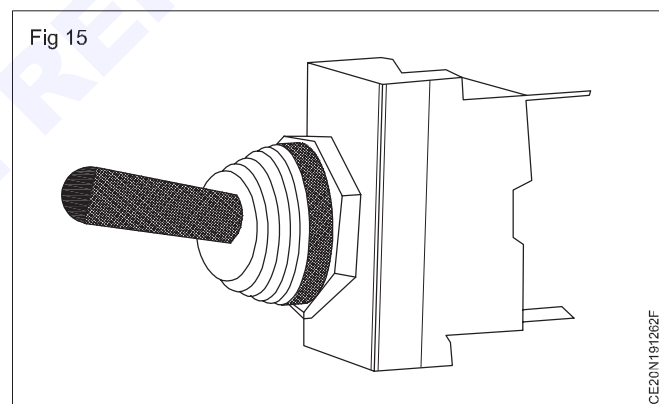
These are used where the total load is high and is to be divided into a number of circuits. These are used where the load is more than 800W. The number of fuses in the board is according to the number of circuits, and a neutral link is also provided so that the neutral wire can be taken for different circuits. All these branch fuses are enclosed in a metal box. These boards are available as two-way, three-way, 4, 6, 12-way types.

Neutral link: In a three-phase system of wiring installations, the phases are controlled through switches, and the neutral is tapped through a link called neutral link. (Fig 14). The ratings are 16A, 32A, 63A, 100A neutral link.



The accessories' rating shall be 240V and 6 or 16 amps from the year 1991, instead of 250V and 5 or 15 amps as per BIS 1293-1988.

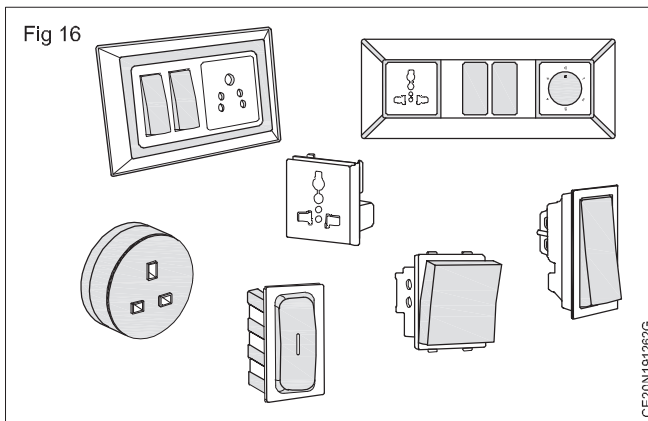
Toggle switches (Fig 15)



It is an electric switch operated by means of a projecting lever that can be moved upward and downward and is also called as snap switches.

Modular switches (Fig 16)

The latest version of modular switch of different sizes and colours along with sockets combined and switches with indicators are available in market.



Indian electricity rules regarding to internal wiring

- 1 The minimum size of conductor used in domestic wiring must not be of size less than 1/1.12mm in copper or 1/1.40mm (1.5mm) in aluminum wire.
- 2 For flexible wires the minimum size is 14/0.193mm.
- 3 The height at which meter board, Main switch board are to be fitted 1.5 meters from ground level.
- 4 The casing will be run at a height of 3.0 meters from the ground level.
- 5 The light brackets should be fixed at a height of 2 to 2.5 meters from ground level.
- 6 The maximum number of points in a sub circuit is 10.
- 7 The maximum load in a sub circuit is 800W.

I.E. Rules regarding - Voltage drop concept

- 1 I.E. Rule 48: The insulation resistance between the wiring of an installation and earth should be of such

a value that the leakage current may not exceed 1/50000 the part or 0.02 percent of the F.L. current.

- 2 The permissible voltage drop in a lighting circuit is 2% of the supply voltage plus one volt.
- 3 The maximum permissible voltage drop in a power industrial circuit should not be more than 5% of the declared supply voltage.
- 4 The insulation resistance of any wiring installation should not be less than 1M Ω .
- 5 The earth resistance should not exceed the value of one ohm.

I.E. Rules regarding to power wiring

- 1 In a power sub circuit, the load is normally restricted to 3000 watts and number of outlets to two in each sub circuit.
- 2 All equipment used in power wiring shall be iron clad construction and wiring shall be of the armoured cable or conduit type.
- 3 The length of flexible conduit used for connections between the terminal boxes of motors and starters, switches and motors shall not exceed 1.25 meters
- 4 Every motor, regardless of its size shall be provided with a switch fuse placed near it.
- 5 The minimum cross-sectional area of conductor, that can be used for power wiring of 1.25 mm for copper conductor cables and 1.50 mm for Aluminum conductor cables (refer ISI recommendations). Hence VIR or PVC cables of size lower than 3/0.915 mm copper or 1/1.80 mm Aluminum cannot be used for motor wiring.

Illumination terms - Laws

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

- state and explain different terms used in illumination
- state properties and advantages of good illumination
- state and explain laws of illumination.

Definitions

A few principle terms in connection with illumination are defined below.

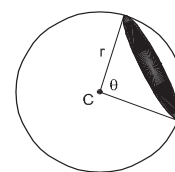
Luminous flux (F or Φ): The flux of light emitted from a luminous body is the energy radiated per second in the form of light waves. The unit of luminous flux is 'lumen'(lm).

Luminous intensity(I): The luminous intensity of a light source in a given direction is the luminous flux given out by the light source per unit solid angle. The angle subtended by an area r^2 on the surface of sphere of radius r , at the centre of sphere is unit solid angle. In SI, the unit of luminous intensity is the candela.

Candela: This is the amount of light emitted in a given direction by a source of one candle power. SI base unit is candela (cd). 1 candela = 0.982 international candles.

Lumen (lm): It is the unit of luminous flux. This is defined as the amount of light contained in one steradian from a source of one candela at its focus. (Fig 1)

Fig 1



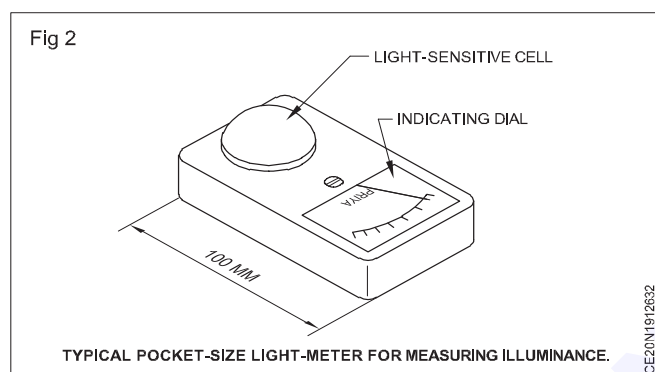
If the shaded area = r^2 and a source of one candela is at the centre C, the light contained within the solid angle is one lumen.

The light output of electric lamp is measured in lumens and their luminous efficiency is expressed in lumens per watt (lm/w).

Illuminance or Illumination (E): Illuminance of a surface is defined as the luminous flux reaching it perpendicularly per unit area. The metric unit is the lumen / m² or lux (lx).

Lux: This is the total output of light. Lumen per square meter (1m/m²) or lux is the intensity of illumination produced in the inner surface of a hollow sphere of radius one meter by a standard candle at the centre. Sometimes this is also known as metre-candle.

Lighting engineers use a pocket-size instrument called a 'light meter' to measure illuminance; and the reading in lux is read off the scale (Fig 2).



Properties of good illumination

An illumination source should, have the following properties.

- It should have sufficient light.
- It should not strike the eyes.
- It should not produce glairiness to the eyes.
- It should be installed at such a place that it gives uniform light.
- It should be of correct type as needed.
- It should have suitable shades and reflectors.

Advantages of good illumination

- It increases production in the workshop.
- It reduces the chances of accidents.
- It does not strain the eyes.
- It reduces the wastage or loss of material.
- It increases the interior decoration of the building.
- It gives smoothing effect to mind.

Laws of illumination

Inverse square law: If the internal radius of a sphere is increased from 1 metre to r metres, the surface area of it is increased from 4 to $4\pi r^2$ square metres. With a uniform point source of light of one candela at the centre, the number of lumen per square metre on the sphere of radius r metres.

$$= \frac{4\pi}{4\pi r^2} = \frac{1}{r^2}$$

Hence the illumination of a surface is inversely proportional to the square of its distance from the source. This is called the **Inverse Square Law of Illumination**.

Earthing

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

- explain the reasons for system and equipment earthing
- define the terminology related to earthing
- state and explain the methods of preparing pipe earthing and plate earthing.

Earthing

Earthing of an electrical installation can be brought under two major categories.

- System earthing
- Equipment earthing

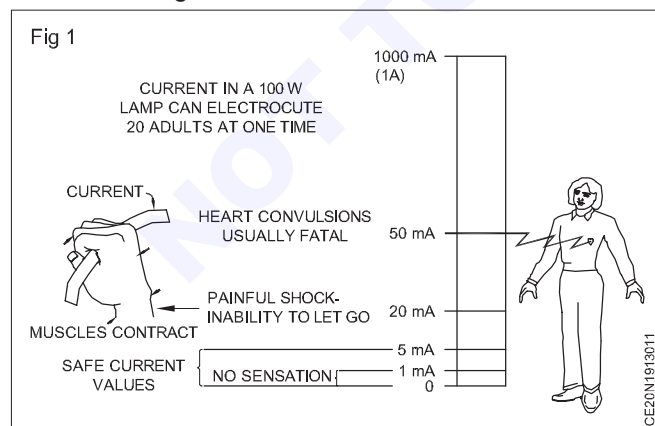
System earthing: Earthing associated with current-carrying conductors is normally essential to the security of the system, and is generally known as system earthing.

Equipment earthing: Earthing of non-current carrying metal work and conductor which is essential for the safety of human life, animals and property is generally known as equipment earthing.

Earth-continuity conductor (ECC): The conductor which connect the non-conductive metal part/body of an electrical system/equipment to the earth electrode is called as earth continuity conductor.

Reasons for earthing: The basic reason for earthing is to prevent or minimize the risk of shock to human beings and livestock. The reason for having a properly earthed metal part in an electrical installation is to provide a low resistance discharge path for earth leakage currents which would otherwise prove injurious or fatal to a person or animal touching the metal part.

An electric shock is dangerous only when the current through the body exceeds beyond a certain milli ampere value. In general, any current flow through the body beyond 5 milli amperes is considered dangerous. Fig 1 shows the magnitude of current and its effect.



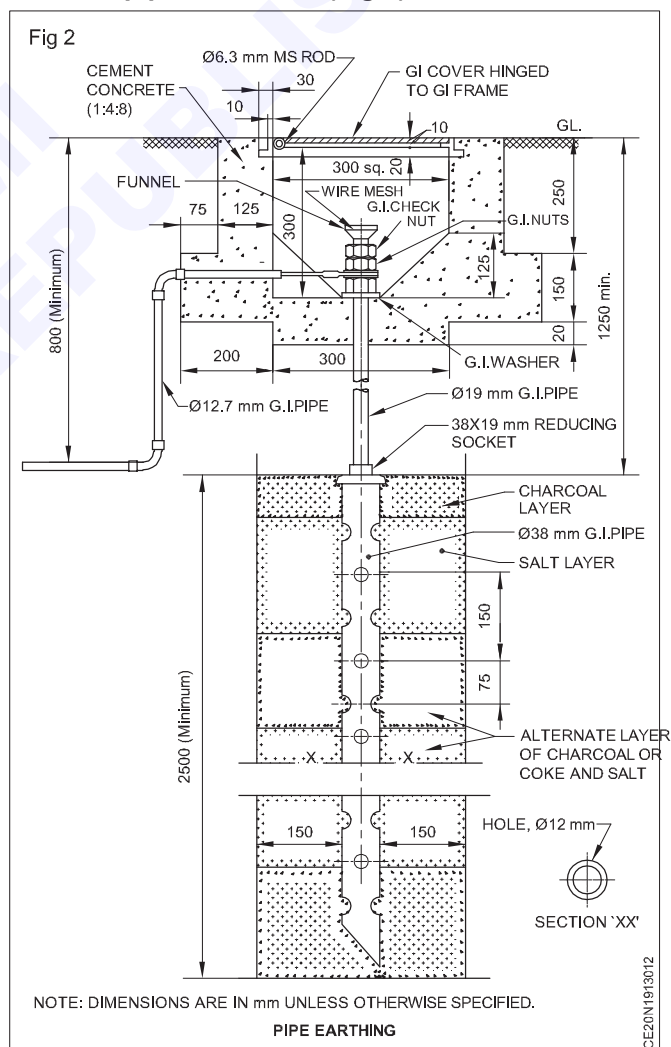
However, the degree of danger is also dependent on the time during which it flows, and resistance of the body. In human beings, the resistance between hand and hand or between hand and foot can easily be as low as 400 ohms under certain conditions. Table 1 shows the body resistance at specified areas of contact.

Table 1

Types of earth electrodes

Skin condition or area	Resistance value
Dry skin	100,000 to 600,000 ohms
Wet skin	1,000 ohms
Internal body-hand	400 to 600 ohms to foot
Ear to ear	about 100 ohms

Rod and pipe electrodes (Fig 2)



These electrodes shall be made of metal rod or pipe having a clean surface not covered by paint, enamel or other poorly conducting material.

Rod electrodes of steel or galvanised iron shall be at least 19 mm in diameter, and those of copper shall be at least 12.5 mm in diameter.

Pipe electrodes shall not be smaller than 38 mm internal diameter, if made of galvanised iron or steel, and 100 mm internal diameter if made of cast iron.

Electrodes shall, as far as practicable, be embedded in earth below the permanent moisture level.

The length of the rod and pipe electrodes shall not be less than 2.5 m.

Except where rock is encountered, pipes and rods shall be driven to a depth of at least 2.5 m. Where rock is encountered at a depth of less than 2.5 m, the electrodes may be buried, inclined to the vertical. In this case too, the length of the electrodes shall be at least 2.5 m, and the inclination not more than 30° from the vertical.

Deeply driven pipes and rods are, however, effective where the soil resistivity decreases with depth or where a sub-stratum of low resistivity occurs at a depth greater than those to which rods and pipes are normally driven.

Pipes or rods, as far as possible, shall be of one piece.

For deeply driven rods, joints between sections shall be made by means of a screwed coupling, which should not be of a greater diameter than that of the rods which it connects together.

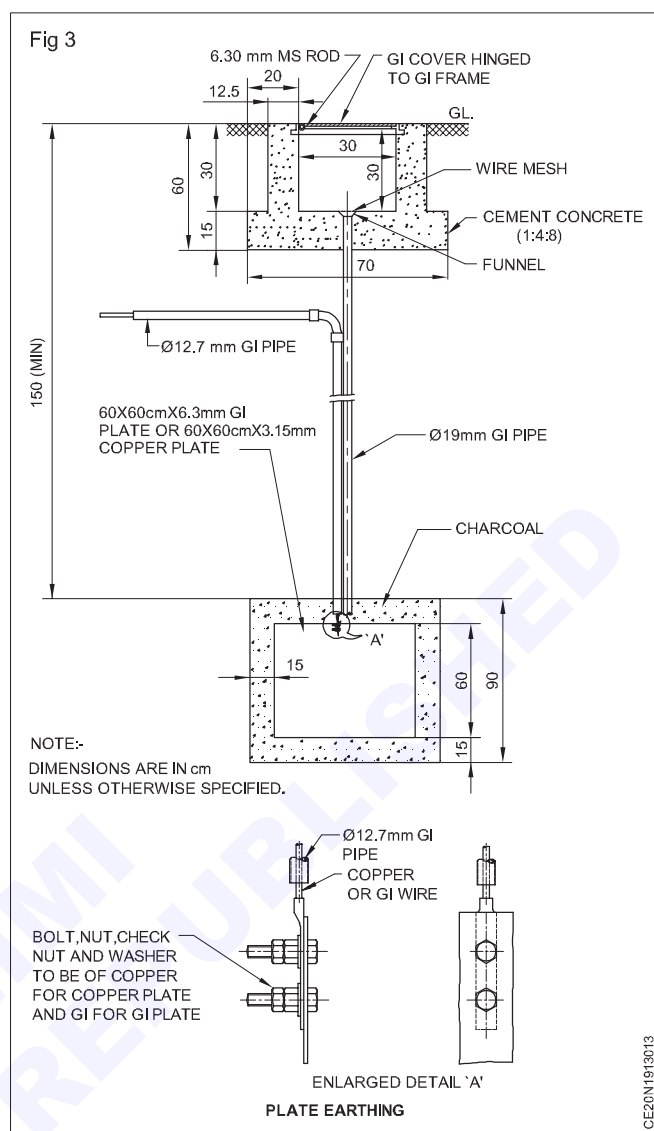
Plate electrodes (Fig 3): Plate electrodes, when made of galvanised iron or steel, shall not be less than 6.3 mm in thickness. Plate electrodes of copper shall be not less than 3.15 mm in thickness. Plate electrodes shall be of a size, at least 60 cm by 60 cm.

Plate electrodes shall be buried such that the top edge is at a depth not less than 1.5 m from the surface of the ground.

Where the resistance of one plate electrode is higher than the required value, two or more plates shall be used in parallel. In such a case, the two plates shall be separated from each other by not less than 8.0 m.

Plates shall preferably be set vertically.

Use of plate electrodes is recommended only where the current-carrying capacity is the prime consideration; for example, in generating stations and substations.



If necessary, plate electrodes shall have a galvanized iron water pipe buried vertically and adjacent to the electrode. One end of the pipe shall be at least 5 cm above the surface of the ground, and it need not be more than 10 cm. The internal diameter of the pipe shall be at least 5 cm and need not be more than 10 cm. The length of pipe, if under the earth's surface, shall be such that it should be able to reach the centre of the plate. In no case, however, shall it be more than the depth of the bottom edge of the plate.

Different electrical domestic appliances, accessories and voltmeter

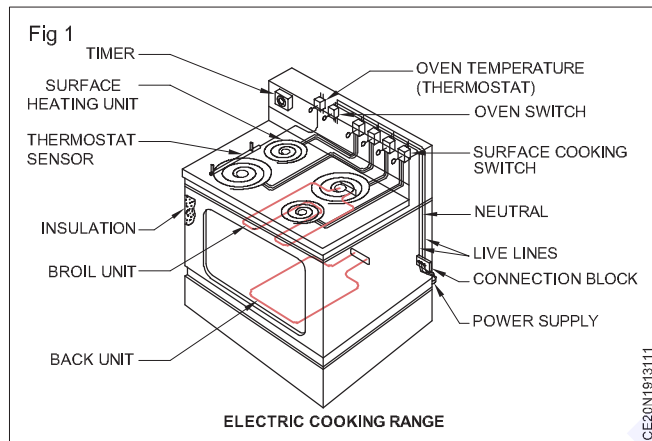
Objective: At the end of this lesson you shall be able to

- explain the domestic appliance, accessories and voltmeter.

Domestic appliance

Domestic appliance is an electrical equipment machine used in houses for the various house hold tasks click cooking, washing and cleaning etc.

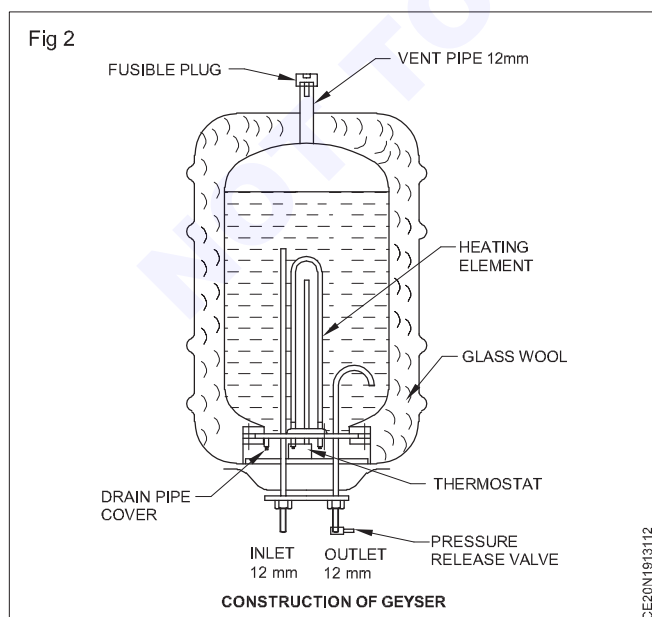
Cooking range (Fig 1)



Electric cooking range is the combination of an oven and hot plate. The electric range consist of highly efficient heating elements, it gives better cooking control, has shelf oven, fingertip controls and designs to fit almost every possible kitchen need.

The surface heating units are set in the top of the range, the electric connections for these units are carried in the space between the top of the range (Fig 1). Oven controls are also kept in the top but in separate elevated pedestal.

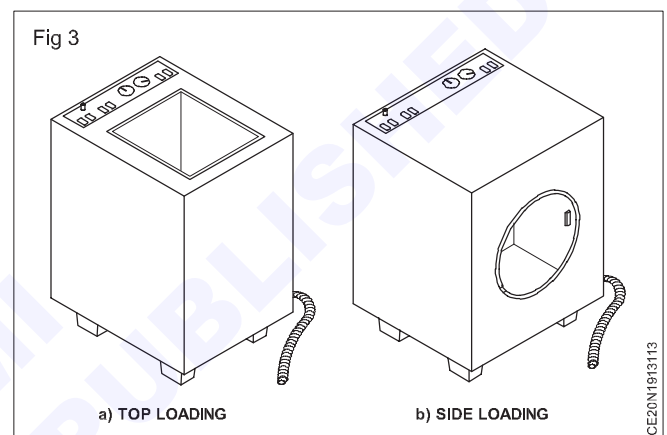
Geyser (Fig 2)



It is an electric water heater which heats and maintains the temperature of the water stored in it.

There are several types of water heaters. The most usual one is the geyser, which is more efficient as the hot water can be directly drawn through a tap at different points.

Washing machine (Fig 3)



It is a domestic electric appliance which is used to soak, rinse, wash, wrinkle /dry the cloth/fabrics etc.

Types of washing machines: The modern washing machines can be divided roughly into three main groups according to their function.

i Semi-automatic type

This type has two tubs. One for washing and rinsing, the other for spin drying the cloths. The washing tub operates at lower speed whereas the spin drier tub operates at a higher speed. The machine may contain either one or two motors.

ii Fully automatic type

In this type, the microprocessor enables to programme the wash cycle. There will be only one tub. The machine could be programmed for wash cycle, detergent intake and water input. The machine does washing, rinsing and also dry the cloth and stops.

Further to the above types the washing machine could be further divided by the type of loading i.e. top loading and front loading. In some machines the water used for washing could be preheated with the help of an electric heater.

Pump set

Pump set is a combination of an electric motor and a impeller/pump coupled together to pump the water from well (or) bore (or) sump etc.,

Selection of pump : The following points are to be considered before selecting a pump for lifting the water.

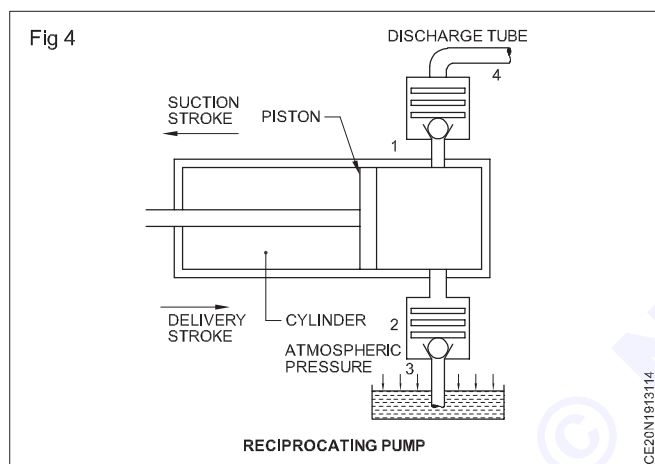
- The quantity of water to be lifted
- Height of water to be delivered
- The time for lifting.

Based on the above considerations the pump has to be selected along with the motor to lift the water from a well/sump.

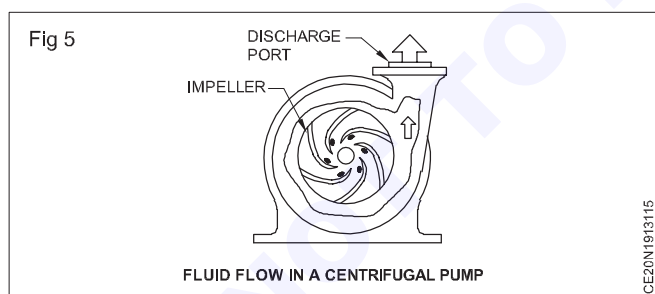
Pumps : Pumps can be classified mainly into two categories. They are

- Reciprocating pumps
- Rotary pumps.

Reciprocating pumps : In this type of pump, the main moving part has reciprocating motion only and hence the name. Fig 4 shows the main parts of a reciprocating pump.



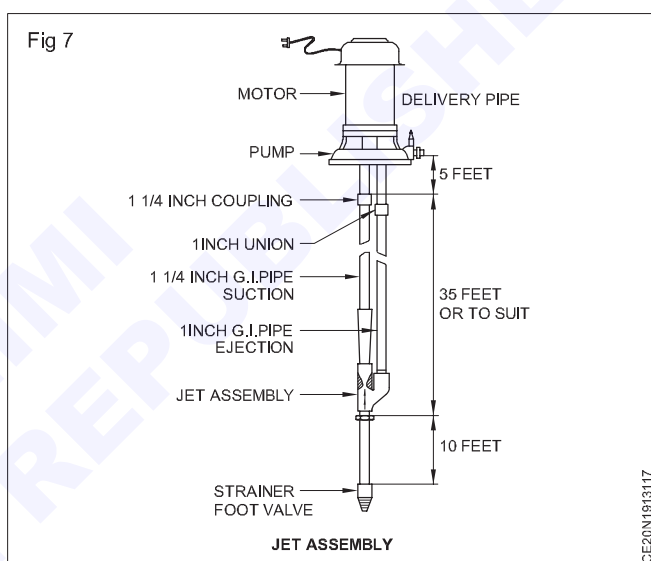
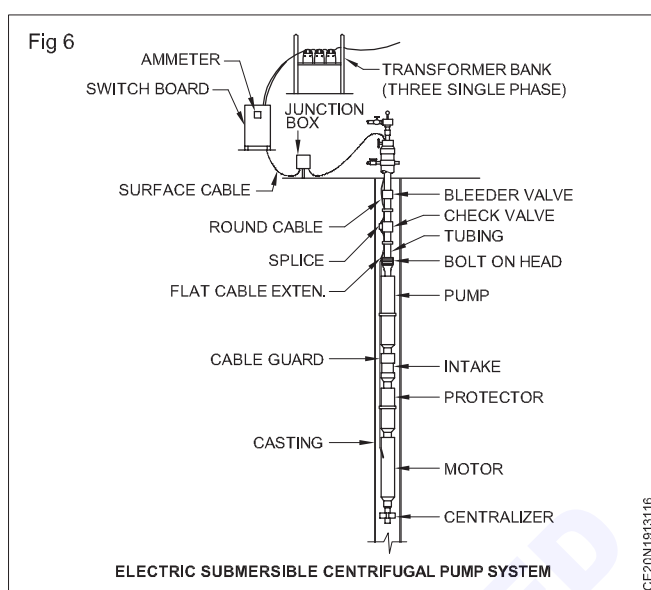
Rotary pumps : There are very many varieties of this pump in the market. However centrifugal pumps, jet pumps and submersible pumps are the commonly used pumps for lifting water in houses. (Fig 5,6,7)



Electric iron

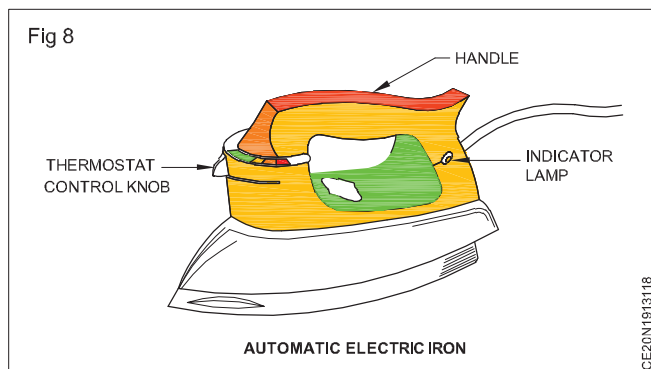
An electric iron is a heating device in which the heat is concentrated on a smooth, flat, bottom surface which is applied to the fabrics to be ironed.

The electric iron will probably be the first appliance that an individual will be called upon to repair when entering the appliance servicing field. In spite of the fact that irons are quite expensive, many old irons are in use today.



Automatic electric iron

The difference between an automatic iron and the ordinary (non-automatic) iron is that the automatic type has a thermostatic device to regulate the temperature. The other parts are more or less the same in both the types of irons. (Fig 8)



Automatic irons are fitted with a thermostatic switch to regulate the heat to a specific predetermined value. The thermostatic switch disconnects the supply when the predetermined value is reached and reconnects the

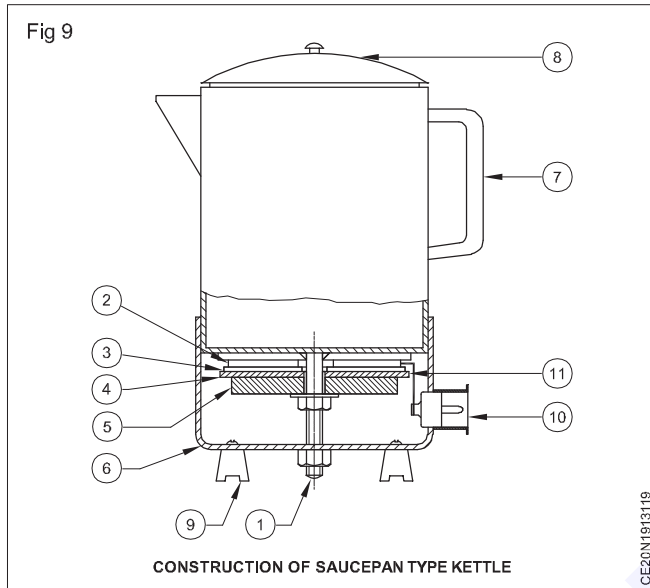
supply when the iron cools down. A turning knob with a dial just below the handle, marked as rayon, cotton, silk, wool etc. can be operated to select the preset temperature.

Electric kettle

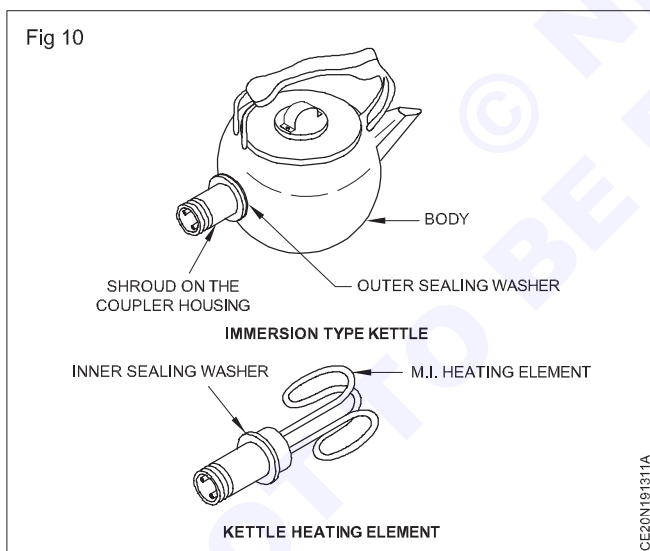
Electrical kettle is a heating device which is used to heat the liquid (like water, milk, etc) poured in it.

There are two types of electric kettles:

- Saucepan type (Fig 9)



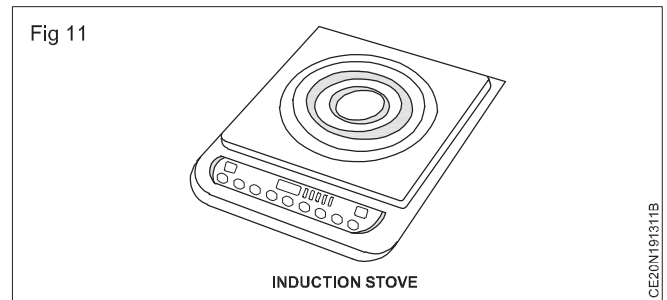
- Immersion heating type (Fig 10).



Induction heater

An induction heater uses an electromagnetic field to heat food. When the heater is turned on, an electric current passes through a coil of metal, creating a magnetic field. This magnetic field then penetrates the metal of a cooking pan, inducing a current in the pan. The current then dissipates energy in the form of heat, cooking the food in the pan. (Fig 11)

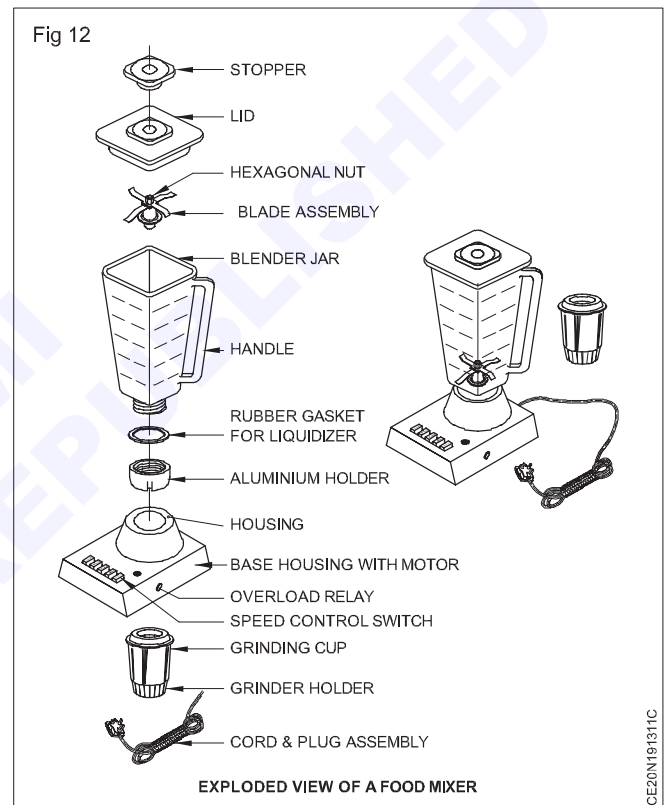
Fig 11



Food mixer (Fig 12)

It is an electric domestic appliance which is used to mix, juice, grind and blend the fruits and food grains.

A medium sized universal motor is used in it. Fig 12 shows an exploded view of a mixer.



Wet grinder

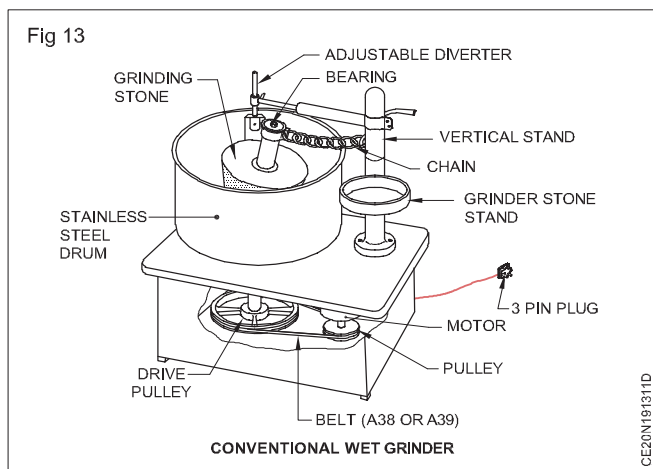
It is a domestic electrical appliance, which is used to grind the wet grains.

Types: There are three types of wet grinders

- Conventional (regular) wet grinder.
- Table top wet grinder.
- Tilting wet grinder.

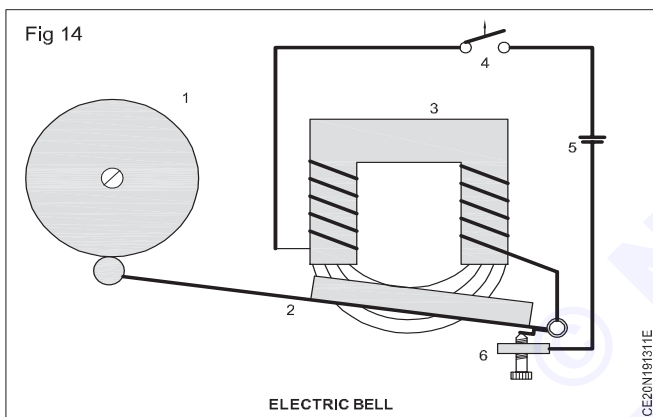
Conventional (regular) wet grinder (Fig 13)

The most common wet grinder used in houses is the container rotating type wet grinder.



Electric bell

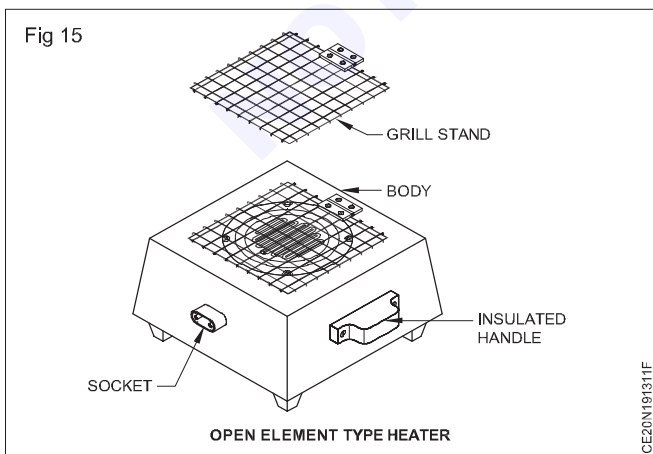
An electric bell is a mechanical bell that works of an electromagnet. When the current is passed through it, produces buzzing sound. It is used in rail road crossings, telephones, fire/burglar alarms, school bells and doorbells etc., Now, they are replaced with electronic sounders. (Fig 14)



Electric buzzer

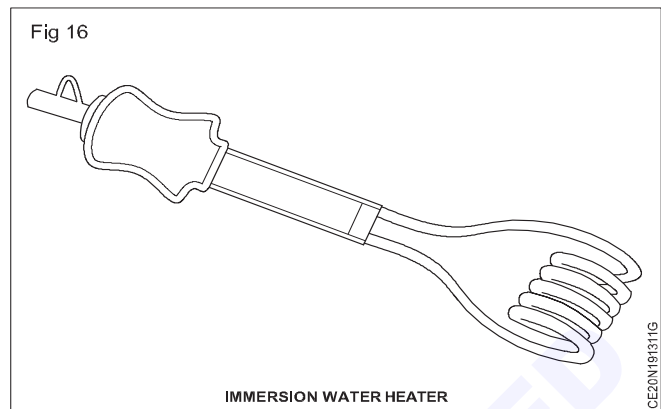
A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical (or) piezoelectric

Electric heater: One of the methods of obtaining heat for cooking is to use the heating effect of electricity. An electric heater is the simplest form of an electric cooking device. (Fig 15)



In most of the cases, for general heater element 20 SWG nichrome wire is used for 2000 W heater, 22 SWG for 1500 W, 24 SWG for 1000 W heater and 26 SWG wire for 750W heater.

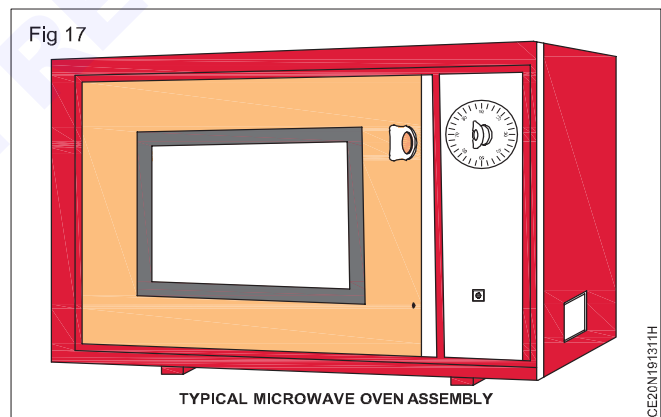
Immersion heater (Fig 16)



Generally there are two elements in an iron which are connected in parallel or in series. These elements are pressed in a case of iron sheet which is placed in a solid iron. The two main leads of the element are connected to the supply in a connector. The body of the iron is connected with earth for the purpose of safety from shock. These are available in different wattages 15W, 25W, 40W, 65W, 125W, 240W etc.

As the name implies, these heaters are used in immersed conditions. These are used to heat the water or other liquid directly.

Microwave Oven (Fig 17)



It is an electronic cooking device which uses energy of microwaves to cook /prepare/preserve the foods. Unlike the conventional ovens, microwave energy cooks the food without applying external heat.

Ceiling fan: It is a domestic electric appliance which is hanged from ceiling to circulate air for cooling purposes. The capacity of the fan is usually expressed in cubic feet per minute and is determined largely by the length, pitch and speed of the blades. (Fig 18)

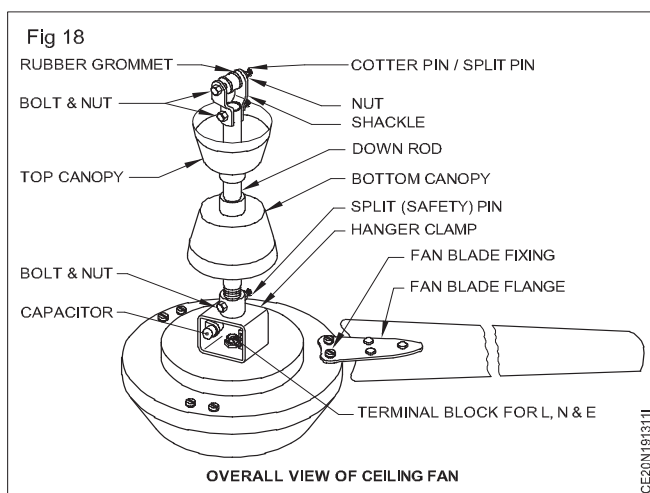
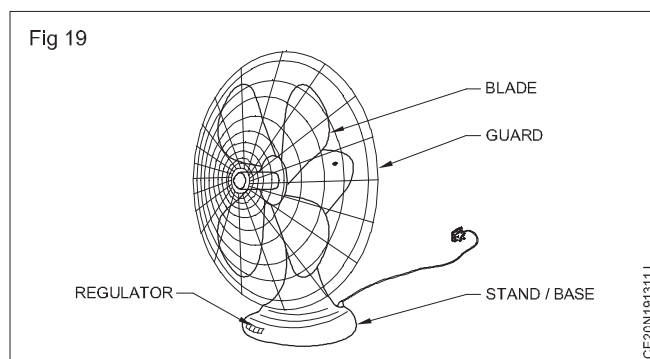


Table fan

The table fan is also called the desk fan which can be oscillating or non-oscillating. They are commonly mounted on a heavy base and are furnished with a set of blades.

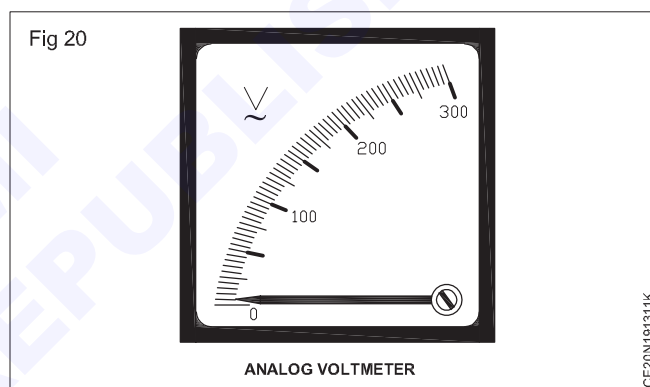
Oscillating fans are so termed because they oscillate in a back and forth motion as the motor of the fan rotates. In this manner they can move a larger volume of air in the room or area in which the fan is placed. The table fan is a portable fan which can be kept on the table or wherever air circulation is needed (Fig 19).



The table fan motor is mostly of a capacitor start or split phase, single phase induction type.

Voltmeter

The potential difference between two points is known as voltage. The voltmeter is connected across (parallel connection) to the sources. It is connected between two points for example phase to neutral (or) between two phase (R - Y, Y - B, B - R) in DC voltage connected between positive (+) and negative (-). (Fig 20)



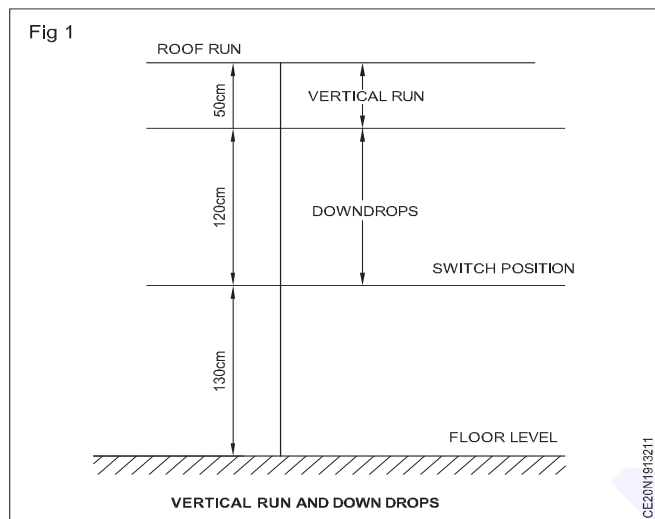
Estimation and costing for 3 phase domestic and commercial wiring

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

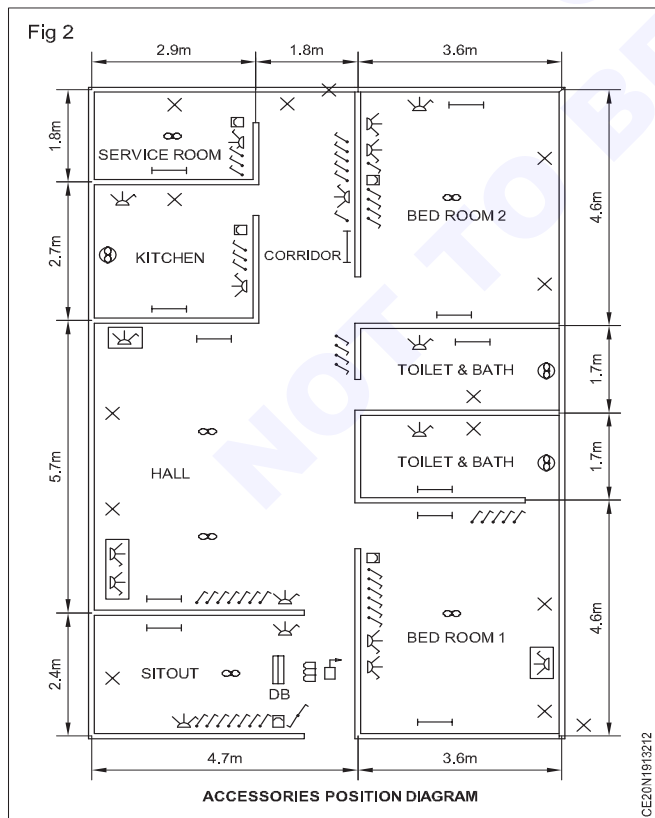
- state specific rules related to 3-phase wiring installations
- estimate the wiring by load calculation, load distribution, layout diagram, wiring diagram, selection of cables, selection of conduit, calculation of conduit length, cable length, accessories required and the cost of wiring.

Estimation of wiring

Fig 1 shows the vertical and down drops and switch position measurement from the ground level.



Study the consumer's requirement of light, fan and power points in each room (Fig 2).



Required conduit length has to be calculated as per given method.

NE code recommends the horizontal run of cables should be at a height of 2.5m (250cm) and the height of switches from floor level should be 130cm. The example taken here for the roof height is 3m (300cm) from floor level. In all cases the dimension of the rooms should be available for estimating.

Vertical run : As such all vertical runs can be calculated as under (Refer Fig 4) for L 2 phase.

Length of selected conduit =

$$\text{Roof height} - (\text{down drop} + \text{switch height}) \times \text{No. of vertical runs}$$

$$= 3\text{m} - (1.20\text{m} + 1.30\text{m}) \times \text{No. of vertical heights} \\ = (3\text{m} - 2.5\text{m}) \times \text{No. of vertical heights} \\ = 0.5\text{m} \times \text{No. of vertical heights (Eqn. 1)}$$

The value 0.5m will change if there is difference in roof height and height of horizontal run of conduit changes.

Length of conduit required for down drops

This could be calculated as under:

Length of selected conduit = Height of conduit in horizontal run - Switch position height x No. of down drops for switches

Length of conduit required for roof runs

This could be calculated as under

Length of selected conduit = Sum of the actual length of roof run taken in each case.

For each size the total requirement is to be calculated.

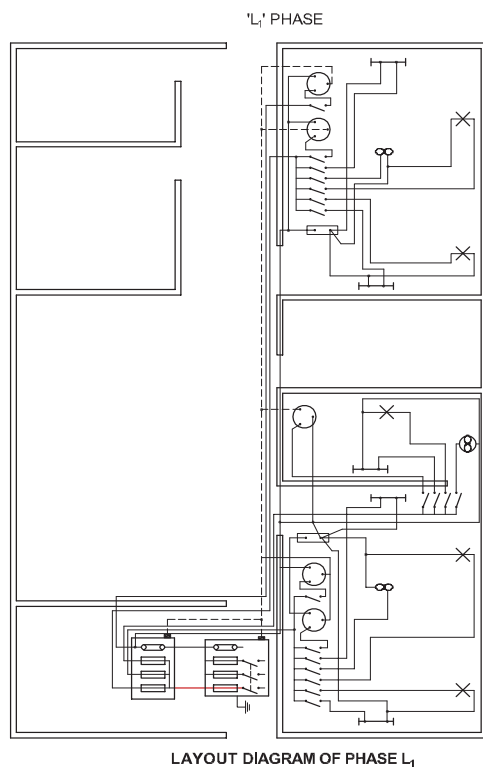
Length of conduit required for horizontal run

Length of selected conduit = sum of the actual length of horizontal run taken in each case.

Length of conduit required for the distance between main switch and DB is to be calculated. In most of the cases wall thickness has to be taken into account.

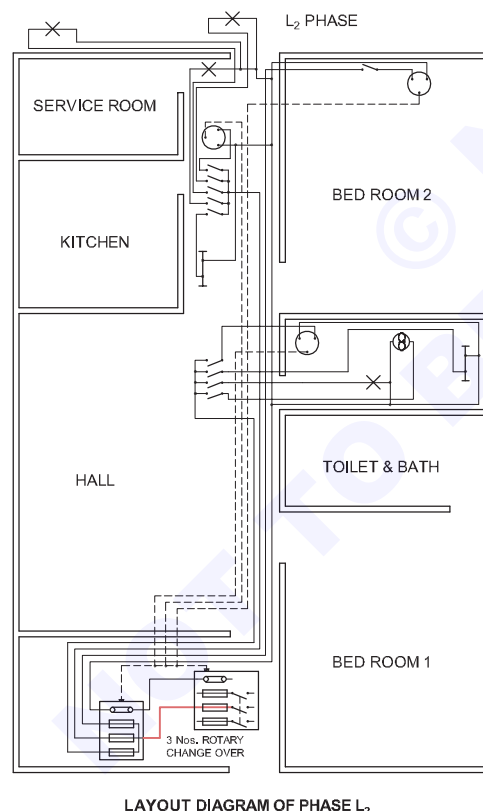
Example : (Refer the layout and wiring diagram with respect to phase L1) In all cases except for main switch and DB the cable used is 1/1.12 copper cable and maximum number of cable it can accommodate in 19mm conduit is 7 cables. Hence PVC conduit of 19mm is chosen.

Fig 3



CE20N1913213

Fig 4



CE20N1913214

1 Length of conduit required for vertical run

Length for vertical run = 0.5m x No. of vertical height

A careful study of layout indicates there are 8 vertical height runs

= 0.5m x 8 = 4m of 19mm PVC conduit

2 Length of conduit required for down drops

Length of down drops = 1.2m x No. of down drops

A careful study of layout indicates there are 9 down drops = 1.2m x 9 = 10.8m

3 Length of conduit required for roof runs

Length of conduit = 2.35m + 2.35m + 2.35m + 2.35m + 1.45m + 0.9m = 9.75m

4 Length of conduit required for horizontal runs

Length of conduit = 4.7m + 3.6m + 1m + 1m + 1.2m + 4.7m + 2.4m + 1.35m + 1.2m + 2m + 2.35m + 5.7m + 2.9m + 2.9m + 1.35m + 2.7m + 2.5m + 1.45m + 1.8m + 1.45m = 48.25m

5 Length of conduit required for main switch and DB

If individual phase line is to be drawn through 19mm PVC conduit will be sufficient on the other hand if all three phase cables to be drawn through single pipe, the requirement to be calculated separately.

Assuming individual phases will be drawn through individual conduits the 19mm PVC conduit will be sufficient to draw two cables of sizes up to 1/2.8 or 7/1.06 aluminum and copper cables respectively.

Length of conduit required for the distance between main switch and DB : Length of conduit = wall thickness + allowance for connection = 0.36m + 0.5m + 0.5m = 1.36m

Total length of PVC conduit 19mm for wiring phase L₁ as per layout and wiring diagram

= Vertical run + down drops + roof runs + horizontal runs + switch DB = 4m + 10.8m + 9.75m + 48.25m + 1.36m = 74.16 m

Assuming 10% wastage, the total required length of 19mm PVC conduit will be 73.81m + 7.3m = 81.11m or say 80m

Calculation of length of cable required for wiring phase L₁: For calculating the length of cable accurately the layout and wiring diagrams should be referred. Selected cable in this case is 1 sq.mm copper cable.

Cable required=For outside runs ((L₁ + L₂ + L₃ + L₄) down drop + Horizontal run + switch board to outside wall (thickness of wall) + DB to switch board (DD + HR + DD) + Switch board to L₅ + (DD + HR) + L₅ to F₁ (VR + RR) + L₅ to L₆ L₇ (HR + HR) + DB to SB₂ (DD + HR + DD) + SB₂ to L₉ (DD + HR) + L₉ to F₂ (VR + RR) + SB₂ to S₃, S₄ (DD + HR + DD) + L₉ to L₁₀ (HR) + L₁₀ junction to F₃ (VR + RR) + L₁₀ junction to L₁₁ (HR) + S₃, S₄ to S₅ (DD + HR + DD) + From DB to S₆ (DD + HR + DD) + From S₆ to L₁₂ (DD + HR)

+ L12 to F5 (HR)	
+ S6 to F4 (DD + HR + DD)	
+ S6 to L13 (DD + HR)	
+ S6 to S8 (DD + HR + DD)	
+ S6 to S7 (DD + HR + DD)	
+ S8 to F6 (DD + RR)	
+ F6 to L15	
+ F6 to L14	
= + (3.6m + 1m) ² + (4.7m + 1m) ³	26.3m
+ (0.36m + 0.5m) x 5	
+ (1.2m + 3m + 1.2m) ²	15.1m
+ (1.2m + 3m + 1.2m) ²	10.8m
+ (1.2m + 4m + 1.2m) ⁵	32.0m
+ (0.5m + 2.35m) ²	5.7m
+ (1.2m + 2.35m) ³ + 2.35m x 2	15.35m
+ (1.2m + m ² + 1.2m) ²	8.8m
+ (1.2m + 4m + 2m) ⁶	43.2m
+ (0.5m + 2.35m) ²	5.7m
+ (1.2m + 1.5m) ²	5.4m
+ (1.2m + 4m + 2m + 1.2m) ²	14.8m
+ 2m x 4	8.0m
+ (0.5m + 2.35m) ^{25.7m}	
+ (2m + 2.5m) ^{29.0m}	
+ (1.2m + 5m + 1.2m) ²	14.8m
+ (1.2m + 4m + 5.7m + 2.9m	
+ 2m + 1.2m) ²	34.0m
+ (1.2m + 1.4m + 1.5m) ³	12.3m
+ (1.5m + 1.35m) ²	5.7m
+ (1.35m x 3m) + (1.35m x 2m)	6.75m
+ (1.35m + 1.45m + 1.2m) ²	8.00m
+ (1.2m + 1.4m + 0.9m + 1.2m) ²	9.4m
+ (1.2m + 1.45m + 1.2m) ²	7.7m

+ (1.2m + 1.45m) ³	7.95m
+ 0.9m x 2m	1.8m
+ 0.9m x 2m	1.8m
	325.95m
Add 10%	32.59m
Say 360m of 1 sq.mm copper	358.54m

The length of the cable required for power circuit in phase L1. The cable chosen is 4 sq.mm copper cable which can carry 24 amps

Total length of cable	= (1.2m + 0.36m + 2.4m + 3.6m + 2.4m + 1.2m) ²
	= 11.16m x 2
	= 22.32m

Add 10% for wastage	= 2.2m
	24.52m

Say 25m of 4 sq.mm copper cable is required.

In the same way for the circuits in L2 and L3 phases should be calculated. After the list of accessories for entire wiring is prepared the cost of the accessories could be obtained from any local electrical dealer.

Instructor is requested to discuss with the trainees about the number of days required to complete the job along with the cost of labour.

Total cost of wiring comprises of following components.

Total cost of wiring = cost of the accessories
+ cost of cable
+ cost of conduit
+ cost of hardware items
+ labour cost

Explanation and working of different type of transformers and classification

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

- explain a transformer
- explain the construction of two winding transformer.

Transformer

Transformer is a static electric device which transfer the electric energy from one circuit to other without changing the frequency and power.

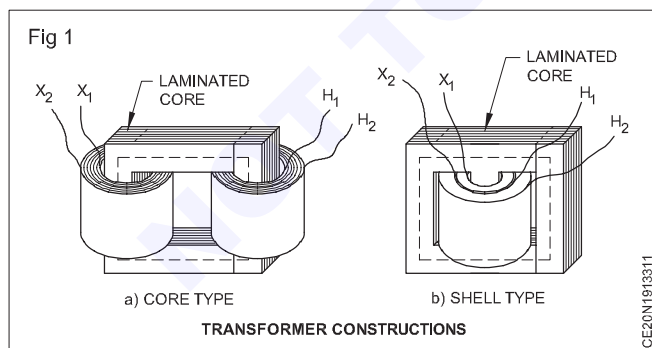
The three-phase synchronous generator is used extensively to generate bulk power. The voltage levels at which this power is generated is typically in the range 11 kV to 22 kV. Electrical power is to be provided at a considerable distance from a generating station. It is possible to transmit the generated power directly but this results in unacceptable power losses and voltage drops.

Transmission voltages vary up to the 400 kV level. This is made possible by power transformers. At the receiving end this high voltage must be reduced because ultimately it must supply three phase load at 415V or single phase load at 240V.

The transformer makes it possible for various parts of a power system to operate at different voltage levels.

Standard safety norms: Trainees can be instructed to refer the standard safety norms related with transformer in the International Electrotechnical commission (IEC - 60076-1) for the further details.

Construction: There are basically two types of iron-core construction. Fig 1a shows a core type transformer. It consists of two separate coils, one on each of the two opposite legs of a rectangular core.



Normally, this is not a desirable design. Its disadvantage is the large leakage fluxes associated with it. The large leakage fluxes cause poor voltage regulation. Therefore, to ensure that most of the

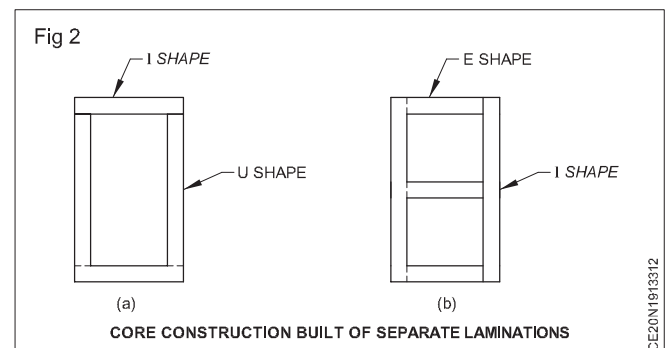
flux set by the primary will link the secondary, the construction Fig 1b is employed. This is called shell type construction.

Here the two windings are wound concentrically. The higher voltage winding is wound on top of the lower voltage winding. The low-voltage winding is then located closer to the steel. This arrangement is preferable from an electrical insulating point of view. From the electrical viewpoint there is not much difference between the two constructions.

Cores may be built up of lamination silicon steel sheet. Most laminating materials have an approximate alloy content of 3% silicon and 97% iron. The silicon content reduces the magnetizing losses. Particularly, the loss due to hysteresis is reduced. The silicon makes the material brittle. The brittleness causes problems in stamping operation.

Most laminated materials are cold-rolled and often specially annealed to orient the grain or iron crystals. This provides very high permeability and low hysteresis to the flux in the direction of rolling. Transformer laminations are usually 0.25 to 0.27 mm thick for 50 Hz. operation. The laminations are coated on one side by a thin layer of varnish or paper to insulate them from each other.

Coils are pre-wound, and the core design must be such that it permits placing the coil on the core. Of course, the core must then be made in at least two sections. The laminations for the core-type transformer of Fig 1a may be made up of (and) shaped laminations, as shown in Fig 2a. The core for the shell type transformer is normally made up of E and I shaped laminations (Fig 2b).

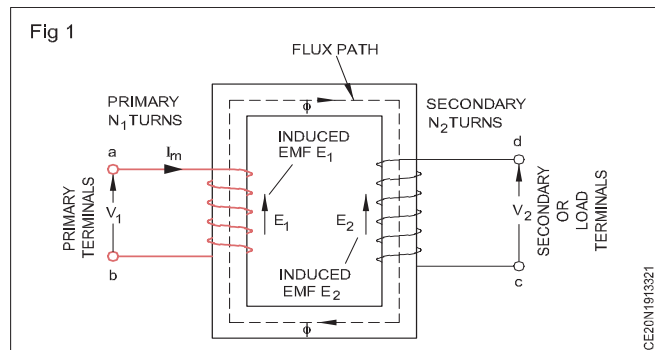


Transformer principle

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

- explain the principle of the operation of a transformer
- derive the EMF equation of a two-winding transformer
- derive the transformation ratio of a transformer.

Let us consider an ideal transformer (Fig 1) whose secondary is open and whose primary is connected to a sinusoidal voltage V_1 .



Working principle

The transformers work on the principle of mutual induction of faraday's law of electro - magnetic induction.

The applied voltage causes a small current to flow in the primary winding. This no-load current is meant to build up a counter-electromotive force equal and opposite to the applied voltage.

Since the primary winding is purely inductive and there is no output, the primary draws the magnetizing current I_m only. The function of this current is merely to magnetize the core. The I_m is small in magnitude and lags V_1 by 90° . This alternating current I_m produces an alternating flux ϕ which is proportional to the current and hence is in phase with it (I_m). This changing flux is linked with both the windings. Therefore, it produces self-induced EMF (E_1) in the primary which lags the flux ' ϕ ' by 90° . This is shown in vector diagram Fig 2.

The flux ' ϕ ' produced by the primary links with the secondary winding and induces an EMF (E_2) by mutual induction which lags behind the flux ' ϕ ' by 90° Fig 2. As the EMF induced in primary or secondary per turn is same the secondary EMF will depend on the number of turns of the secondary.

When secondary is open circuit, its terminal voltage ' V_2 ' is the same as the induced EMF (E_2). On the other hand, the primary current at no load is very small, hence the applied voltage ' V_1 ' is practically equal and opposite to the primary induced EMF (E_1). The relationship between primary and secondary voltages Fig 2.

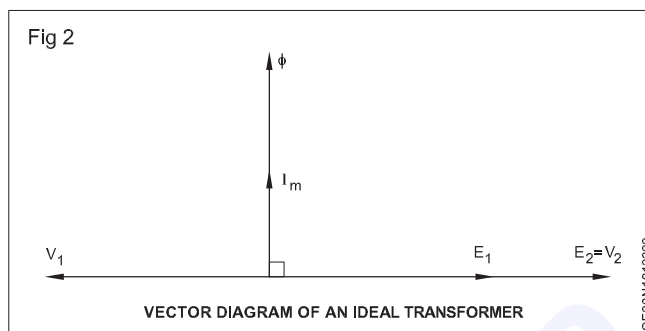
Hence we can say that $\frac{\text{Total emf induced in secondary 'E}_2\text{'}}{\text{Total emf induced in primary 'E}_1\text{'}}$

$$= \frac{N_2 \times \text{emf per turn}}{N_1 \times \text{emf per turn}} \quad \text{OR}$$

$$\frac{E_2}{E_1} = \frac{N_2}{N_1}$$

$$\text{as } E_1 = V_1 \text{ and } E_2 = V_2$$

$$\text{We have } \frac{V_2}{V_1} = \frac{N_2}{N_1}$$



Ideal transformer on Load: When the secondary is connected to a load, secondary current flows this in turn makes the primary current to increase. How this happens is explained below.

The relationship between primary and secondary currents is based upon a comparison of the primary and secondary ampere turns.

When the secondary is open circuit, the primary current is such that the primary ampere turns are just sufficient to produce the flux ' ϕ ' necessary to induce an EMF (E_1) that is practically equal and opposite to the applied voltage ' V_1 '. The magnetising current is usually about 2 to 5 percent of the full load primary current.

When a load is connected across the secondary terminals, the secondary current - by **Lenz's law** - produces demagnetising effect. Consequently, the flux and the EMF induced in the primary are reduced slightly.

But this small change may increase the difference between applied voltage ' V_1 ' and the induced EMF (E_1) by say 1 percent in which case the new primary current would be 20 times the no load current.

The demagnetising ampere turns of the secondary are thus nearly neutralized by the increase in the primary ampere turns and since the primary ampere turns on no load are very small compared with the full load ampere turns.

Therefore, Full load primary ampere turns $\sim$ full load secondary ampere turns

$$\text{i.e. } I_1 N_1 \sim I_2 N_2$$

$$\text{so that } \frac{I_1}{I_2} \sim \frac{N_2}{N_1} \sim \frac{V_2}{V_1} \quad \text{Transformation ratio}$$

From the above statement, it is clear that the magnetic flux forms the connecting link between the primary and secondary circuits and that any variation of the secondary current is accompanied by a small variation of the flux and therefore of the EMF induced in the primary, thereby enabling the primary current to vary approximately, proportional to the secondary current.

$$E_{\text{avg}} = \text{turns} \times \frac{\text{change in flux in a given time}}{\text{given time}} \quad \dots(1)$$

$$E_{\text{avg}} = N \times \frac{2\phi_m}{\frac{1}{2f}} = 4fN\phi_m \quad \dots(2)$$

$$E = 4.44 N \phi_m \quad \dots(3)$$

$$E_1 = 4.44 f N_1 \phi_m \quad \dots(4)$$

and

$$E_2 = 4.44 f N_2 \phi_m \quad \dots(5)$$

Classification of transformers

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

- state the classification of transformers based on various factors.

Classification of transformers

1 Classification based on the type of Core Material used

- **Air core transformers:** Fig 1, air core transformers consists of a hollow non magnetic core, made of paper or plastic over which the primary and secondary windings are wound. These transformers will have values of k less than 1. Air core transformers are generally used in high frequency applications because these will have no iron-loss as there is no magnetic core material.

2 Classification based on the shape of core

- **Core type transformers:** In Core type of transformer, the primary and secondary windings are on two separate sections/limb of core. (Fig 1 in chart 1)
- **Shell type transformers:** In this type, both the primary and the secondary windings are wound on the same section/limb of the core. These are widely used as voltage and power transformers. (Fig 2)
- **Ring type transformers:** In this, the core is made up of circular or semicircular laminations (Fig 3). These are stacked and clamped together to form a ring. The primary and secondary windings are then wound on the ring. The disadvantage of this type of construction is the difficulty involved in winding the primary and secondary coils. Ring type transformers are generally used as instrument transformers for measurement of high voltage and current.

3 Classification based on the Transformation ratio

- **Step-up Transformers:** Transformers in which, the induced secondary voltage is higher than the source voltage given at primary are called step-up transformers.

- **Step-down Transformers:** Transformers in which, the induced secondary voltage is lower than the source voltage given at primary are called step-down transformers.
- **Isolation transformers:** Transformers in which, the induced secondary voltage is same as that of the source voltage given at primary are called one-to-one or isolation transformers. In these transformers the number of turns in the secondary will be equal to the number of turns in the primary making the turns ratio equal to 1.

4 Single phase and three phase transformers

Transformers Fig 4 of Chart 1 are designed for use with single phase AC mains supply. Such transformers are known as single phase transformers. Transformers are also available for 3 phase AC mains supply. These are known as poly-phase transformers. Refer Fig 5. Three phase transformers are used in electrical distribution and for industrial applications.

5 Classification based on application

Transformers can also be classified depending upon their application for a specialized work. There are innumerable number of applications, However, a few of these are listed below:

Instrument transformers - used in clip - on current meters, overload trip circuits etc.,

Constant voltage transformers - used to obtain stabilized voltage supply for sensitive equipments

Ignition transformers - used in automobiles

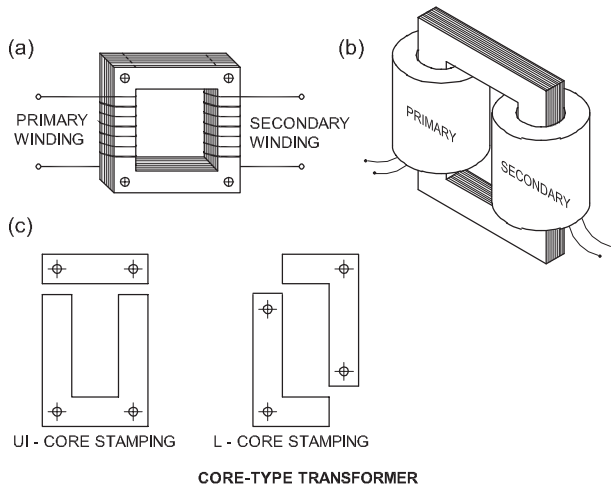
Welding transformers - used in welding equipments

Dry type transformers : Dry type, or air-cooled, transformers are commonly used for indoor applications where other transformer types are considered too risky.

Chart 1

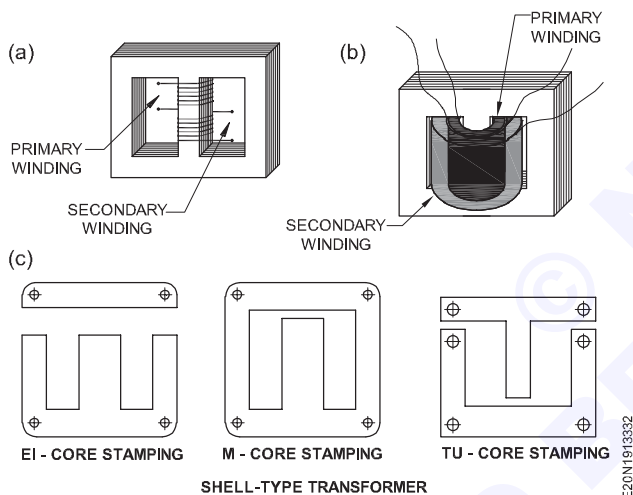
TYPES OF TRANSFORMERS

Fig 1 **CORE - TYPE TRANSFORMER**



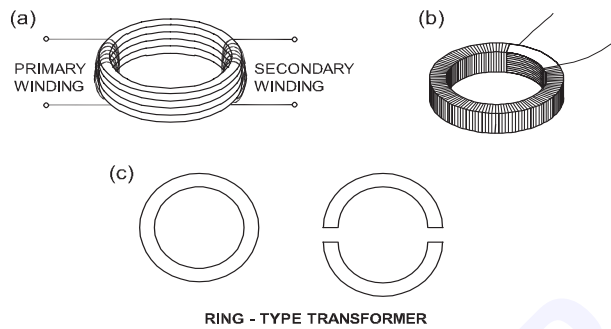
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Fig 2 **SHELL - TYPE TRANSFORMER**



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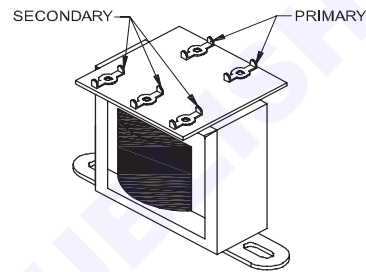
Fig 3 **RING - TYPE TRANSFORMER**



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SINGLE PHASE TRANSFORMER

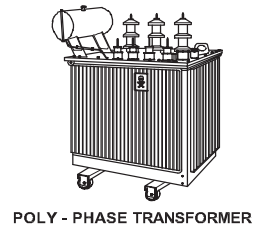
Fig 4



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POLY PHASE TRANSFORMER

Fig 5



CE20N1913335

Plumber common hand tools - different types of pipes, fittings and joints, method of cutting and joining of pipes, drills, tap and dies

Objectives: At the end of this lesson you shall be able to
• state the different types of plumbing tools and uses.

Plumbing tools

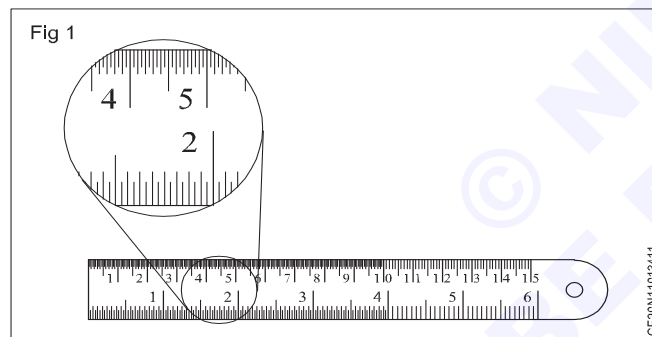
- Measuring tape
- Try square
- Calipers
- Bench vice
- Ball pein hammer
- Rasp file
- Flat file
- Portable electric drill light duty
- Portable power heavy duty hammer drill machine
- Portable electric screw driver

Refer Exercise No 1.8.100

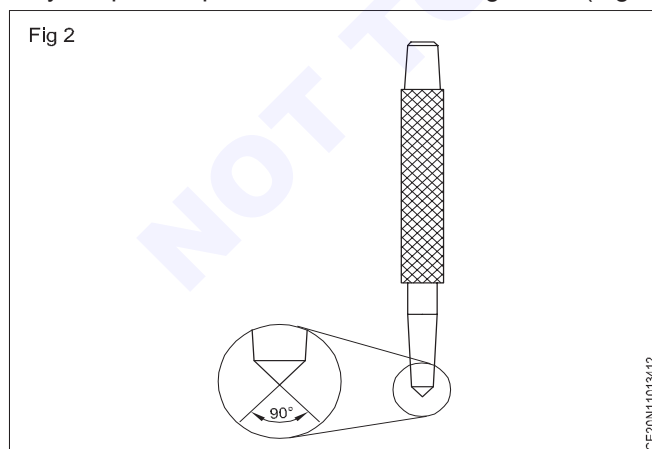
Steel rule

Engineer's steel rules (Fig 1) are used to measure the linear dimensions of work pieces.

Steel rules are made of spring steel or stainless steel. These rules are available in lengths of 150 mm, 300 mm and 600 mm. The reading accuracy of the steel rule is 0.5 mm.



Centre punch: The angle of the point is 90° in a centre punch. The punch mark made by this is wide but not very deep. This punch is used for locating holes. (Fig 2)

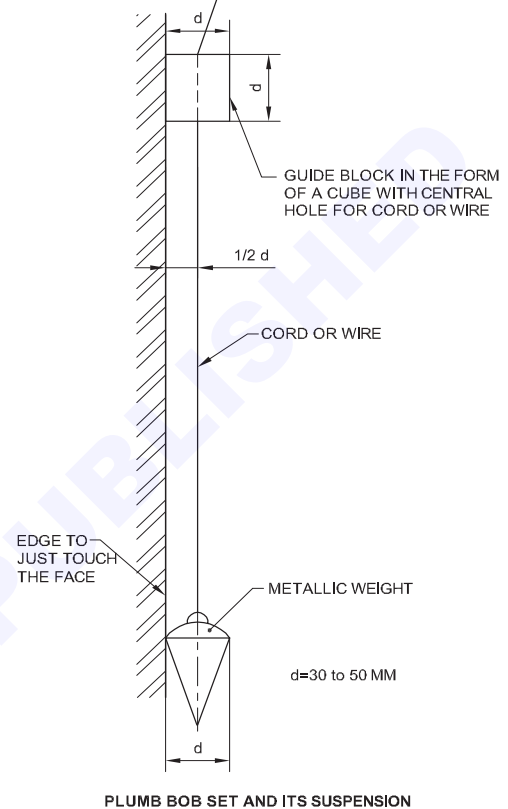


Plumb bob

Plumb bob set is a brass or mild steel cone of 30 to 50 mm over all diameter as shown in (Fig 3).

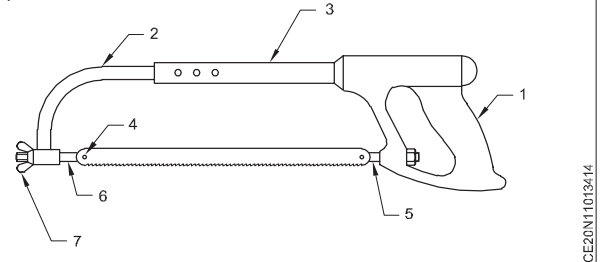
The main use of plumb bob set is for checking the plumbness or verticality of wall face.

Fig 3



Adjustable hacksaw frame (tubular type) (Fig 4): This is the most commonly used type. It gives a better grip and control while sawing.

Fig 4

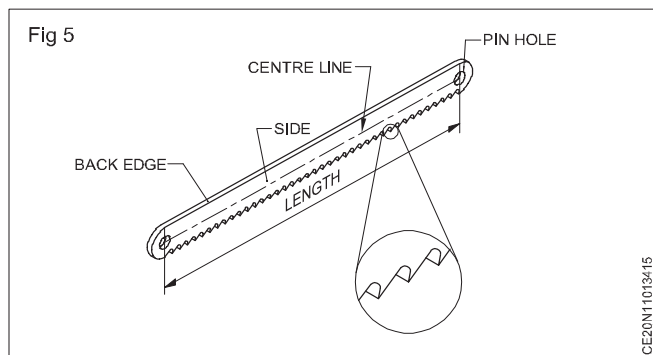


Parts of a hacksaw frame

1 Handle	2 Frame
3 Tubular frame with holes for length adjustment	
4 Rotating pins	5 Fixed blade holder
6 Adjustable blade holder	7 Wingnut

Hack saw blades

A hacksaw blade is a the narrow steel band with teeth with two pin holes at the ends. It is used along with a hacksaw frame. The frame is made of either low alloy steel (LA) or high speed steel (HB) and is available in standard lengths of 250 mm and 300 mm. (Fig 5)



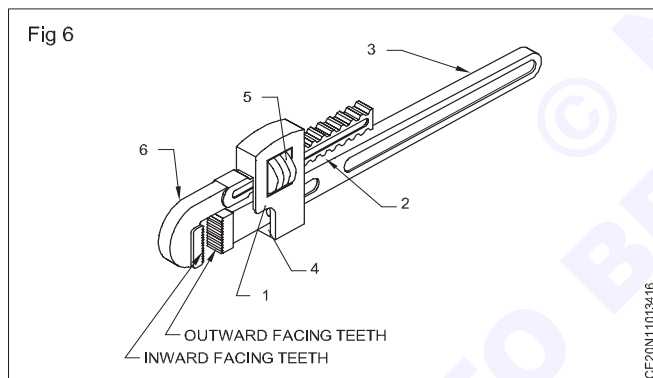
Pipe wrenches: These are adjustable pipe wrenches with different shapes. They are used for:

- holding and gripping pipes
- assembling and dismantling of pipes and fittings.

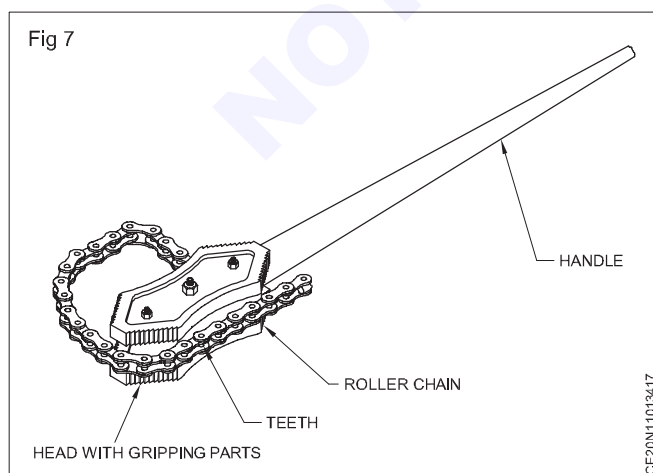
Parts (Fig 6)

The Stillson pipe wrench consists of the following parts

1 Pivot	2 Spring
3 Handle or lever	4 Spring
5 Adjusting nut	6 Moveable jaw.



Chain pipe wrench (Fig 7) : Chain pipe wrenches are used for pipes with diameters of 50mm to 150mm. They may be used for gripping cylindrical or irregular objects.

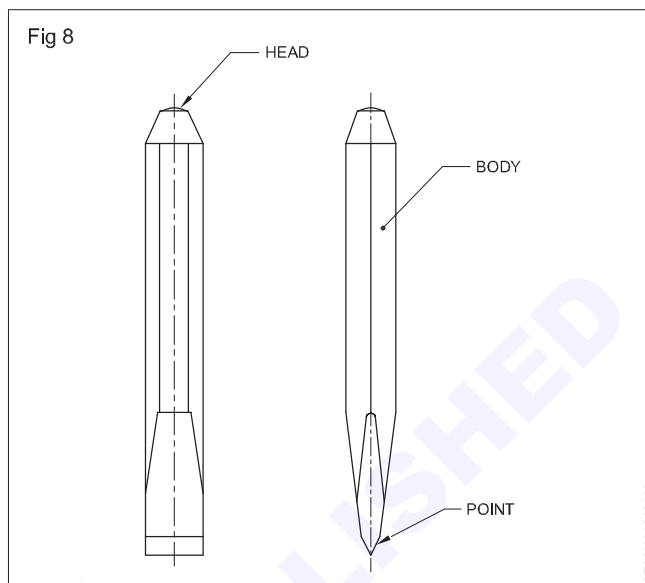


Flat Chisel

The cold chisel is a hand cutting tool used by fitters for chipping and cutting off operations.

Chipping is an operation of removing excess metal with the help of a chisel and hammer.

Parts of chisel (Fig 8)



A chisel has the following parts.

Head

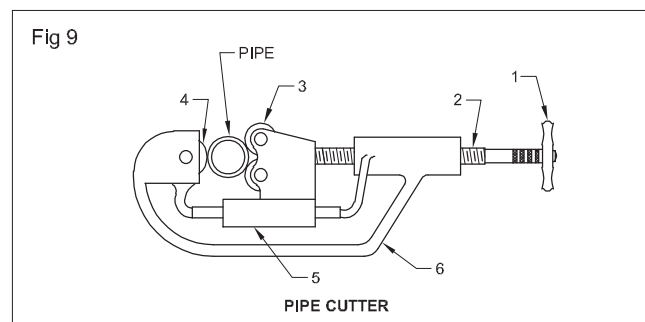
Body

Point or cutting edge

Chisels are made from high carbon steel or chrome vanadium steel.

Pipe cutter

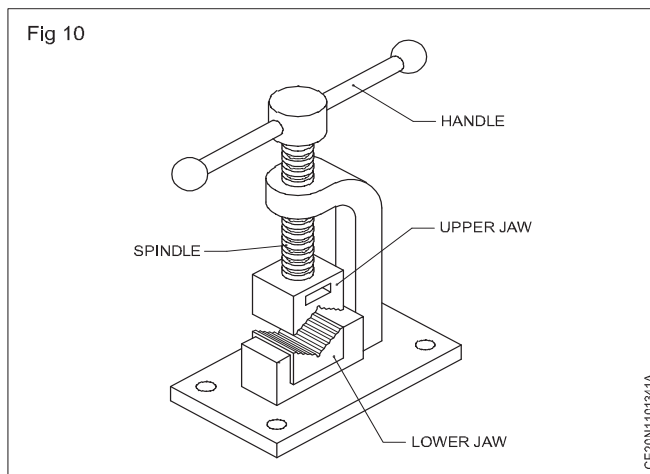
It is used for cutting the pipes. Generally cutter consists of three wheels. These wheels are fixed at 120° apart. Out of these three, one is cutter and two are roller fixed on base. (Fig 9)



Parts of pipe cutter

1 Handle	2 Jacking screw
3 Cutting wheels	4 Roller wheel (Fixed) to face
5 Moving reel base	6 Frame

Pipe vice (Fig 10): A pipe vice is used for holding round sections of metal, tubes and pipes. In this vice, the screw is vertical and movable. The jaw works vertically.



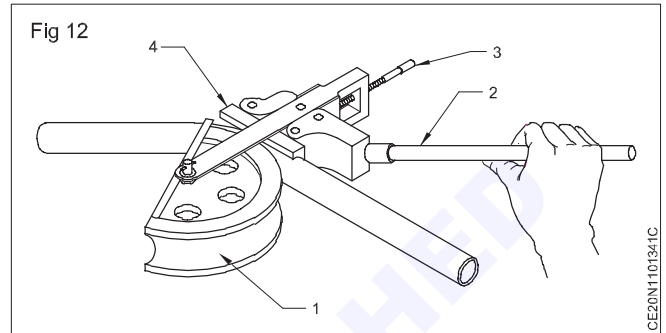
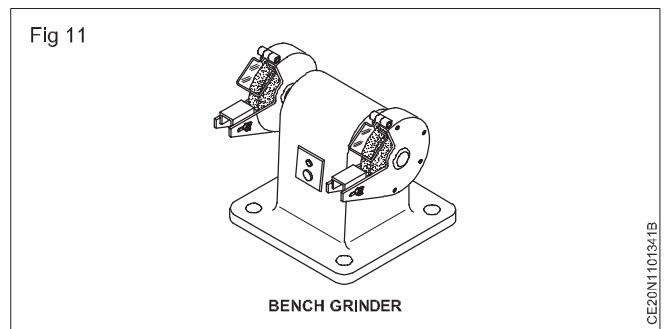
Bench grinders (Fig 11)

Bench grinders are fitted to a bench or table, and are useful for light duty work.

Bench type hand operated pipe bender (Fig 12)

This consists of the following parts. It is used for bending galvanized iron and steel pipes.

1 Inner former.	2 Lever or handle
3 Adjusting screw with lock nut.	4 Pipe guide.



About different types of pipe G.I, C.I, PVC, CPVC, and AC and HDPE

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

- state various types of pipes used for various purposes.

Pipes and pipe fittings

Various types of pipes and tubes are used for the following purposes.

- Domestic hot and cold water supplies.
- Waste water outlets.
- High pressure steam supplies.
- Hydraulic oil supplies.
- Lubricating oil supplies.
- Special fluid and gases for industrial processes.
- Pneumatic systems.
- Refrigeration systems.
- Fuel oil supplies.

The common types of pipes classified according to material are:

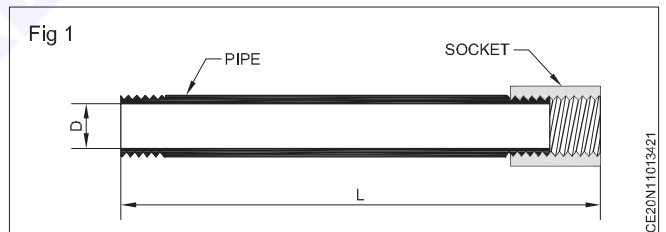
galvanized iron pipes	mild steel pipes
cast iron pipes	C.I. soil pipes
copper pipes	aluminium pipes
brass pipes	lead pipes
P.V.C. pipes	rubber pipes
plastic pipes	stoneware pipes

Standard pipe fitting: 'Pipe fittings' are those fittings that may be attached to pipes in order to:

- change the direction of the pipe
- connect a branch with a main water supply pipe
- connect two or more pipes of different sizes close the pipe ends.
- to close the pipe ends.

G.I. pipe

The hollow long open ended object of circular cross section is a pipe. (Fig 1)



Mild steel pipe after galvanisation are called galvanised iron pipes.

Advantages of G.I. pipes

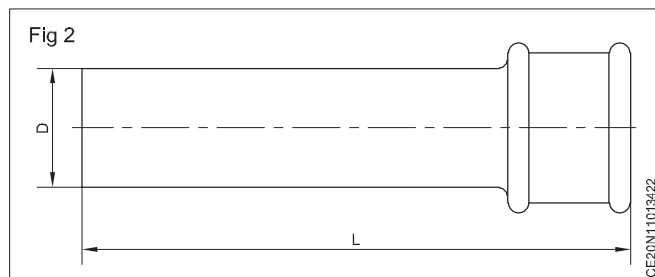
- It can withstand high pressure.
- It can be used for hot water supply.
- It will not get rusted easily because of galvanisation.
- It can be easily joined after threading.
- Cutting and making holes are easy.
- Standard fittings like bend, elbow, union are available.
- It is easy to detach joints.

Disadvantage

- These pipes are liable to corrosion in hazardous environments.
- This pipe can easily have affected by acidic or alkaline water.
- It is costlier compared to PVC pipe.

AC pipes

General: AC pipes are manufactured from pure asbestos fiber, portland cement and silica under high pressure in machines and are available from 5cm to 100cm in diameter and 2m to 3m in length. The pipes have socket at one end of the pipe for joining. AC pipes are used for carrying waste water or rain water. (Fig 2)



Advantages

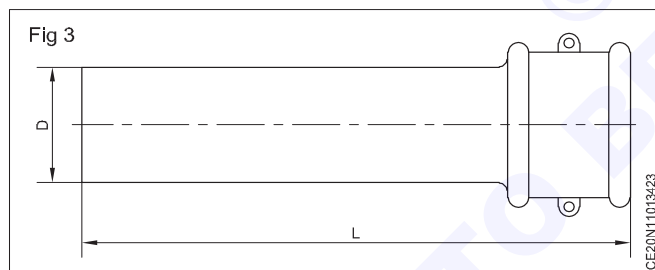
- It does not corrode.
- Transportation is easy because of its light weight.
- Cost is less compared to GI, CI pipes.
- It is easy to join.
- Cutting and drilling is easy.
- Inside of the pipe is smooth; therefore, has good carrying capacity.

Disadvantages

- AC pipes are brittle in nature therefore chances of breaking during handling and transportation is high.

C.I. pipe

C.I. pipes are manufactured using good quality grey cast iron. These pipes are manufactured in two different methods. i.e. sand casting or centrifugal casting. (Fig 3).



C.I. pipes are classified into 5 types based on its use and physical properties.

- C.I water supply pipes
- C.I drain and sewer pipes
- C.I soil pipes
- C.I waste pipes
- C.I rain water pipes

Types of PVC pipes

Polyvinyl Chloride (PVC)

- Polyvinyl chloride (PVC) is manufactured from ethylene or acetylene.
- It is essentially consisting of polymerisation of vinyl chloride.
- PVC has to be mixed besides plasticizers, with release agents, stabilizers etc. to make it easily processable.

Uses

- Non plasticized grades are widely used for the manufacture of pipes and conduits.
- It is used as cable coating because of its high Electrical Resistance.
- Blow molded components are used for replacement of glass for its high transparency.
- Non-toxic products are used for packing foods.
- Manufacture of Toys, dolls, paper coating, lampshade, etc.
- PVC is used for temperature below about 140°F.

Poly propylene Random Co-polymer (PPR)

- Latest and advanced Technology using raw material PP co-polymer.

Co-polymer vinyl chloride (CPVC)

- CPC and CPVC are made of the same basic elements.
- CPVC is altered by a free radical chlorination reaction that effectively increases the chlorine content of the material
- CPVC to be used for temperatures up to 190°F.
- CPVC pipe is an off-white or yellowish colour.
- CPVC pipe is more suitable for hot water and potable water system

Different types of pipe fittings socket, elbows, tee, union, bend, cap, plug, cross, ferrule. etc.,

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

- state the standard pipe fittings of various types and sizes and uses.

Standard pipe fittings

Coupling: An ordinary coupling shown in (Fig 1), usually comes with the pipe, one coupling to each length. The couplings are made of wrought iron or cast iron metal or of brass.

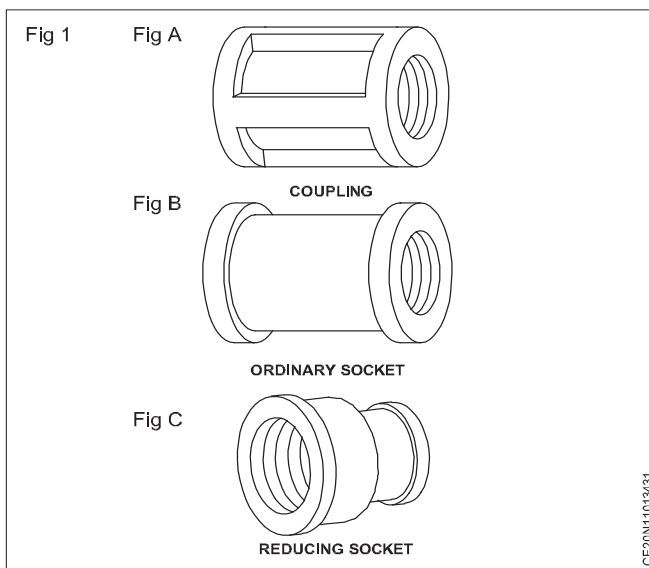
Reducing socket (Fig 1c): This is an internal threaded fitting. A reducing socket is used to connect two pipes with different diameters.

Elbows (Fig 2): Elbows and bends provide deviations of 90° and 45° in pipe work systems.

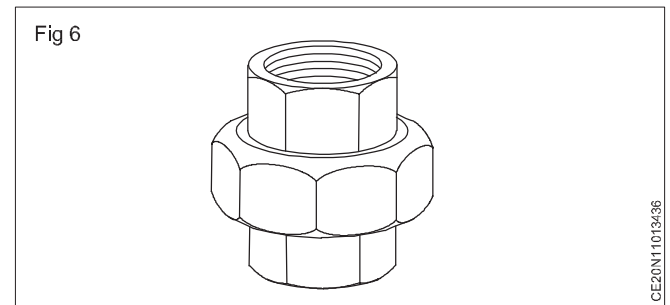
The 45° elbows allow pipe deviation of 45° (Fig 2b).

Reducer elbow (Fig 2 C): A reducer elbow is used to connect two different dia pipes in deviation of 90° in pipe line work systems.

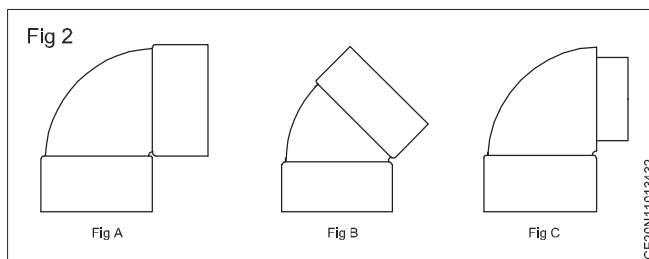
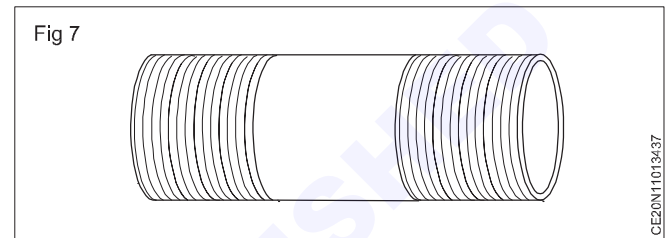
Three way elbow: A times way elbow is used to connect three pipes at deviation of 90°. (Fig 3)



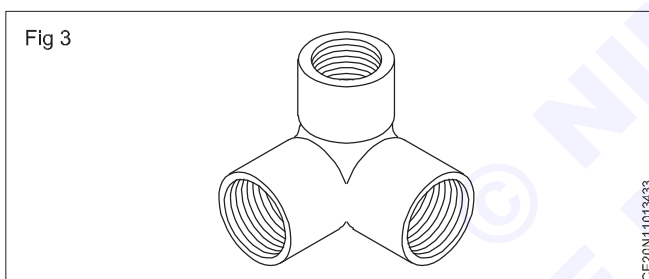
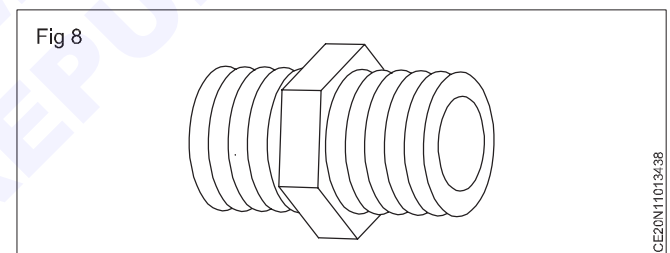
Union: A device used to connect pipes when unions are used in pipe lines and it is easy to dismantle and repair. (Fig 6)



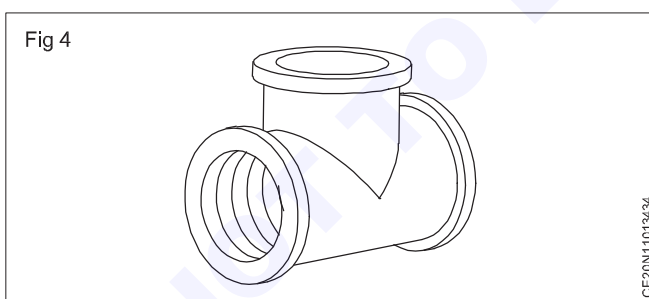
Pipe nipples (Fig 7): A nipple is a piece of pipe less than 3 CM length thread on both end.



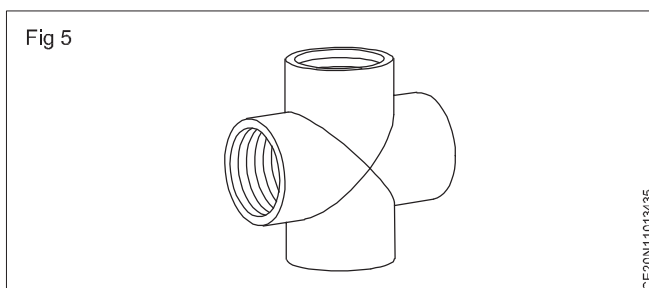
Hexagonal nipple (Fig 8): This nipple is used where fittings or valve are to be very close to each other. Both sides are external threaded and a hexagonal step at the middle for gripping. (Fig 8)



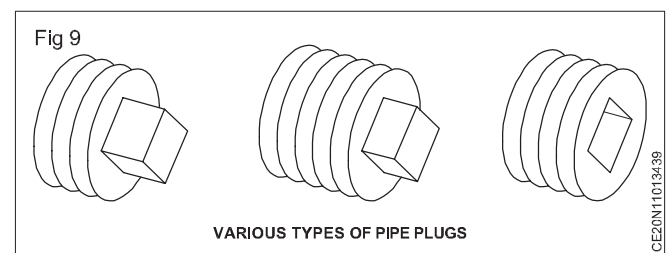
Tee (or) Three way: A tee is used to take a branch line at deviation of 90°. (Fig 4)



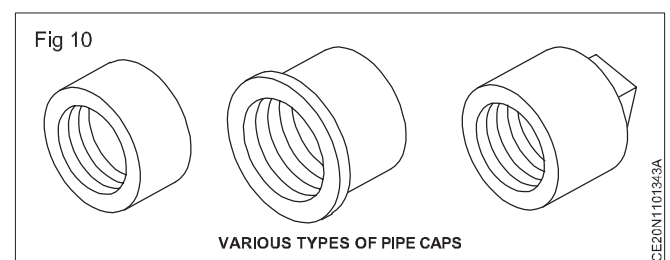
Four way: A fourway is used to connect four bits from straight line two opposite 90° are joined. (Fig 5)



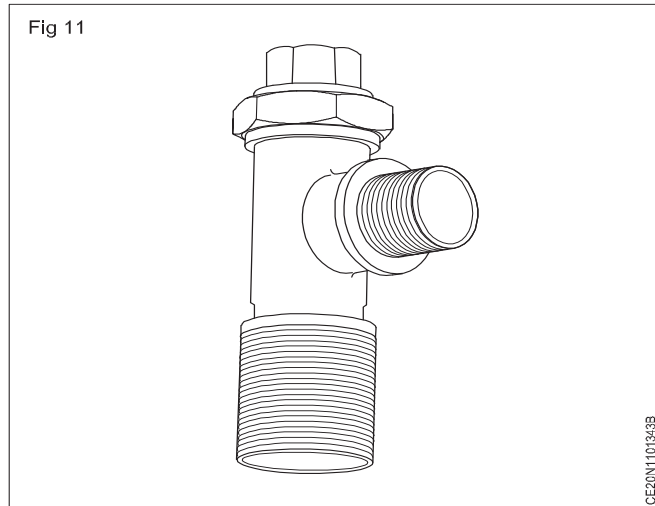
Plug (Fig 9): A plug is used for closing the end of a pipe or a fitting having a female thread.



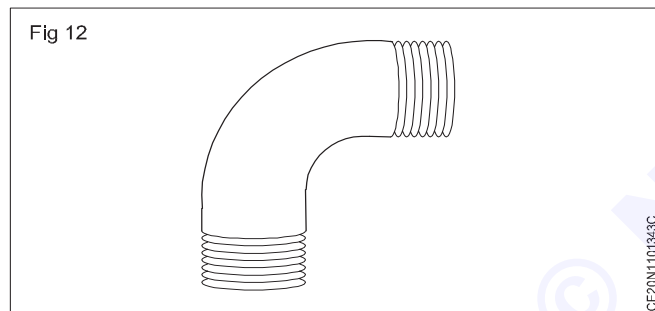
CAP (Fig 10): A cap is female threaded and is used for closing the end of a pipe.



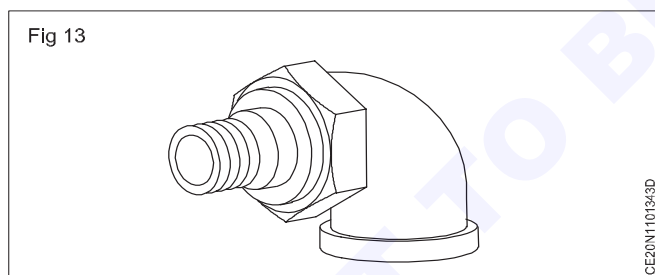
Ferrule (Fig 11): This ferrule is made of gun metal and is used to take service connection from water supply main line. It is fitted in the C.I pipes and P.V.C supply main line. It is fitted in the C.I pipes and P.V.C saddle.



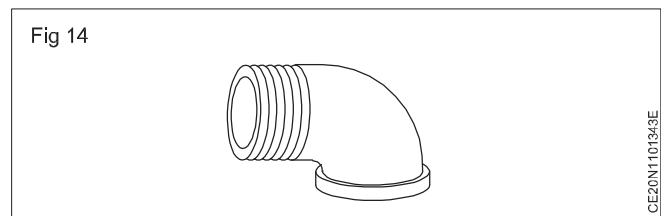
Bend (Fig 12): This bend is made of G.I pipe having external thread on both end. It is used to join with the male threaded pipes using couplings or flanges join directly to the female threaded fittings.



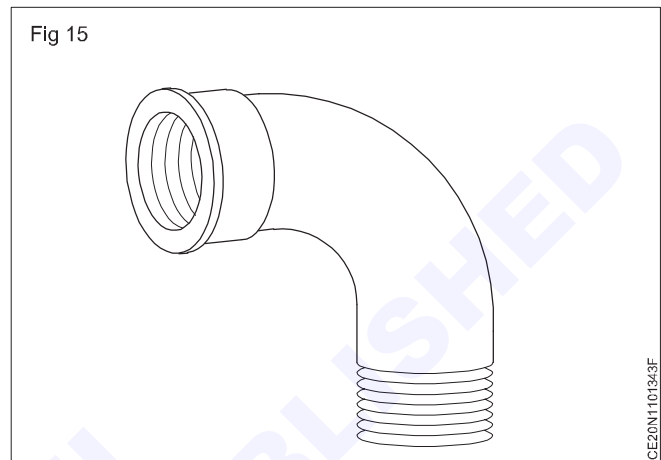
Union elbow (Fig 13): A pipe fitting with a male union at one end.



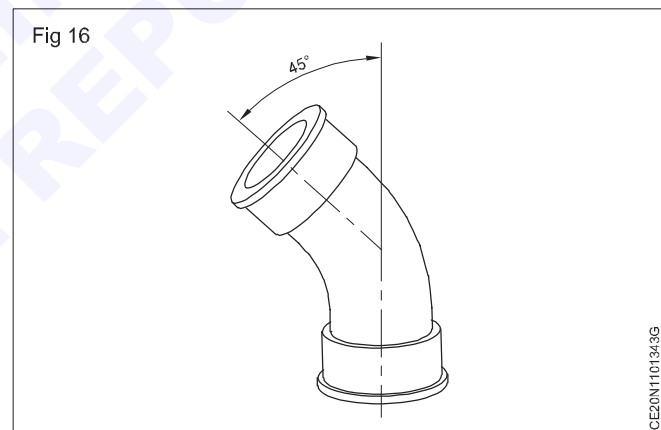
Elbow M+F: A pipe fitting as above only one internal threads and other one external thread. (Fig 14)



Bend (M+F): A fitting as before but with an external thread and internal thread. (Fig 15)



Bend 45° (F+F): A fitting as before. Both ends have internal threads. (Fig 16)



Types of fittings for different joints and different pipes

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

- state the different fittings used for different pipe joints and their uses.

Describe

Mainly pipes are used for handling & transporting the water in position.

The pipe joints are classified as follows

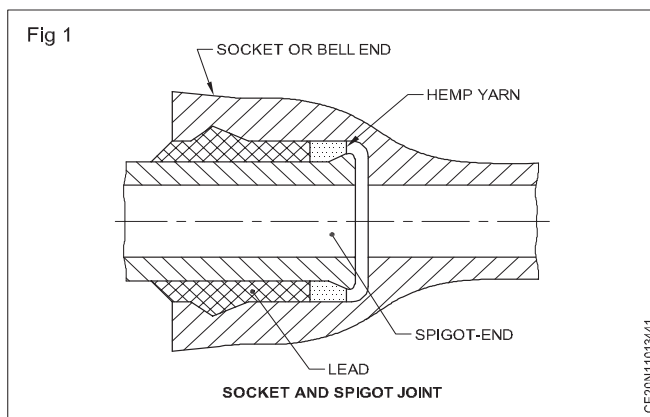
1 Socket and spigot joint (Fig 1)

This types of joints are mostly used for cast iron pipes.

2 Expansion joint (Fig 2)

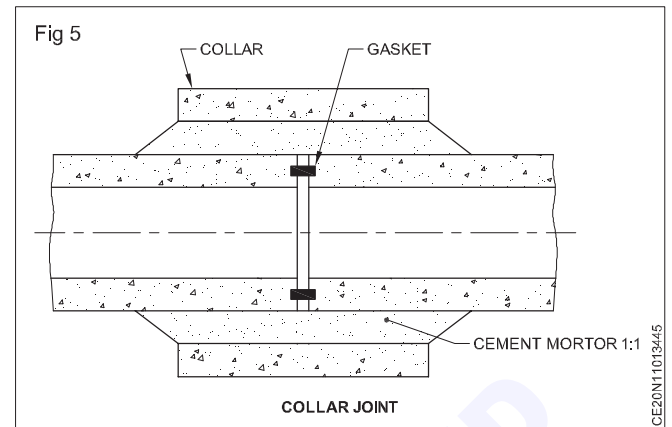
This joint is used at such places where pipes contract due to change in atmospheric temperature and thus checks the setting of thermal stresses in the pipe.

3 Flanged joint (Fig 3): This joint is mostly used for temporary pipe lines, because the pipe line can be dismantled and again assembled at other place. The pipe in this case has flanges on its both end welded or screwed with pipe.



This joint is mostly used for connecting small dia. cast iron, wrought iron and galvanised pipes.

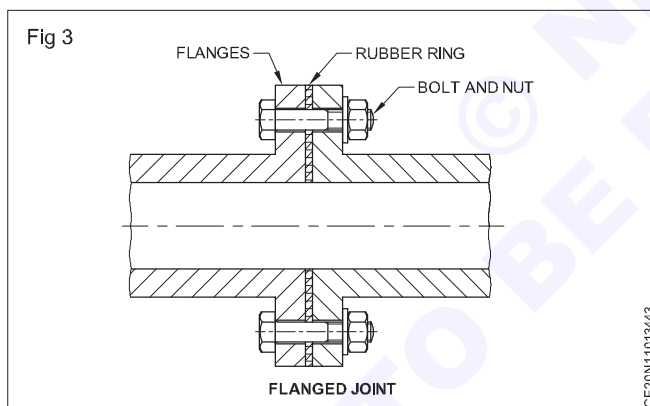
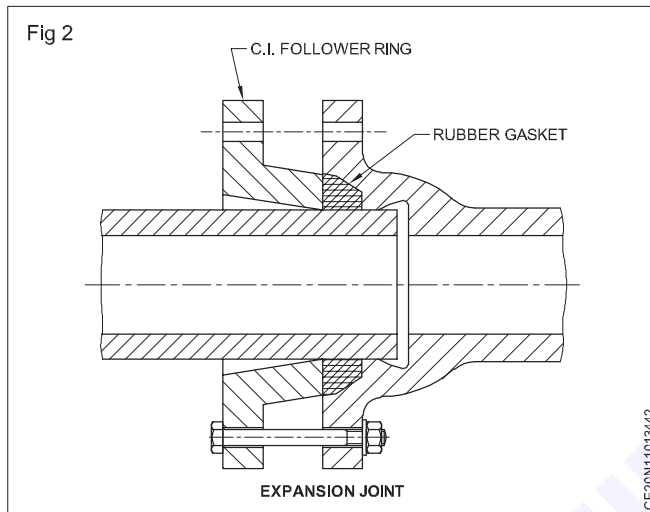
5 Collar joint (Fig 5)



This type of joints are mostly used for joining big diameter concrete and asbestos cement pipes.

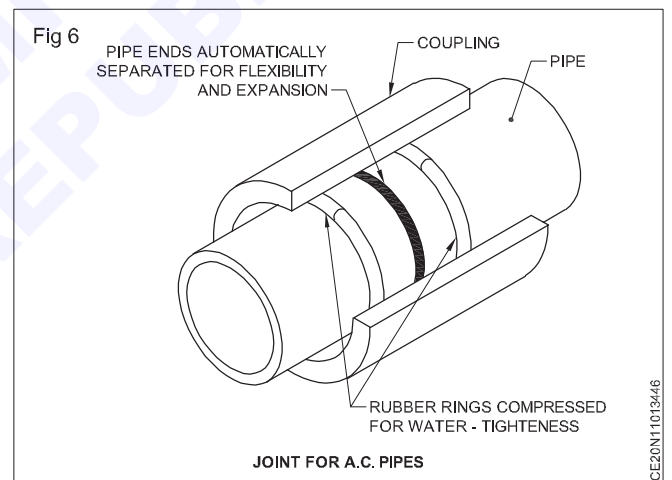
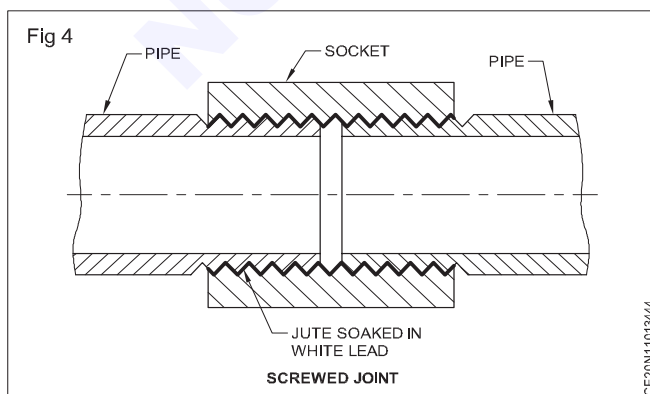
6 AC pipe Joint

For joining small diameter AC pipe the two ends of pipes are butted against each other than two rubber ring will be slipped over the pipes and the coupling will be pushed over the rings as shown in (Fig 6).



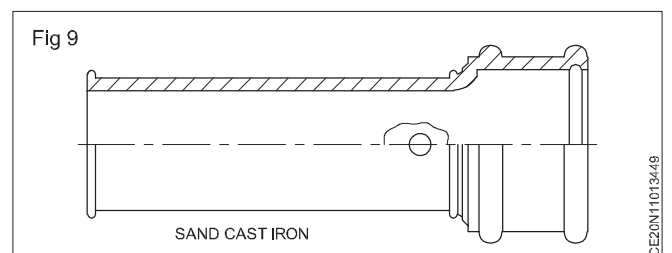
These joints are commonly used for joining pumping station, filter plants, hydraulic laboratory boiler, house etc.

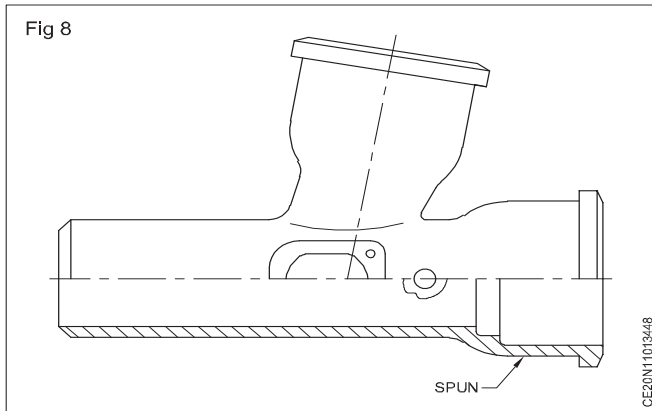
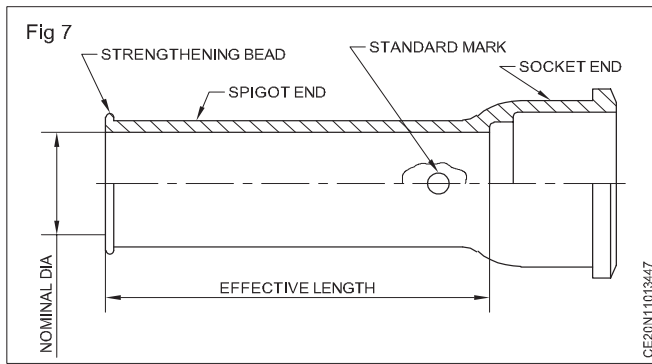
4 Screwed joint (Fig 4)



Sand cast iron pipes

Sand cast iron spigot as socket soil and waste and ventilating pipes, fittings and accessories should confirm is 1729. Centrifugally cast (spun) iron spigot and socket soil, waste and ventilating pipes fittings and accessories should confirm IS3989. These pipes can be recognized by looking at the socket shape. These pipes are available at 1.5, 1.75, 2, 2.5 and 3m lengths. (Figs 7,8,9)





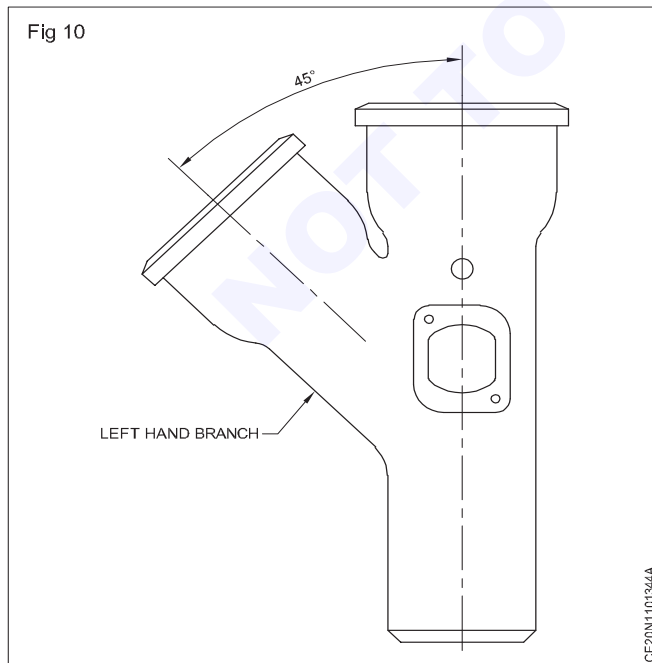
C.I Pipe fittings

Very extensive range of cast iron fittings is available. Always check the following points.

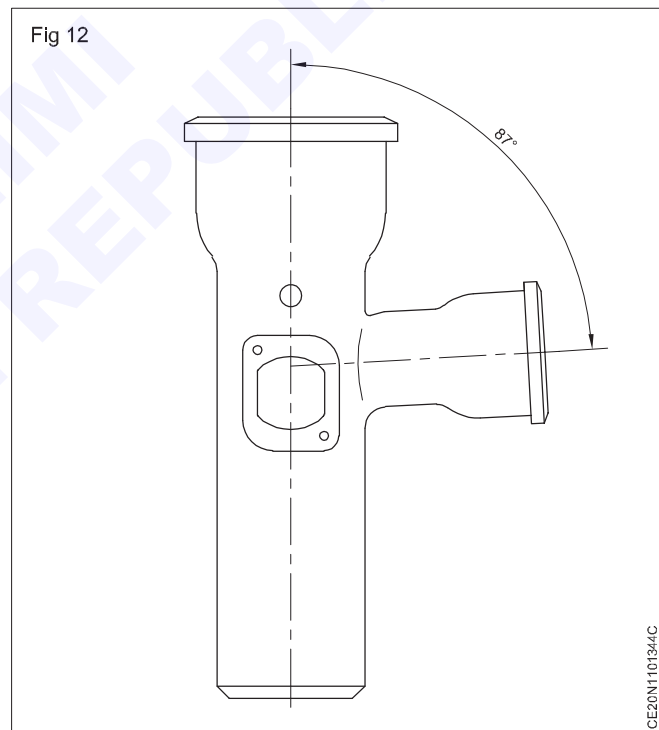
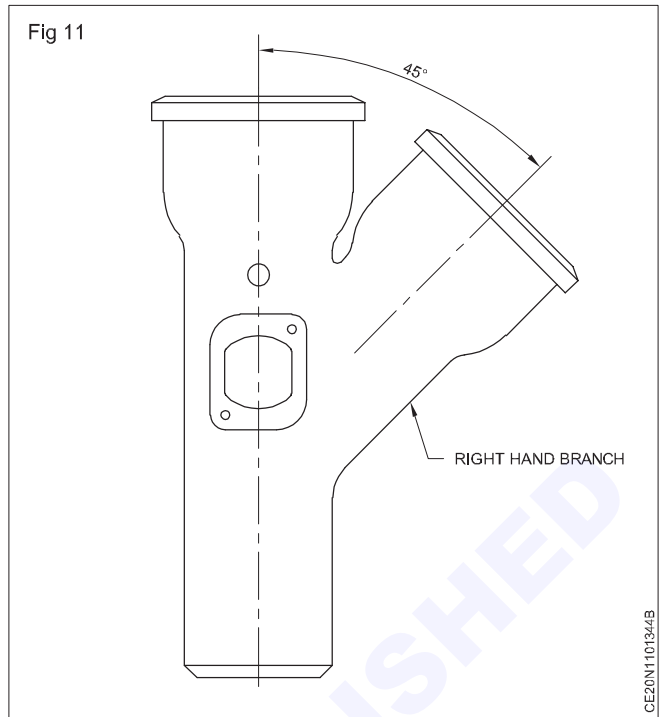
- Nominal diameter
- Standards mark
- Inspection opening
- Left or right hand branch
- Angle of branch
- Effective length

Specification branches can be handed either left or right.

- Shows a left hand branch (Fig 10).

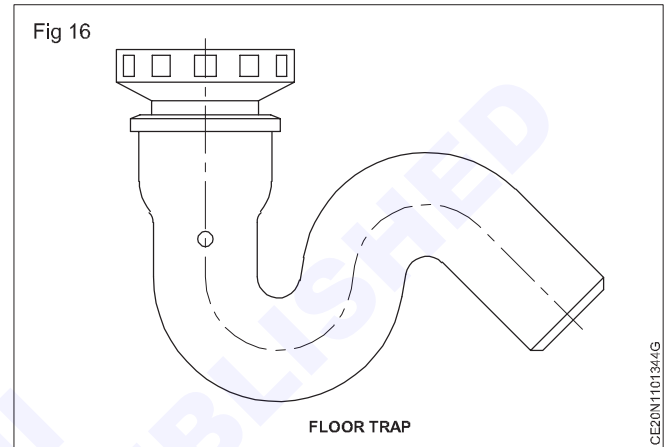
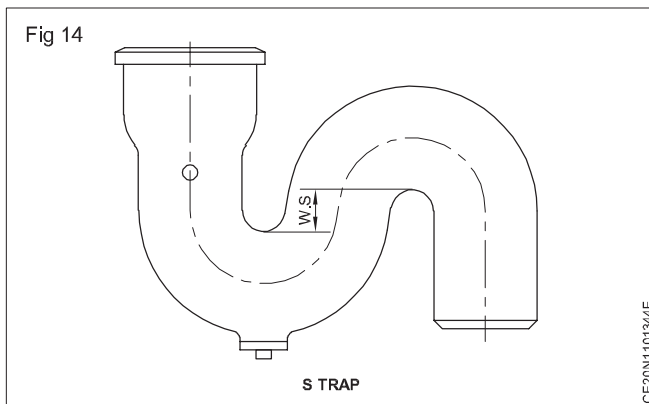
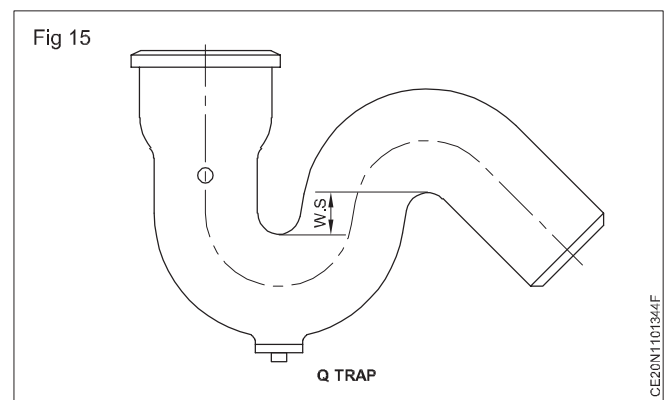
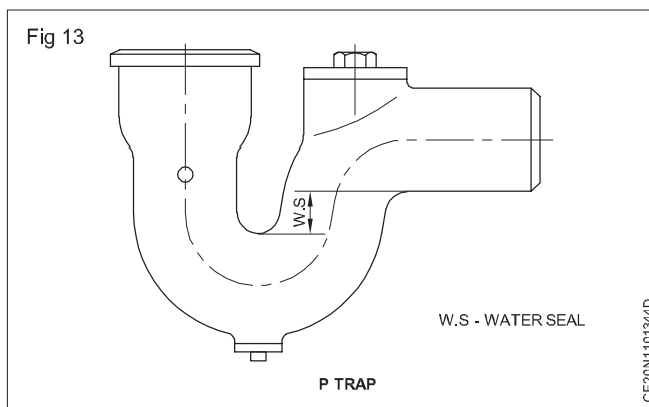


- Shows a right hand branch (Fig 11,12).



C. I traps are fitted in an installation to prevent foul air passing into the building. Three common types of traps are P trap, S trap and Q trap. (Figs 13, 14, 15).

Floor outlets are fitted areas such as kitchen, bathrooms and corridors. Surface cleaning water is discharged into outlet through a trap as shown in (Fig 16).



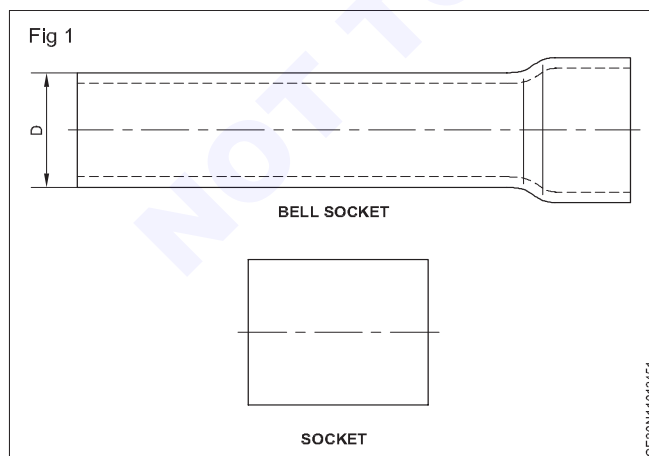
Different kinds of joints fittings and materials in joining pipes PVC/CPVC, PPR and HDPE

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

- state the different PVC fittings used for different purposes
- state the different CPVC pipe and HDPE fittings.

PVC pipes

General: PVC pipes are manufactured using poly vinyl chloride and additives. PVC pipes are available in 6 metres length and the pipe is specified by the outer diameter of the pipe. PVC pipes are available with bell or socket end. (Fig 1)



Advantages

- PVC pipes are light weight.
- They are corrosion free.

- Cost of PVC pipe is cheaper than G.I./C.I./A.C pipes.

Disadvantages

- PVC pipes could not be used for carrying hot water.

Types of PVC pipes

- Low density polyethylene pipes.
- High density polyethylene pipes.
- Polyethylene pipes are normally available in black colour.
- Rigid (un plasticized).

Uses: PVC pipes are used for carrying drinking, waste and rain water.

PVC pipe fitting (Fig 2)

Un plasticized polyvinyl chloride (UPVC) pipe: There are two types of pipes as detailed under

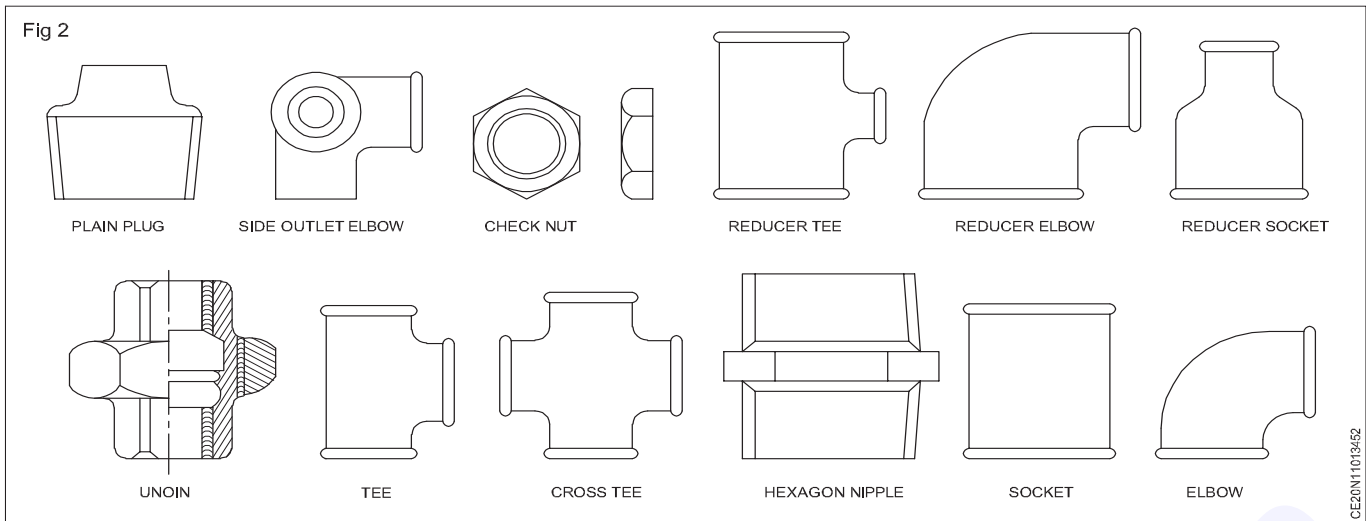
Type A: for use in ventilation pipe work and rain water application.

Type B: for use in soil and waste discharge system.

Types of PVC joints and their uses union

It is a fitting used to connect two pipes.

Fig 2



Socket

These fittings are used to connect one length to another, for continuation of the pipe line.

Elbow

It connects two pipes at 90° has a short curvature.

Bend

Bend connects two pipes at any required angle. It cannot be used in walls because of a layer curvature.

Tee

Tee is a fitting with a side outlet at 90° to the run of the pipe.

Cross Tee

Cross tee is a fitting with four branches arranged in pairs each at right angles to the other.

Reducer

This fitting is larger at one end than the other. It is used to connect pipes of two different diameters

Barrel nipple

It is a piece of pipe threaded at both ends and can be used for short extension of the plumbing line.

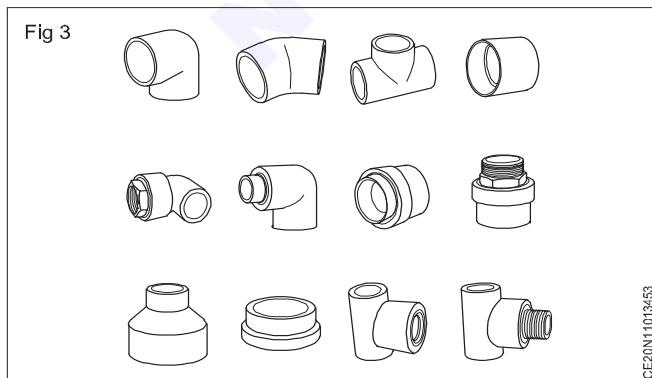
Double nipple

It is used to connect two fittings within a short distance. It has threads on both sides of the central piece.

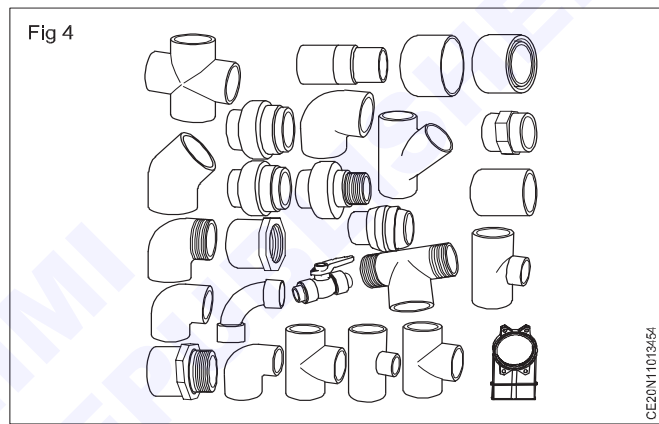
Plug

Plug has an exterior pipe thread end and a projecting head for fitting in the socket.

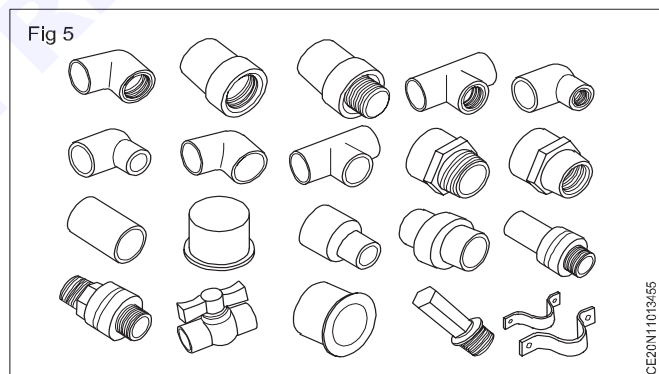
HDPE pipe fittings (Fig 3)



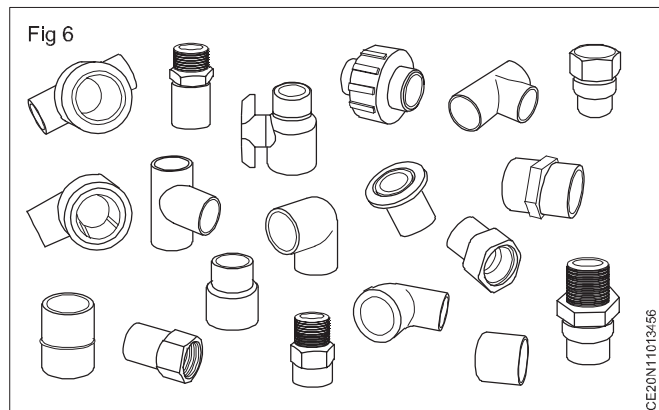
PVC pipe fittings (Fig 4)

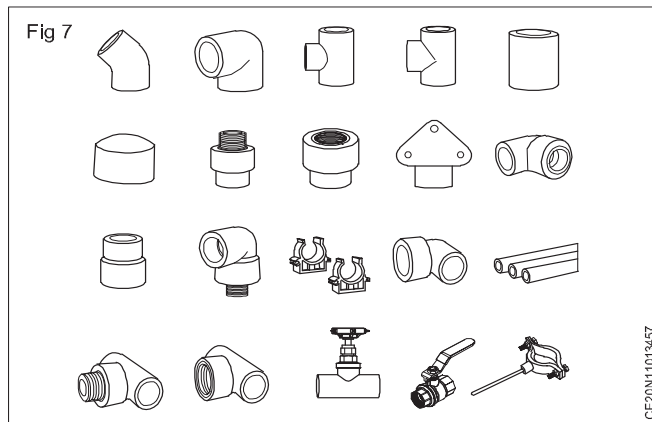


UPVC pipe fittings (Fig 5)



CPVC pipe fittings (Fig 6)





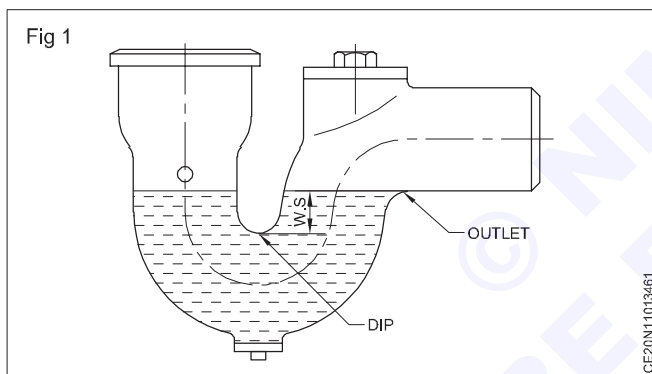
Types of traps

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

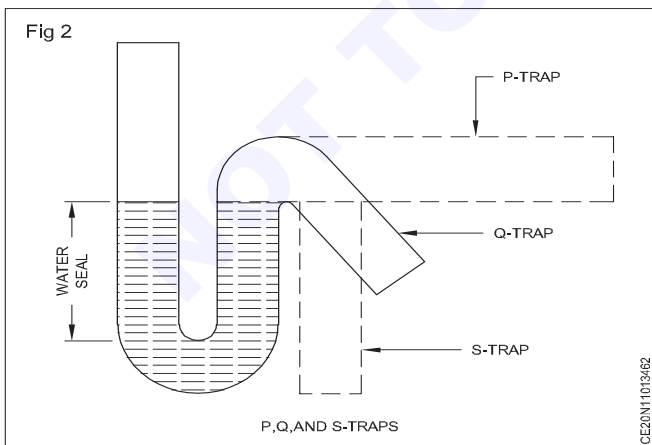
- state types of traps and uses.

Definition

Traps may be defined as fittings, placed at the ends of the soil pipes or the sullage pipes (waste pipes) to prevent the passage of foul gases from the pipes to the outside. (Fig 1)



Types: Depending upon their shapes, the traps may be of three types i.e P-trap, Q-trap and S-trap are used for water closet soil discharge. (Fig 2)

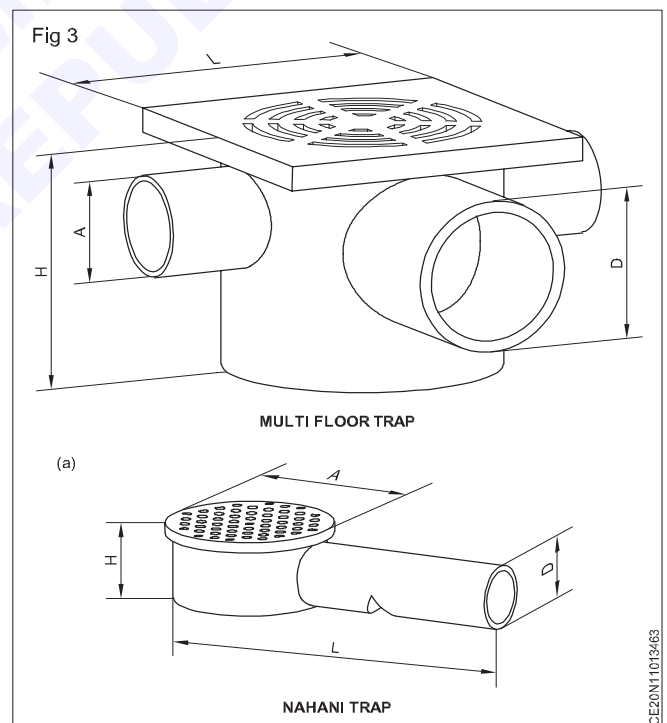


Depending upon their use, the traps may again be of three types i.e Floor trap, Gully trap and Intercepting trap.

These three different types of traps are briefly described below: 'P', 'Q', and 'S', traps. (Fig 2)

Floor traps (Fig 3): These traps are generally used to admit waste water (sullage) from the floors of rooms, kitchens, baths, etc. into the said room drain (sullage pipe).

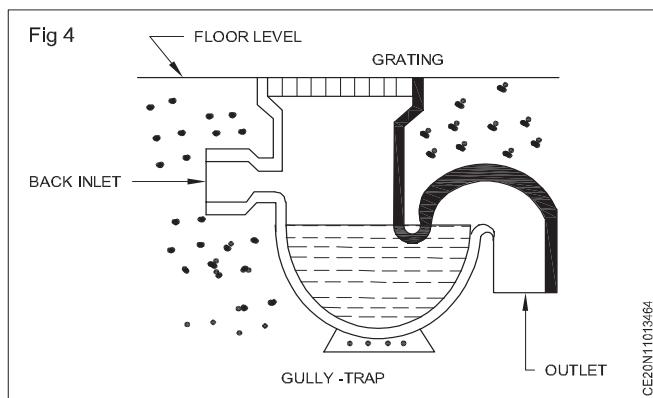
A commonly used trap is Nahani trap. (Fig 3a) for multi in let multi floor trap is used Fig 3a.



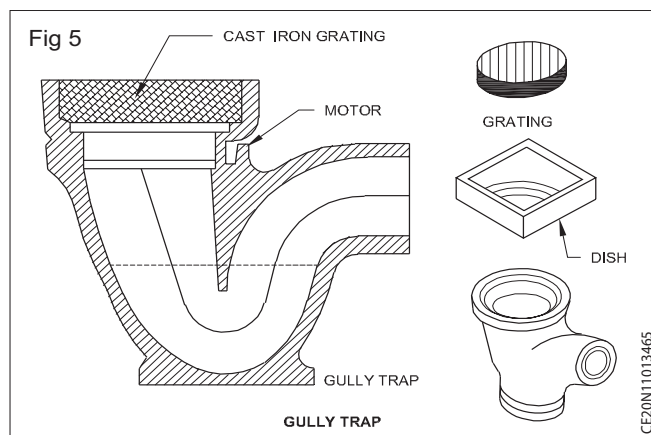
The following types of traps are most commonly used in practice:

A gully trap or a gully is often provided at the junction of a room or a roof drain and the other drain coming from bath, kitchen etc.

Gully traps may either have a S-trap or a P-trap. The water seal is usually 50mm to 75mm deep. The top of the trap is covered by a C.I grating to exclude the entry of coarser materials to avoid blockage. (Fig 4)



Gully Trap Chambers: The Gully Trap Chambers shall consist of brick masonry chambers suitable for the specified size of the Gully Traps. The traps shall be glazed stoneware of approved make. (Fig 5)



Method employed for bending, Joining and fixing PVC pipe

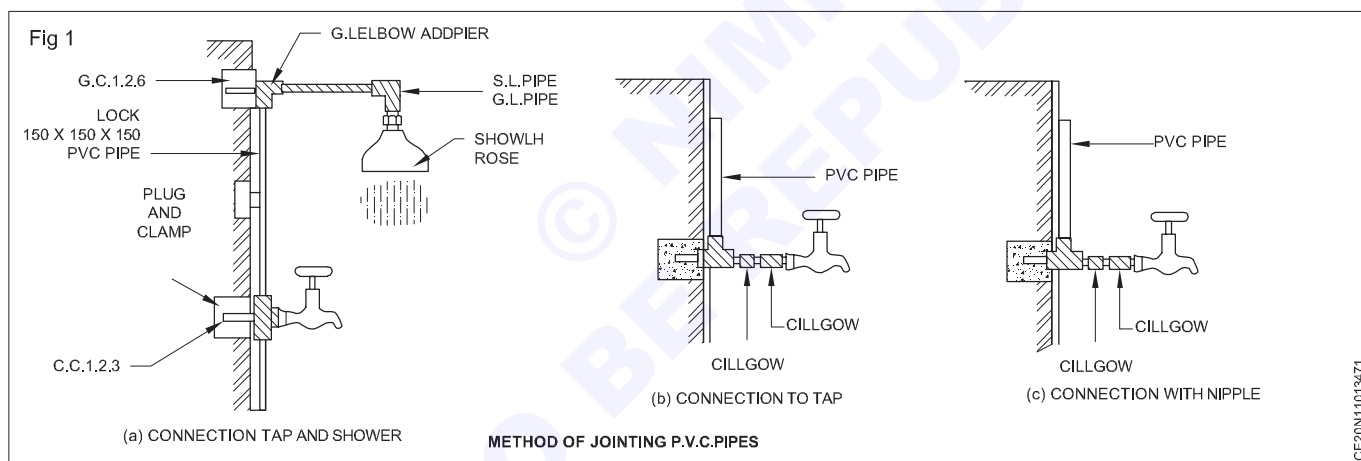
Objective: At the end of this lesson you shall be able to

- state the laying and jointing PVC pipes.

Laying and jointing un plasticized P.V.C. Pipes (External work) (Fig 1)

Un plasticized P.V.C. pipes are light in weight material.

Reasonable care shall be taken in handling and storage of to prevent damages.



a Trenches

The trench bottom shall be carefully examined for the presence of hard object such as flints, rock projections or tree roots etc. Pipes free from rock and gravel. Back fill 15 cm above the pipe to prevent damages pipes shall not be painted. The width of the trench shall be outside diameter of the pipe plus 30 cm. Pipes shall be laid at least 90 cms below the ground level (measured from surface of the ground to the top of the pipe).

b Jointing with solvent cement joint (Fig 1)

The pipe shall be cut perpendicular to the axis of the pipe length with a metal cutting saw. The total length of insertion socket shall be marked on the pipe and checked how far the pipe end could be inserted into the fitting socket. Attempt shall be made to push the pipe to the marked distance, if not possible it shall at least be pushed for 2/3 of this distance.

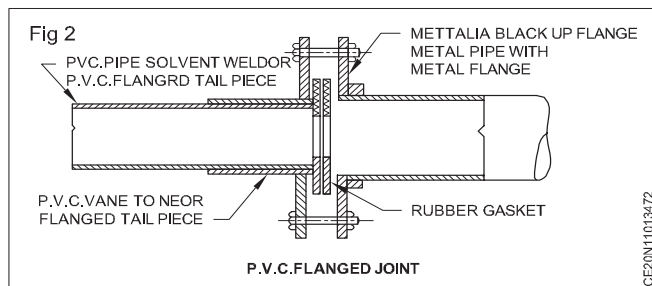
Dust, oil, water, grease etc. shall be wiped out with a dry cloth from the surface. Further the grease should be thoroughly removed with a suitable solvent, such as methylene chloride outside surface of the pipe and the inside of the fitting may be roughed with emery paper.

Generous coatings of solvent cement shall be evenly applied on the inside of the fitting and outside of the pipe end up to the marked line with non-synthetic brush. The pipe shall be pushed into the fitting socket and held for 1 or 2 minutes. If the surplus cement on the pipe surfaces pipe will come out of the fitting.

In summer month's joints shall be made preferably early in the morning or in the evening when it is cooler. This will prevent joint from pulling apart when the pipe cools off at night.

c Flanged Joints (Fig 2)

For jointing P.V.C. pipes particularly of large sizes to valves and vessels and large size metal pipes where the tensile strength is required for the joint.

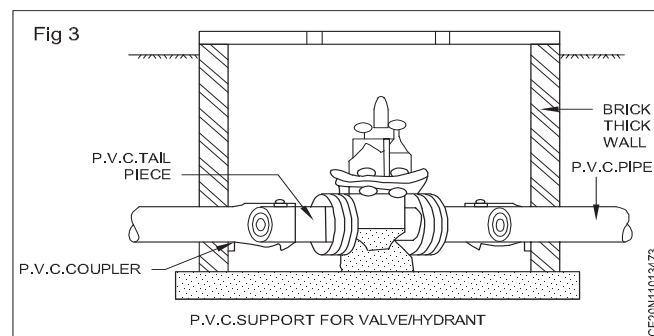


e Supports for Valve and Hydrant (Fig 3)

Valve and hydrant tees shall be supported as shown in (Fig 3) So that the torque applied in operating a valve is not transmitted to the pipe line.

Laying and jointing P.V.C. pipes (Internal work)

Clamping: The pipes shall be laid and clamped to wooden plugs fixed above the surface of the wall. Line or point contact with the pipe shall be avoided. Heavy components such as metal valves shall be individually supported.



- **Connection to a water Tap:** Connection to the water tap shall be made by means of a G.I. adopter.
- **Connection to a Shower Rose:** Shower rose connection shall be of G.I. pipes as shown
- **Connection from Masonry/Concrete Water Tank:** Solvent cement shall be coated on the section of the pipe to be embedded concrete.

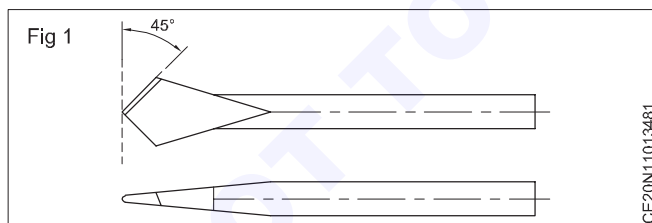
Drills types and uses

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

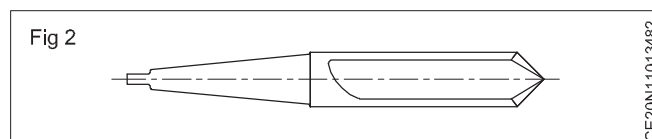
- state the various types of drill and uses.

Drilling is a process of making holes on work pieces. The tool used for drilling is a drill and it is rotated with a downward pressure causing the tool to penetrate into the material.

Flat or spade drill (Fig 1) : This type of drill is used where the required size of twist drill is not available. It is made from a round tool steel piece. This type of drill is used for hand drilling (without power) or with a ratchet brace.

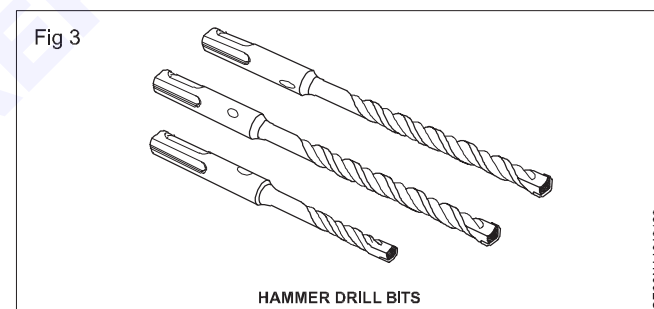


Straight fluted drill (Fig 2): It has grooves or flutes running parallel to the drill axis. It is mainly used in drilling brass, copper or soft materials.

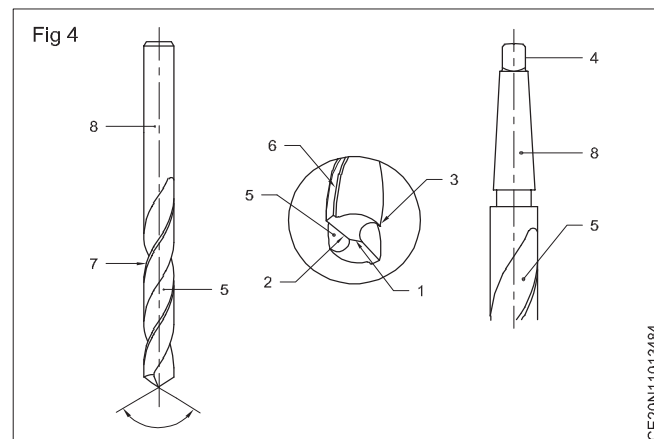


Hammer drill bit (Fig 3)

Hammer drills are not typically used for production construction drilling but rather for occasional drilling of holes into concrete masonry or stone.



Twist drills (Fig 4) : In this type, two spiral flutes or grooves run length wise around the body of the drill. It is the most common type of drill used for all purposes, and especially for faster drilling of accurate holes and for harder materials - in comparison with the other drills.



Parts of a twist drill

Point: The cone shaped end which does the cutting is called the point. It consists of a dead centre (1), lips or cutting edge (2) and a heel (3).

Tang (4): This is provided only on taper shank drills, for driving (giving torque to) the drill, which when overloaded, becomes twisted or gets sheared off.

Flutes (5): Flutes are the spiral grooves which run to the length of the drill. The flutes help.

to form the cutting edge

to curl the chips and allow these to come out

the coolant to flow to the cutting edge.

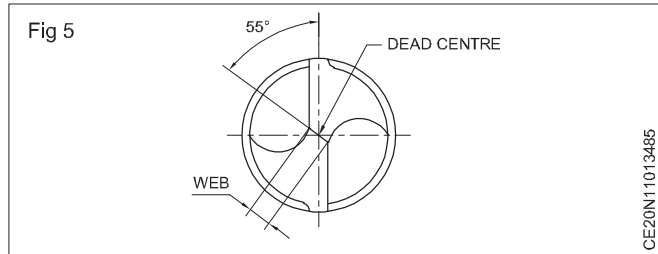
Shank (6): This is the driving end of the drill which is fitted on to the machine. Shanks are of two types.

Taper shank, with Morse taper provided, is used for larger diameter drills, and the straight shank is used for smaller diameter drills.

Land/margin (7): The land/margin is the narrow strip which extends to the entire length of the flutes. The diameter of the drill is measured across the land/margin.

Body clearance (8): Body clearance is that part of the body which is reduced in diameter to cut down the friction between the drill and the hole being drilled.

Web (Fig 5): Web is the metal column which separates the flutes. It gradually increases in thickness towards the shank.



Material for twist drills

Twist drills, used in a machine shop, are usually made out of high speed steel. For drilling hard materials at higher cutting speeds, there are drills with carbide tips, brazed at the lips of the drill.

Tap and dies types and uses, calculation of tap drill size

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

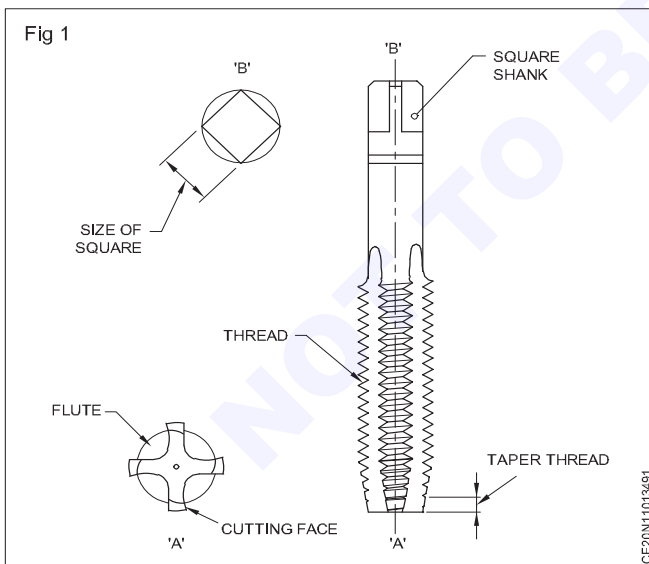
- state the uses of hand taps
- state the types of dies and its uses.

Hand taps and wrenches

Use of hand taps: Hand taps are used for internal threading of components.

Features (Fig 1): They are made from high carbon steel or high speed steel, hardened and ground.

The threads are cut on the surface, and are accurately finished.



To form the cutting edges, flutes are cut across the thread.

The end of the shank of the tap is made of square shape for the purpose of holding and turning the taps.

The ends of the taps are chamfered (taper lead) for assisting, aligning and starting of the thread.

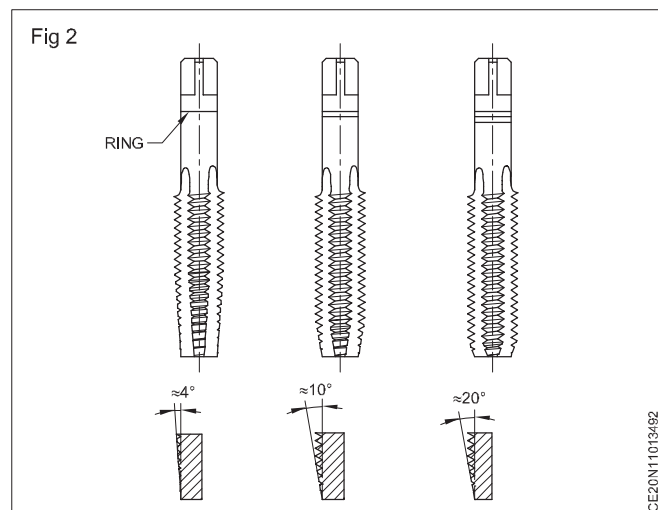
The size of the taps, the thread standard, the pitch of the thread, the dia. of the tapping hole are usually marked on the shank.

Markings are also made to indicate the type of tap i.e. first, second or plug.

Types of taps in a set: Hand taps for a particular thread are available as a set consisting of three pieces. (Fig 2)

These are:

- first tap or taper tap
- second tap or intermediate tap
- plug or bottoming tap.

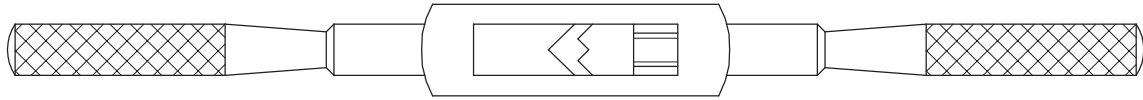


Tap wrenches: Tap wrenches are used to align and drive the hand taps correctly into the hole to be threaded.

Tap wrenches are of different types, such as double-ended adjustable wrench, T-handle tap wrench, solid type tap wrench etc.

Double-ended adjustable tap wrench or bar type tap wrench (Fig 3): This is the most commonly used type of tap wrench. It is available in various sizes - 175, 250, 350 mm long. These tap wrenches are more suitable for large diameter taps, and can be used in open places where there is no obstruction to turn the tap. It is important to select the correct size of wrench.

Fig 3

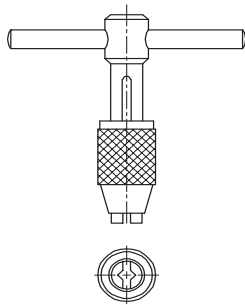


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T-handle tap wrench (Fig 4): These are small, adjustable chucks with two jaws and a handle to turn the wrench.

This tap wrench is useful to work in restricted places, and is turned with one hand only. Most suitable for smaller sizes of taps.

Fig 4

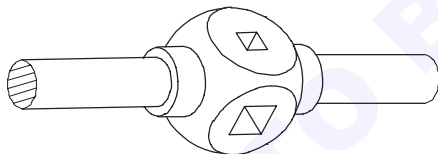


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Solid type tap wrench (Fig 5): These wrenches are not adjustable.

They can take only certain sizes of taps. This eliminates the use of wrong length of the tap wrenches, and thus prevents damage to the taps.

Fig 5



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Tap drill size

What is tap drill size? Before a tap is used for cutting internal threads, a hole is to be drilled. The diameter of the hole should be such that it should have sufficient material in the hole for the tap to cut the thread.

Tap drill sizes for different threads

ISO metric thread

Tap drill size for M10 x 1.5 thread

Minor diameter = Major diameter - (2 x depth)

Depth of thread = $0.6134 \times \text{pitch of a screw}$

2 depth of thread = $0.6134 \times 2 \times \text{pitch}$

= $1.226 \times 1.5 \text{ mm}$

= 1.839 mm

Minor dia. = $10 \text{ mm} - 1.839 \text{ mm}$

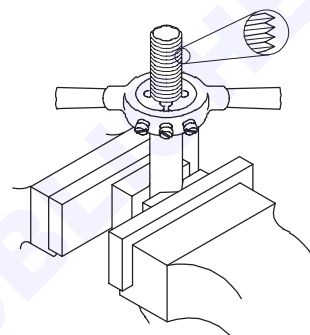
= 8.161 mm or 8.2 mm.

Dies and die stock

Uses of dies

Threading dies are used to cut external threads on cylindrical work pieces. (Fig 6)

Fig 6



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Types of dies

The following are the different types of dies.

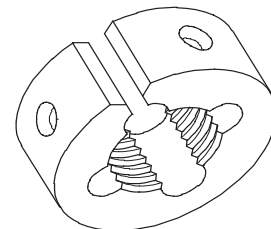
- Circular split die (Button die)
- Half die
- Adjustable screw plate die

Circular split die/button die (Fig 7)

This has a slot cut to permit slight variation in size.

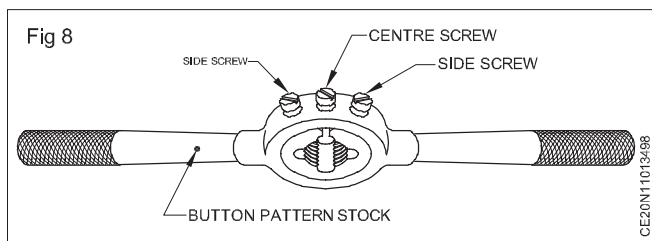
Dies are made of high speed steel.

Fig 7



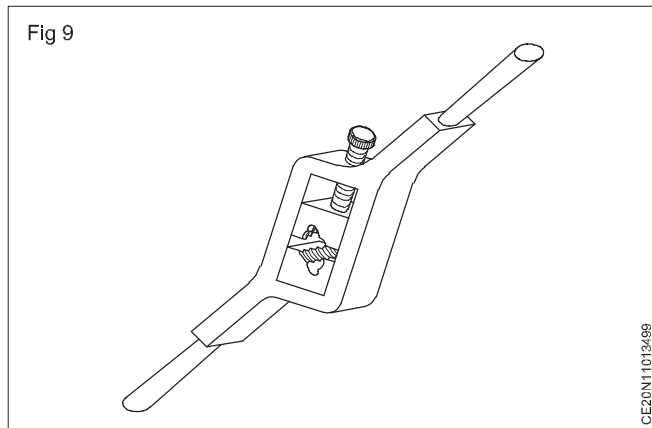
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When held in the diestock, variation in the size can be made by using the adjusting screws. This permits increasing or decreasing of the depth of cut. When the side screws are tightened the die will close slightly. (Fig 8) For adjusting the depth of the cut, the centre screw is advanced and locked in the groove. This type of die stock is called button pattern stock.



Half die (Fig 9)

Half dies are stronger in construction.



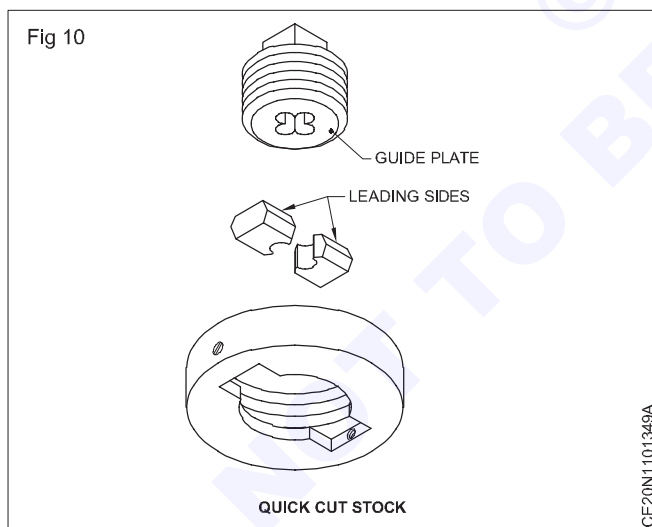
Adjustments can be made easily to increase or decrease the depth of cut.

These dies are available in matching pairs and should be used together.

By adjusting the screw of the die stock, the die pieces can be brought closer together or can be moved apart.

They need a special die holder.

Adjustable screw plate die (Fig 10)



This is another type of a two-piece die similar to the half die.

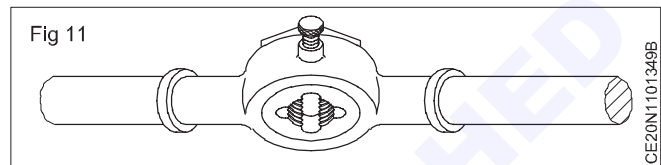
This provides greater adjustment than the split die.

The two die halves are held securely in a collar by means of a threaded plate (guide plate) which also acts as a guide while threading.

When the guide plate is tightened after placing the die pieces in the collar, the die pieces are correctly located and rigidly held.

The die pieces can be adjusted, using the adjusting screws on the collar.

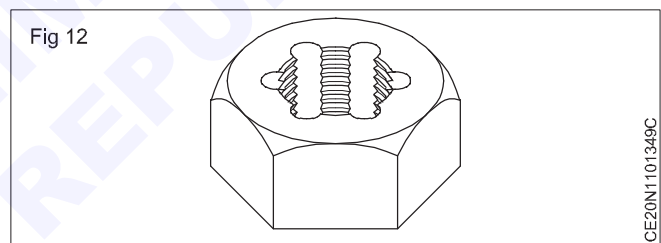
This type of die stock is called quick cut die stock. (Fig 11)



The bottom of the die halves is tapered to provide the lead for starting the thread. On one side of each die head, the serial number is stamped.

Both pieces should have the same serial numbers.

Die nut (Solid die) (Fig 12)



The die nut is used for chasing or reconditioning the damaged threads.

Die nuts are not to be used for cutting new threads.

The die nuts are available for different standards and sizes of threads.

The die nut is turned with a spanner.

Sanitary technical terms

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

- state the different sanitary technical terms.

Technical terms: Wholesome water The water which is unpolluted, free from toxic substances, excessive amounts of minerals and organic matter, pleasant and safe to drink. This is also known as potable water.

Potable water: Wholesome water is also known as potable water.

Safe water: Water which is unpalatable and free from disease producing bacteria.

Distilled water: Distilled water is safe water which is bacteriologically and chemically pure.

Rate of demand: It is the per capita consumption. The total water requirement for the domestic use, public or civic use, industrial use, commercial use and water loss and waste are usually expressed in terms of per capita consumption per day. Also the water requirement for domestic animals and other live stocks are expressed in terms of animal per day.

Fire demand: This is the quantity of water required for firefighting purpose. The quantity of water required for fire prevention is taken as 1 litre per capita per day which is about 5% to 10% of total consumption.

Design period: It is the future period for which various service units of water supply or sanitary works are designed.

Detention period: It is the theoretical time taken by a particle to pass between entry and exit of a sedimentation basin.

Precipitation: Precipitation is the water falling from the atmosphere to the surface of the earth in the form of rain, hail, etc. Rainfall is the most important part of precipitation.

Water bearing stratum: It is an aquifer holding water. It is the underground natural water storage reservoir, from which water can be withdrawn.

Water table: It is the upper surface of free water in top soil. It is also known as ground water level.

Intakes: Intakes are structures used to collect water from the surface sources which are relatively clean, free from pollution, sand and other objectionable floating materials.

Water pollution and contamination of water: Water pollution indicates the act of destroying or spoiling the purity and sanctity of natural water bodies. Hence water pollution makes water foul and filthy. Contamination is the presence of bacteria from the intestinal tract of warm blooded animals including

human beings. The presence of bacteria is an indication of water containing human disease germs.

S.No	Pollution	Contamination
1	General term which includes contamination also.	Specific term which indicates pollution.
2	Makes water unfit for the best use.	Makes water unsafe and unreliable for use.
3	Makes water objectionable to human senses of sight, odour, taste, etc	Does not make apparently objection able.
4	Saline water, turbid water, etc are examples for polluted water.	Water containing high concentration of pathogens, etc, is an example for contaminated water.

Water main: Principal pipe in a system of pipes for conveying water, especially one installed underground.

Storage tank: A tank or cistern for storage of water which is connected to the water main by means of a supply pipe.

House plumbing: The materials and system used for the installation, maintenance, extension, alteration of pipe system of a house or building is called house plumbing.

Plumbing system: It includes supply and distribution pipes, fixtures, taps, valves, soil, vent and waste pipes, drains, sewers and all their connections.

Available head: It is the water head available from a water main to the plinth level of the building.

Air gap: An air gap, is the unobstructed vertical space between the water outlet and the flood level of a fixture.

Back flow: It is a term in plumbing for an unwanted flow of water in the reverse direction. It can be a serious health risk for the contamination of potable water supplies with foul water. In the most obvious case, a toilet flush cistern and its water supply must be isolated from the toilet bowl.

Back siphonage: Back siphonage is the reverse flow of water within a water supply system due to negative pressures in the pipe system enabling atmospheric pressure to force the flow of water backwards through a siphon action.

Residual head: It is the pressure available at the tail end of the distribution system.

Wash out valve: Valve in a pipeline or a dam that can be opened occasionally to clear out sediment.

Down take tap: It is tap fitted to a system of piping which is not subjected to water pressure from the water main.

Barrel: It is that portion of a pipe in which its diameter and wall thickness remain uniform throughout.

Bedding: It is the support provided to pipe on the trench floor by concrete or any other suitable material.

Benching: The sloped floor of a man hole or inspection chamber on both side and above the top of the channel is called benching.

Anti siphonage: It is the device provided in a trap to preserve its water seal.

Dry weather flow (D.W.F): It is the normal flow of sewage during the dry season of the year.

Wet weather flow (W.W.F): It is the normal flow of sewage during the rainy season of the year

Drain: It is the line of assembled pipes with all fittings and equipments like manhole, trap and gully's etc.

Drainage: It is the system by which used and contaminated water is removed by means of drains.

Sewer: It is a separate underground carriage system specifically for transporting sewage from houses and commercial buildings to treatment or disposal.

Sewage: It includes all types of liquid wastes in a building. It may be storm sewage or sanitary sewage.

Sludge: It is the organic matter deposited at the bottom of the sedimentation tank during the treatment of the sewage.

Sewerage refers to the infrastructure that conveys sewage. It encompasses components such as receiving drains, manholes, pumping stations, storm overflows, and screening chambers of the sanitary sewer. Sewerage ends at the entry to a sewage treatment plant or at the point of discharge into the environment.

Sub soil water drain: It is the drain which carries sub soil water

Surface water drain: It is the drain which carries surface water and storm water for its disposal

Waste pipe: The waste pipe is any drainage pipe that carries liquid wastes that do not include human excreta.

Soil pipe: Drain that conveys liquid waste from toilets, etc.

Vent pipe: It is a pipe which is used to provide flow of air to or from drainage system. It provides circulation to the system and protects trap seals from the siphonage or back flow

Refuse: It includes all types of house waste and garbage in dry form

Garbage: It is the solid or semi solid waste from a house, like peelings of vegetables and fruits, wastes of foods etc.

Rubbish: It includes solid wastes like waste papers, broken furniture and pottery, waste materials of building etc.

Ashes: It is the residual substance obtained after burning the wood, coal, coke etc in hearths and furnaces etc - in the building.

Storm water: It is the rain water of the locality

Sub soil water: It is the ground water which finds its entry in to sewers through leaks

Man hole: It is a hole or shaft provided in a drain, sewer or any other closed structure in which a man may enter for inspection, cleaning or maintenance operation. A manhole is provided with a cover at top

Cleaning eye: It is an opening in a drain or sewer which is used for cleaning any obstruction in it by means of drain rod. It is provided with removable cover

Soak pit: It is a pit which is suitably prepared to receive soil waste water or partially treated sewage for seepage into the ground

Types of sewage

1 Fresh sewage

It is the sewage which has been recently produced.

2 Crude or raw sewage

It is the untreated sewage.

3 Dilute or weak sewage

It is the sewage containing small amounts of suspended matter.

4 Septic sewage

It is the sewage which is undergoing decomposition emitting offensive odours.

5 Domestic or sanitary sewage

It is the liquid waste from residences, institutions and business buildings.

6 Storm water or storm sewage

It is the surface runoff collected during and immediately following a rainfall.

7 Industrial sewage

It is the liquid wastes from industries.

8 Combined sewage

It is the combination of sanitary sewage and storm sewage with or without industrial wastes.

Classification of sewer

- i Classification according to type of sewage.
- ii Classification according to layout.

Classification according to type of sewage

1 Sanitary sewer

It is the sewer intended to carry the sanitary or domestic sewage, and industrial wastes if permitted.

2 Storm sewer

It is the sewer that carries only storm water.

3 Combined sewer

It is the sewer that carries domestic sewage, industrial sewage and storm water.

Classification according to layout

1 House sewer

It is a sewer which carries sewage from buildings or houses into the public sewer or street sewer.

2 Lateral sewer or lateral

It is a sewer, collecting sewage from houses or flow from streets, but does not receive sewage from any other sewer.

3 Sub - main sewer

It is a branch sewer which receives discharge from two or more lateral sewers.

4 Main sewer or trunk sewer

It is a sewer which collects the flow from two or more sub main sewers and which serves as an outlet for a large area.

5 Intercepting sewer

When it is not desirable to have the sewers discharge directly into a body of water the sewage from a number of separate sewers and combined sewers is discharged into a sewer. Such a sewer is known as intercepting sewer.

6 Outfall sewer

It is that sewer which carries sewage from the lower end of a collecting system to a treatment plant or to the point of disposal.

7 Relief sewer

It is the sewer which is to carry the excess storm sewage from an existing combined sewer.

8 Depressed sewer

When an obstruction is met with, the sewer is constructed lower than the adjacent section. Such a section of sewer is called a depressed sewer.

Materials for sewers

Based on the sewer materials, the following are the different kinds

- 1 Asbestos cement sewers
- 2 Brick sewers
- 3 Cement concrete (plain or reinforced) sewers
- 4 Cast - iron sewers
- 5 Corrugated iron sewers
- 6 Stoneware sewers
- 7 Steel sewers
- 8 Plastic sewers
- 9 Wooden sewers

Different types of water closets, urinal port, kitchen sinks, bath tub and wash basin

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

- state the size and uses of various sanitary appliances.

Sanitary fittings

In the buildings, various types of sanitary fittings are required to collect the water. These all fittings can be broadly classified as:

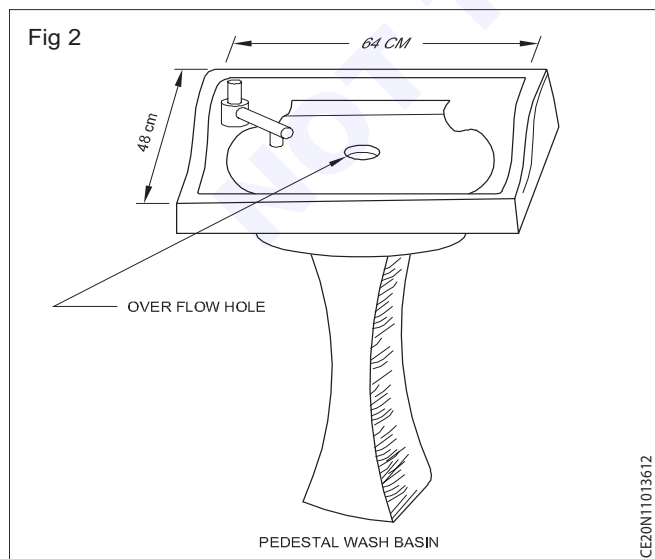
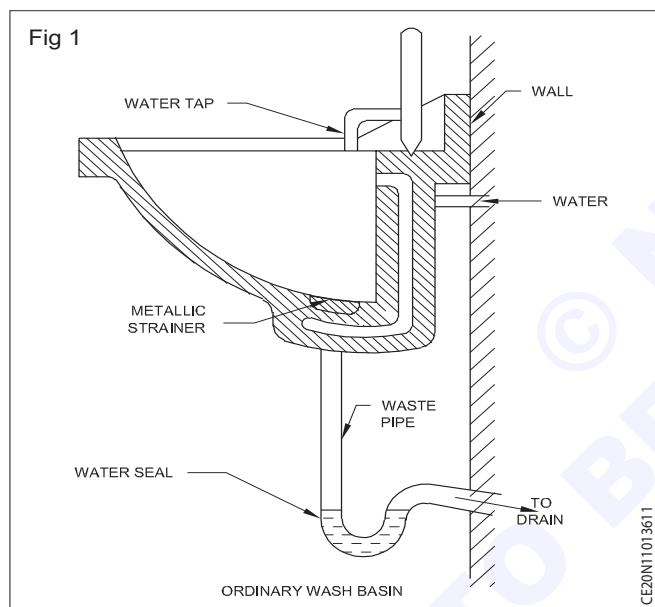
1 Ablution fittings

a Wash basins	b Sinks
c Bath tubs	d Flushing cisterns

2 Soil fittings

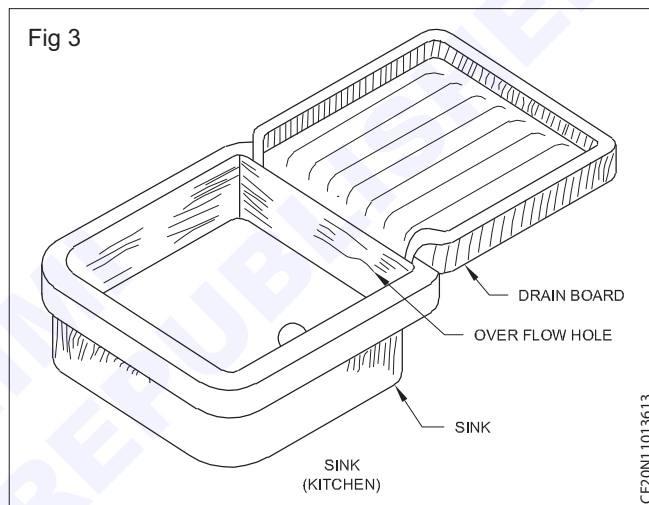
a Water closets	b Urinals	c Bidets

Wash basin (Fig 1&2)



The wash basins are available in various patterns and size in the market. Flat back basins are provided with double or single tap holes. All the wash basins should be of one pipe construction and have should have slotted overflow hole. All the internal angles are designed so as to facilitate cleaning.

Sinks (Fig 3)

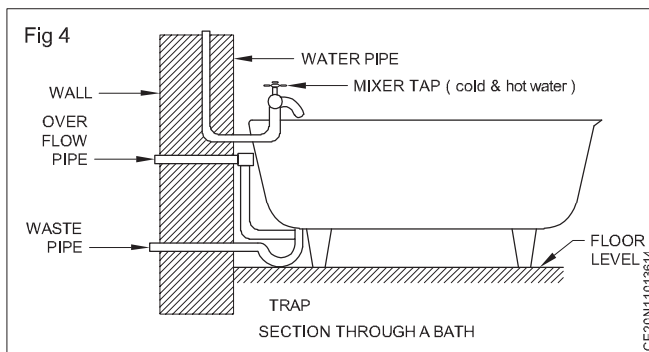


There are rectangular shallow receptacles suitable for kitchens or laboratory. Fig 3 shows a kitchen sink which is mostly used. It is on one piece construction, provided with or without rim.

The floor of the sink is given a slope towards the waste outlet. The sinks are provided with circular waste hole. All the kitchen sinks are provided with a draining board which is fixed on the right of the user.

The height of the top of the sink from the floor should be 80 cm.

Bath tub (Fig 4)



Bath tubs may be made of various materials, such as enamelled iron, plastic, cast iron porcelain enamelled, marble or fire clay etc. For high class residential buildings marble, plastic or enamelled iron or fibre glass baths are used.

Flushing cistern

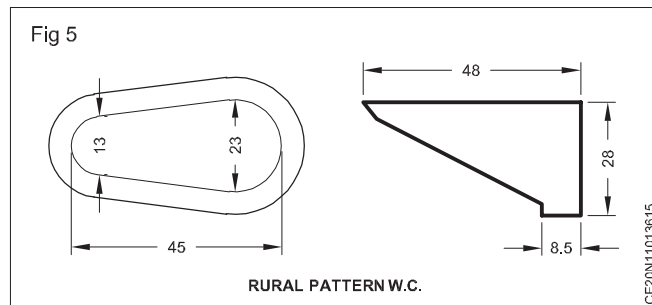
There are used for flushing water closets and urinals after use.

Water closet: This is a sanitary appliance to receive the human excreta directly and is connected to the soil pipe by means of a trap.

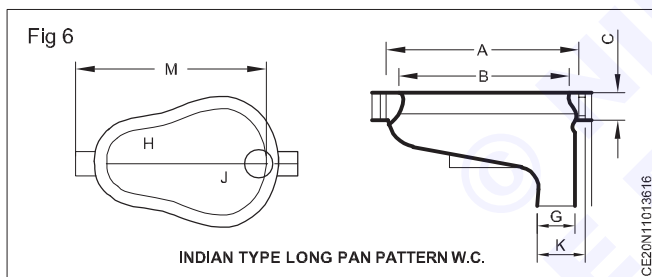
The water closets are classified as follows:

A Squatting types of Indian type water closet

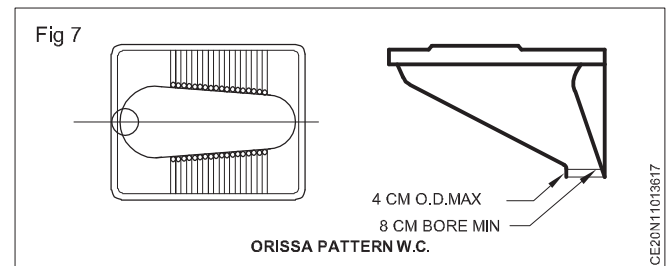
i Rural pattern (length 425 mm) (Fig 5)



ii Long pan pattern (length 450, 580, 680 mm) (Fig 6)



iii Orissa pattern (length 580, 630, 580 mm) (Fig 7)

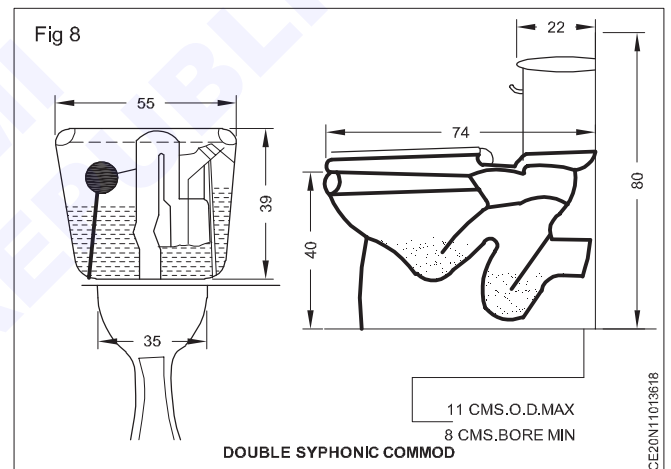


They are made of vitreous china clay. The inner portion is glazed to make it easy in cleaning. The pan is connected to the anti-syphon or vent pipe.

ii European water closet (Fig 8)

- a On dimension 50 mm and over ± 4 percent
- b On dimension of less than 50 mm ± 2 mm
- c On all angles $\pm 3^\circ$

Fig 8 shows the section through a wash-down type water closet, which is most commonly used in high class buildings.



Sensor system for urinals and wash basin sensor taps

Objective: At the end of the lesson you shall be able to

- explain sensor system for urinals, wash basin, sensor taps and soap dispenser.

Urinal sensor/ flusher

Definition

To keep your bathroom & restrooms Hygienic & safe, you need to use a good automatic urinal sensor and sensor flusher. They are very effective & easy to use while giving you a very attractive appearance.

They also tend to save water and uses the water only when required.

Advantages of getting automatic urinal sensor

- Proper cleanliness
- Longer lifespan
- Reduction in wastage of water
- Easy to use

Different types of automatic urinal sensor (Figs 1 & 2)

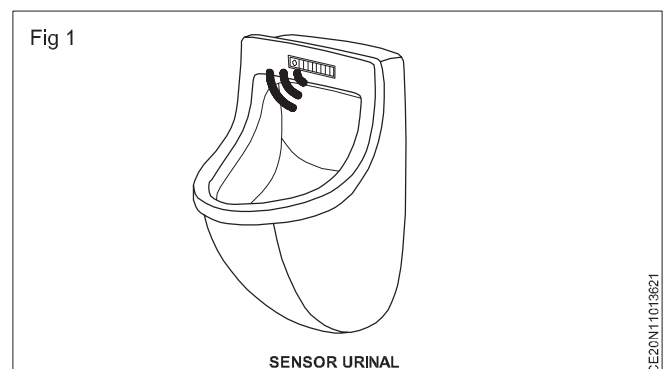


Fig 2



- Concealed urinal sensors
- Exposed urinal sensors
- Integrated urinal sensors

Advantages of getting automatic urinal sensor

- Water conservation
- Energy saving in the long term
- Reduce water bill amount
- Provide cleaner area in the bath room
- Provide dust free prevent cross contamination of users through tap.

Water less urinals

Aqua free white vitreous china clay. This can be put into use without water connections size available is 60 x 30 x 31.5cm. it is costly.

Wall flat back urinal/corner urinal (Fig 3,4 & 5)

Fig 3



Fig 4

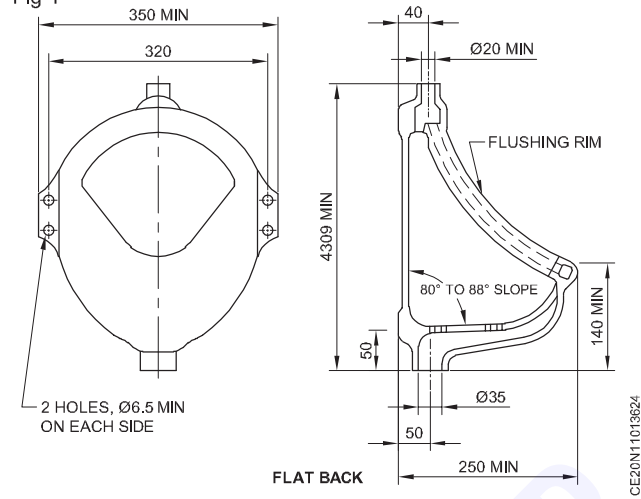
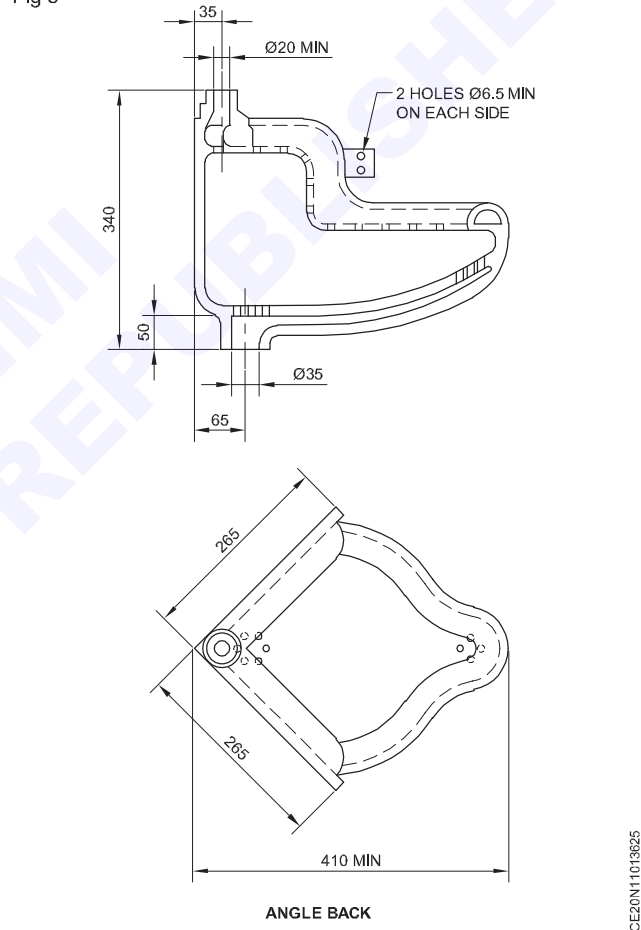


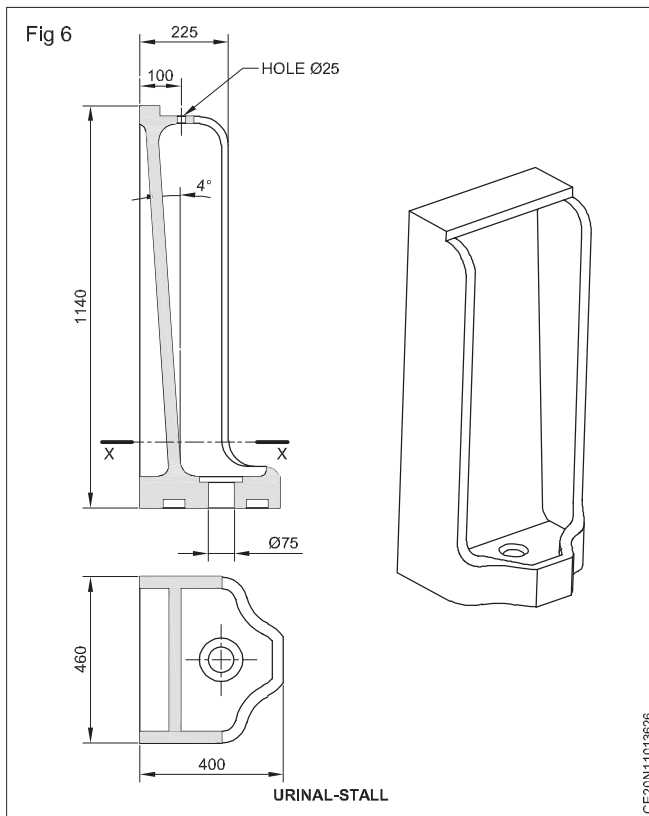
Fig 5



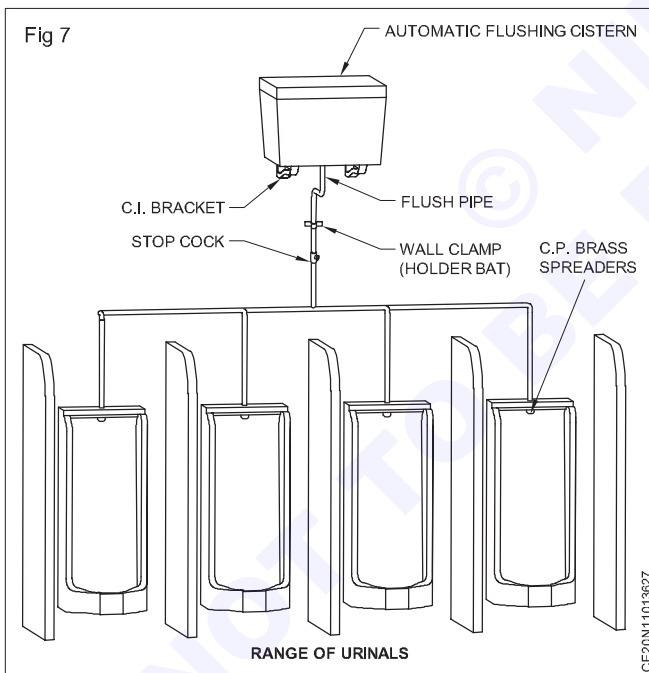
These are manufactured from white vitreous china clay conforming to IS2556 (PVI). The urinals are one piece construction. These have two fixing holes of a minimum Ø 6.5mm each side. It has a connection to outlet pipe. Inside surface of urinals are uniformly smooth.

Stall urinal slope (Fig 6)

The stall urinal and its screen are of white glazed fire clay.



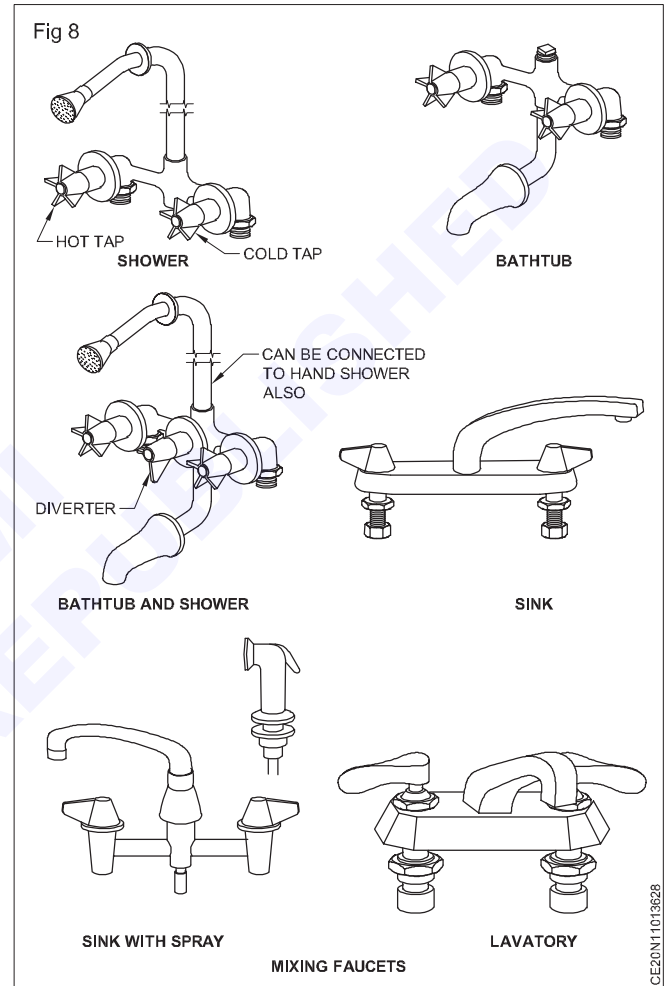
Squaring plate urinal (Fig 7)



These plates are of white vitreous china clay conforming IS2556 Pt and Part VI sec 3. These are having internal flushing rim with front or side inlet. These are of one piece construction - urinals are having integral longitudinal flushing pipe which can be connected to flush pipe.

Mixing tap (Fig 8)

When hot and cold water supply is available the faucets used on lavatories, bath tubs, bidet and kitchen sink are to be mixing type.



Installation of water meter

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

- explain water meter.

Water meter

The devices which are required to determine the quantity of water flowing through pipes are called meter.

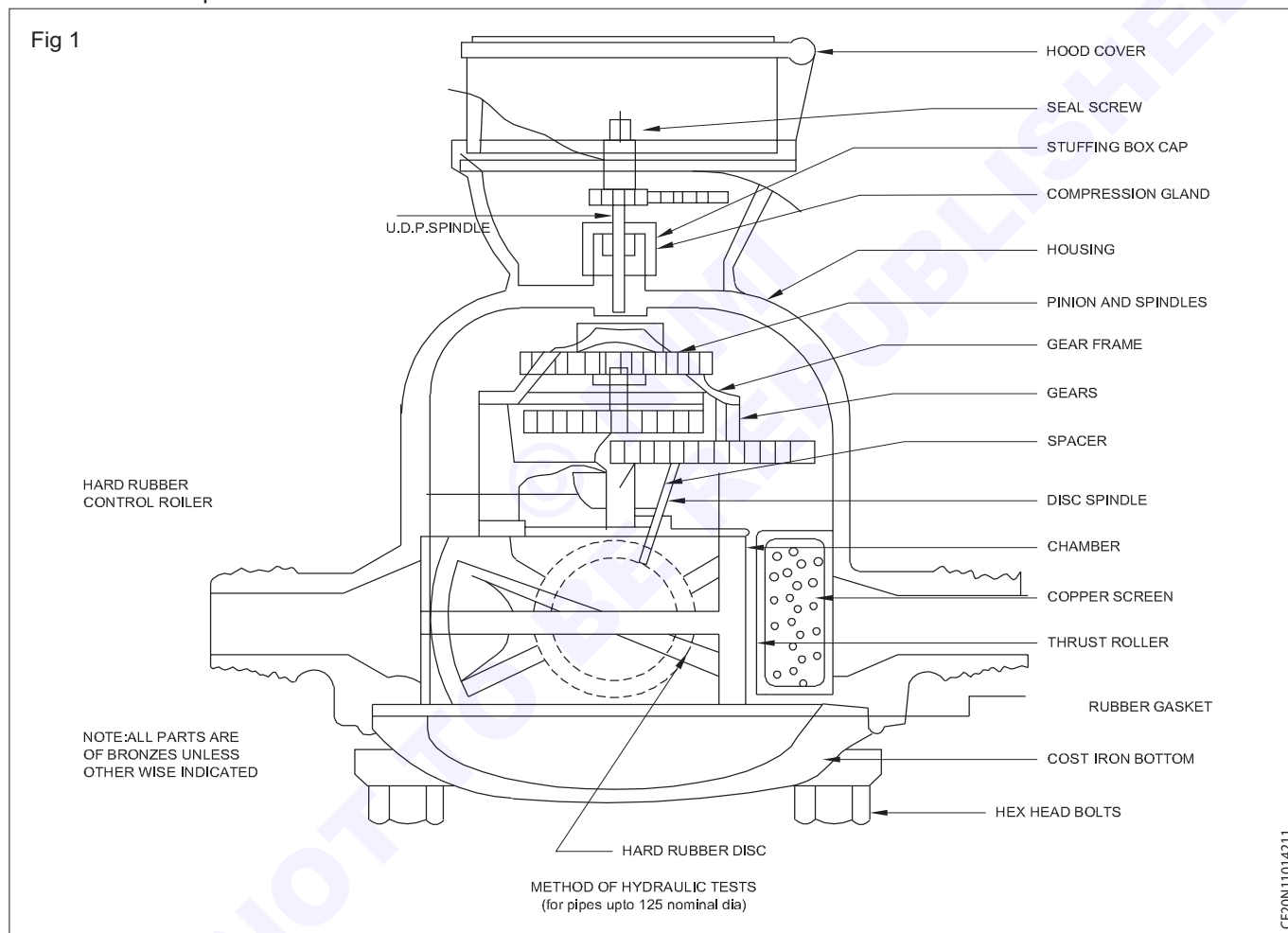
Positive displacement type

These are used for measuring small flow of water. These are designed on displacement principle.

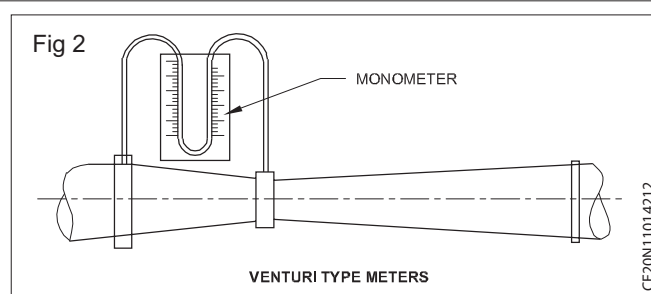
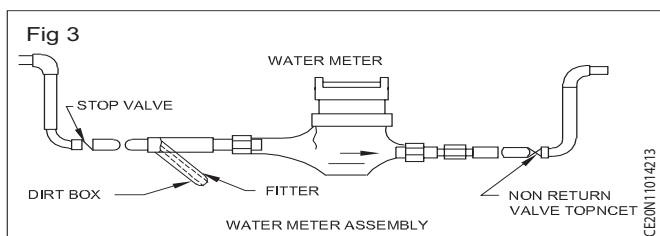
The installation and maintenance of domestic water meter is governed by IS2004. Testing of the water meter is done as per IS6748.

Venturimeter (Fig 1)

These are generally venture or turbine type. These meter tubes are connected to an apparatus which measure the difference of water level between them. By means of an automatic device a graph is recorded of the discharge passing through the venture tube. Such meter is usually provided at the head of main water supply pipe.



The meters are housed in meter boxes at a slightly higher level to prevent flooding of the chamber during rains. The position of water meter is to be as shown in Fig 2. The method of testing water meters (domestic type) is given in IS: 6784-1973. (Fig 3)



Air lock in pipes and its removal

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

- state air lock in pipes and its removal.

Air relief valve

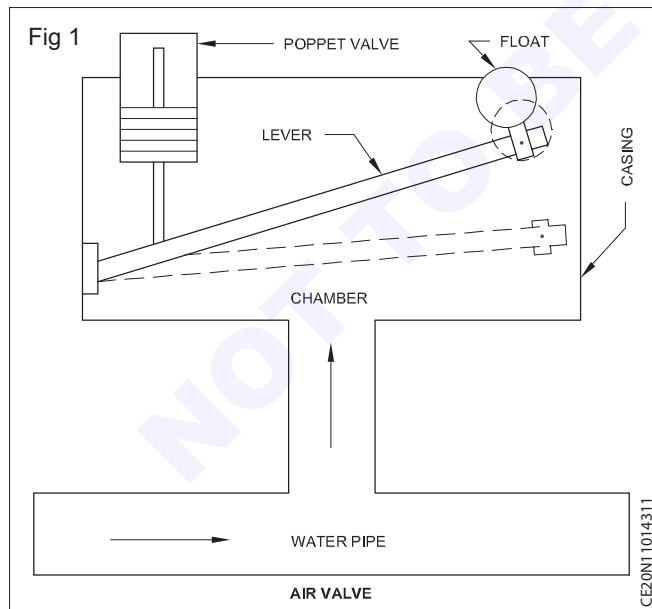
Some quantity of air is contained in the flowing water and this air tries to accumulate at high points along the water pipe. In order to provide an exit for such accumulated air, the air valves are provided at summits along the water pipe. The air valves should be located at points which are close to or above the hydraulic gradient. If air valves are not provided, there are chances for pipes to be air-locked. The effective area of flow and consequently the discharge through water pipe are greatly reduced due to air-locking.

The provision of air valves along water pipe also helps in admitting air quickly when vacuum occurs in water pipe due to sudden breakdown of water pipe at low points.

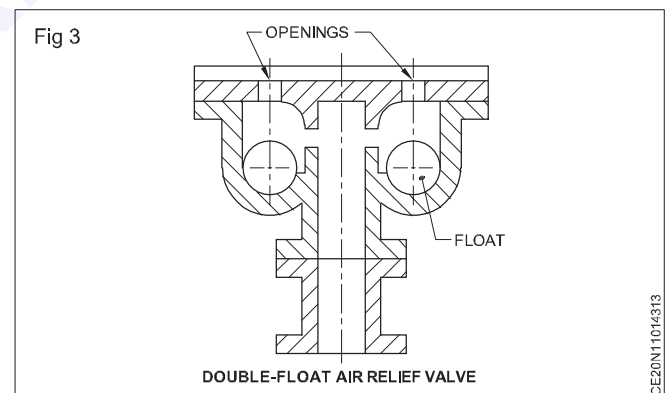
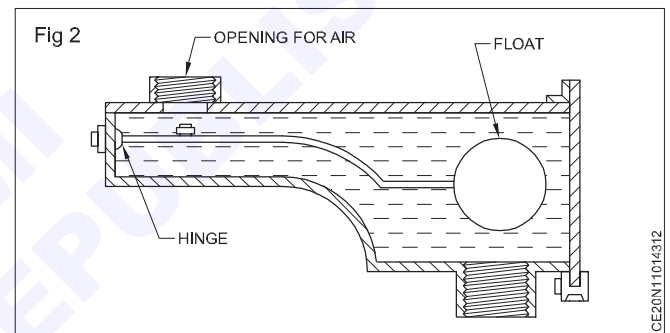
An air valve consists of a cast-iron chamber, float, lever and poppet valve as shown in Fig 1. The chamber may be circular or rectangular in shape. A poppet valve is a valve that is lifted bodily. The working of the air valve is as follows.

Pipe Appurtenances (Fig 1)

- 1 In the normal condition, the chamber is full of water drawn from water pipe. The float therefore touches the roof of chamber and poppet valve is in a closed position.



- 2 When air from water pipe enters the chamber, it starts accumulating just below the roof of chamber. This accumulation of air makes the lever to work and to bring down the float.
- 3 The pulling down of float by lever operates the poppet valve which is then opened. The air is thus allowed to escape through the poppet valve.
- 4 When air escapes, the water rises again in the chamber and the lever works to rise the float. It ultimately results in the closing of poppet valve before escape of water takes place through it.
- 5 The action of air valve is then repeated.



Civil Engineering Assistant - Plumbing work

Purification of water

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

- explain the purification of water.

Treatment of water: Type of treatment process will depend on the quality of raw water and standard of water quality required after treatment.

The following treatment processes are used for removing various types of impurities.

SI No.	Impurity	Process used for removal
1	Floating matters like leaves, dead animals	Screening
2	Suspended impurities like silt, clay, sand etc	Plain sedimentation
3	Fine suspended matter	Sedimentation with coagulation
4	Microorganisms and colloidal matters	Filtration
5	Dissolved gases tastes and odors	Aeration and chemical treatment
6	Pathogenic bacteria	Disinfection

A well-equipped laboratory is required at the treatment plant to test the raw water and also the treated water. The treatment process can be decided depending on the nature of impurities.

Layout of a treatment plant

A layout of treatment plant consists of.

- Intake work near the source.
- Plain sedimentation.
- Sedimentation with coagulation.
- Filtration
- Disinfection
- Clear water reservoir
- Pumps
- Elevated or underground service reservoir.

Intake work shall be near the source of water. It includes intake well, pumping plant.

Plain sedimentation: Water is retained in a basin to settle down the suspended particle by gravity alone in this process. Continuous flow type basins are provided now a days. Water flows continuously at a uniform rate of flow.

Sedimentation with coagulation: Very fine suspended particles cannot be removed by plain sedimentation as it takes long time to settle. Colloidal matters will never settle down by gravity. Such impurities can be removed by sedimentation with coagulation.

Filtration: Filters are used to remove bacteria colour, taste odours, manganese and produce clear water. Filters consists of thick layer of sand and the water is allowed to pass through it.

Filters are classified as:

- Gravity filters
 - Slow sand filters (Fig 1)
 - Rapid sand filters (Fig 2)
- Pressure filters (Fig 3)

Slow sand filter (Fig 1)

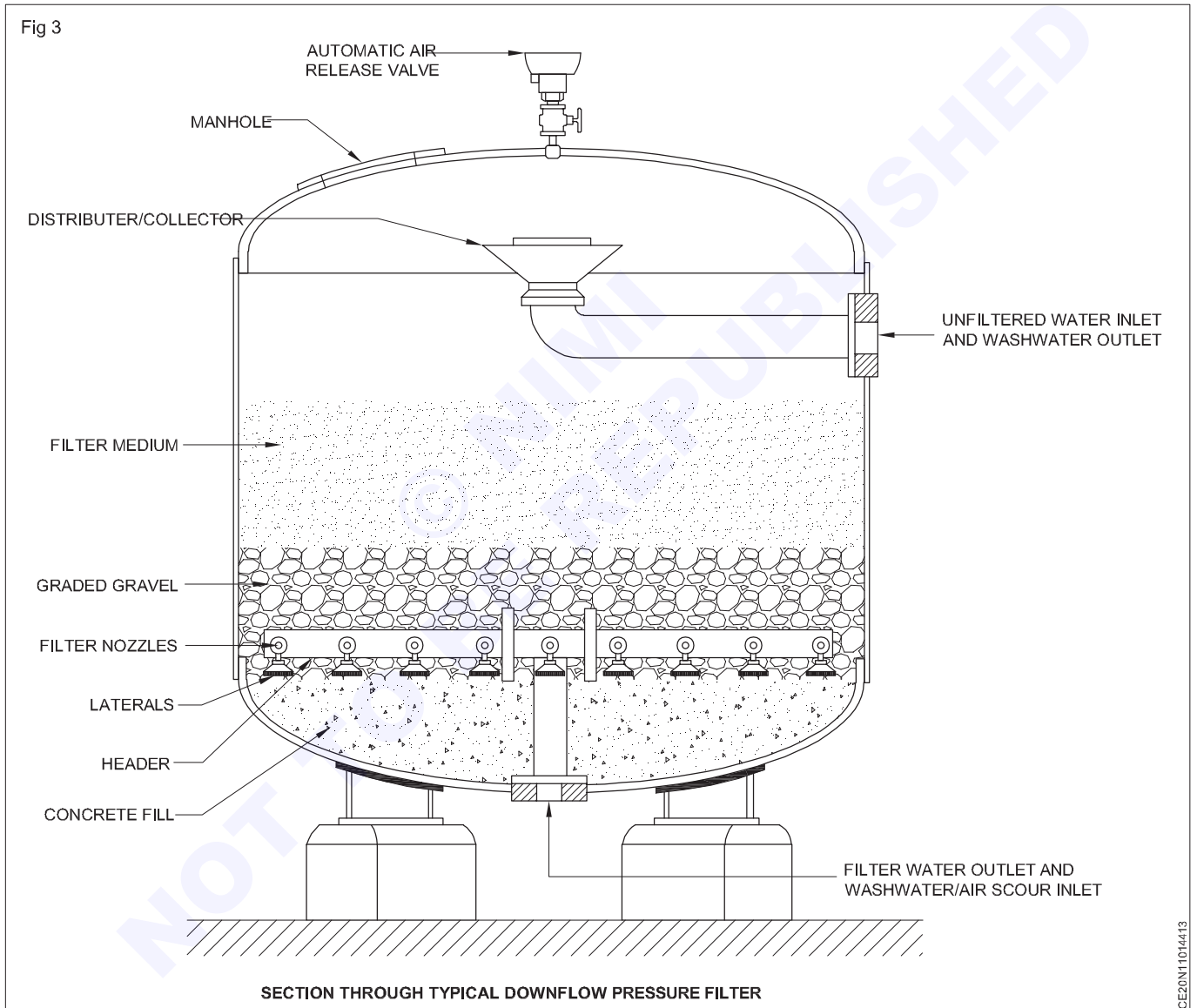
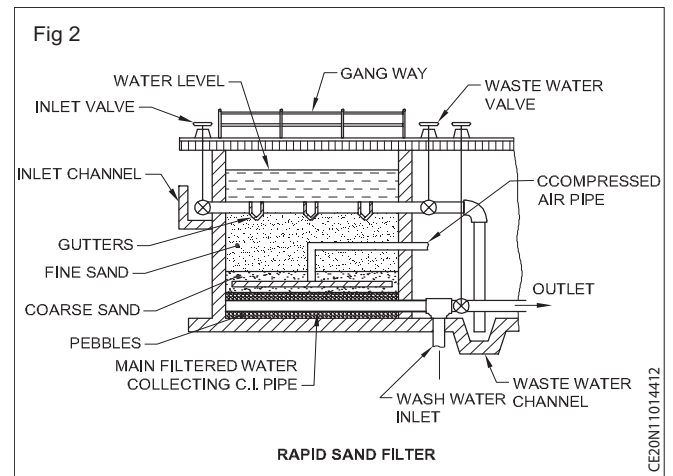
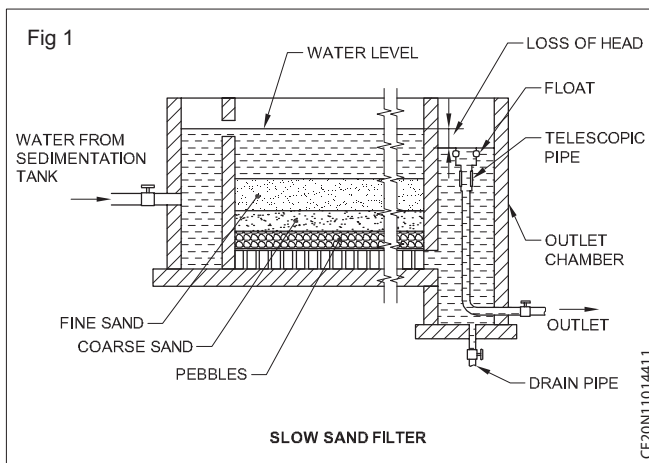
Water from sedimentation tank enters the slow sand filter through a submersible inlet. Then distributed uniformly over the sand bed without disturbing the sand. During the filtration the filter media gets clogged due to impurities. Then the sand from the top bed to be scraped and replaced with clean sand. As the name indicate the rate of filtration is slow. It cannot remove pathogenic bacteria.

Rapid sand filter (Fig 2)

Operation of filter is all most similar to slow sand filter. Outer chamber is fitted with filter rate controller. When the filter bed gets clogged, it is removed by washing. Washing is done by the back flow of water through the sand bed.

Washing of filter is done generally after 24 hours and takes about 10 minutes.

Pressure filters (Fig 3): The water passes through sand bed under pressure greater than atmospheric. These filters are used on small industrial plants. These are not economical on large scale. The cleaning of filter bed is done by back washing similar to rapid gravity filter.



Disinfection

It is the process of killing infective bacteria from the water. The chemicals or substances which are used for killing the bacteria are called disinfectants.

Disinfection of water can be done by the following methods.

- By boiling water

- By ultraviolet rays
- By the use of iodine and bromine
- By the use of ozone
- By the use of excess lime
- By the use of potassium permanganate
- By plain chlorination
- By the application of gaseous chlorine

- By the application of liquid chlorine
- By the use of bleaching powder

Water Softening Treatment

- The permanent hardness cannot be removed easily from water.
- The special treatment is called as the water softening treatment. The following method of removing permanent hardness.

1 Lime-Soda Process:

- In this process the lime and sodium carbonate or soda.

2 Zeolite Process:

- This is a base-exchange or ion-exchange process.
- The zeolite process are compounds of aluminum, silica and soda.
- The naturally available zeolite is green in colour, therefore, it is called green sand.
- When the hard water comes into contact with zeolite, the calcium and magnesium are removed and sodium is given in exchange.

3 Demineralisation Process

- A hard water is passed through a bed of resin materials in the hydrogen form.
- After some interval of time, the hydrogen contents is exhausted.
- The demineralisation process is mainly used for preparing water to be used for the industrial purposes.

4 Reverse Osmosis: Process

- Reverse osmosis is also known as hyper-filtration.
- Reverse osmosis works on the principle of diffusion.

- Diffusion means the movement of molecules from a region of the higher concentration to a region of lower concentration.
- Reverse osmosis is capable of rejecting bacteria, salts, proteins, sugars.

Alternate sources

Alternative source of water may include harvested rainwater and recycled / reclaimed waste water from treatment plants. Catchment area of rainwater for reuse within buildings should be restricted to the roof tops. Provision shall be made for flushing away water collected during initial rains. Rainwater harvested from lawns, building surroundings, roof gardens, balconies, etc. may be used for recharging the ground water table through recharge pits.

Use of alternative water (recycled water from STP) for flushing is not recommended in hospitals and other health care facilities.

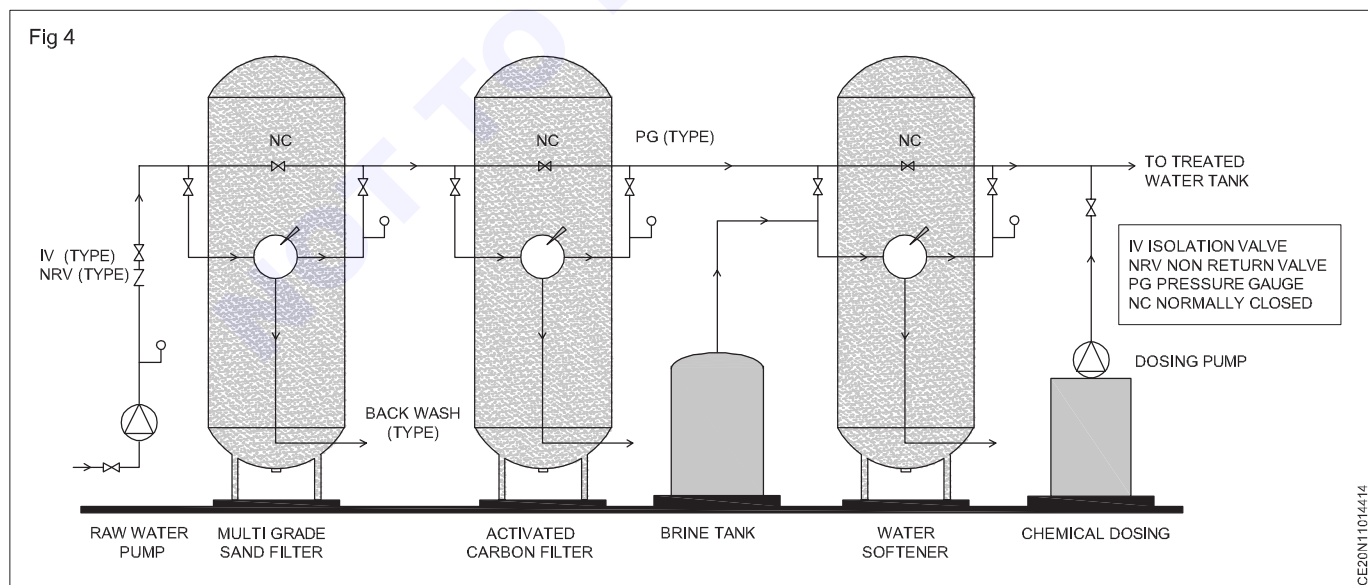
Quality of water and treatment (Fig 4)

Quality of available water source should be established through a test report obtained from a recognized laboratory.

The extent of treatment shall be determined based on the quality of source water. This may include sand filtration to remove suspended solids, activated carbon filter to remove colour and odour, softening to remove hardness and disinfection (chlorination, ozonation, UV, etc). to remove bacteria. (Fig 4).

Modern technologies are currently available to treat several impurities through single equipment. Expert advice shall always be sought on selection of appropriate technology / equipment.

Domestic water purifiers incorporating various technologies like cartridge filter, carbon filter, ultra violet (UV) treatment and reverse osmosis (RO) or combinations of the above are currently available. These are generally installed at the point of usage.



Method of dismantling and rectification of the valves and taps

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

- state the repairing process of bibcock float valve etc
- state the replacing of spindles in the cocks
- State the repairing of gate valve.

Dismantling

The term dismantling implies carefully separating the parts without damage and removing.

Always be well planned before handling in a systematic manner.

Repair of water supply fittings - Bibcock

- 1 Bibcock is commonly referred as tap and it is the most frequently used water supply fitting.
- 2 The defects commonly encountered during the functioning of taps, their causes and remedial measures to be taken are listed below.

Defect	Cause	Remedy
Water flows/drips from the tap even when the tap firmly closed	Worn out defective washer Accumulation of grit, dust or other foreign matter	Replace washer Remove the foreign matter
	Defective seating	Reseat tap
Water flows from around the spindle or stuffing box	Gland nut is loose. the packing in the stuffing box is defective	Tighten the gland nut box. Replace the packing
Difficulty to turn on or turn off the Spindle bent.	Stuffing box packing is dry. some oil. Replace tap.	Replace tap (or) spindle.
Spindle continuously slipping when the tap is turned and tap does not shut off	Spindle thread worn out	Replace tap (or) spindle
There is lot of noise in the tap when tap is turned on	Valve loose on the spindle. Washer loose on the valve	Replace tap Replace washer. (or) replace spindle

Repair of water supply fitting-Flushing cistern and float valve

causes and remedial measures to be taken are listed below:

The commonly encountered defects during the operation of flushing cisterns and float valves, their

Defect Flushing cistern	Cause	Remedy
Water flows from the over-flow pipe of the cistern	The float has broken (or) slip down	Replace the float
Water flows from the over-flow pipe of the cistern through the float is not damaged	The position of the float valve is not correct	Always adjust the ball valve level to 2.5cm below the level of over-flow pipe
Water is leaking from the cistern -flush pipe junction	Check nut is loose, Check nut washer defective	Tighten the check nut. Replace washer
Float valve Water is running continuously into the bowl.	Auxiliary valve seat has worn out. Bypass is clogged	Replace washer. Clean the by- pass by running a fine wire.

Repairing practice of gate-valve

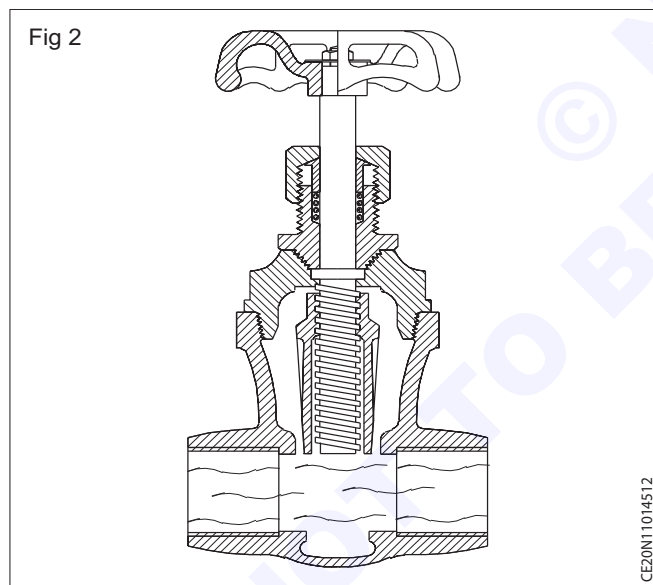
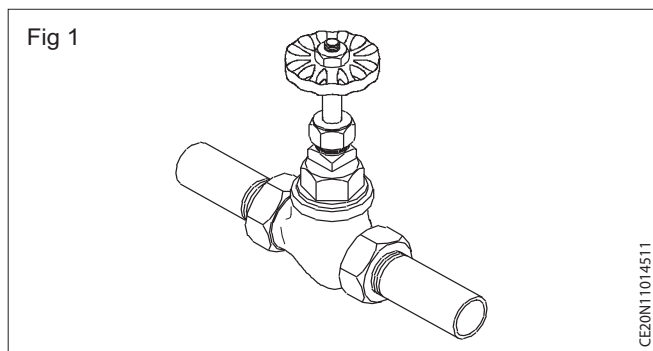
Gate valves is one of the most common valves used in the main supply lines of a water supply system and pump-lines.

The commonly encountered defects during the operation of gate valves, their causes and remedial measures to be taken are listed below.

Gate-valve

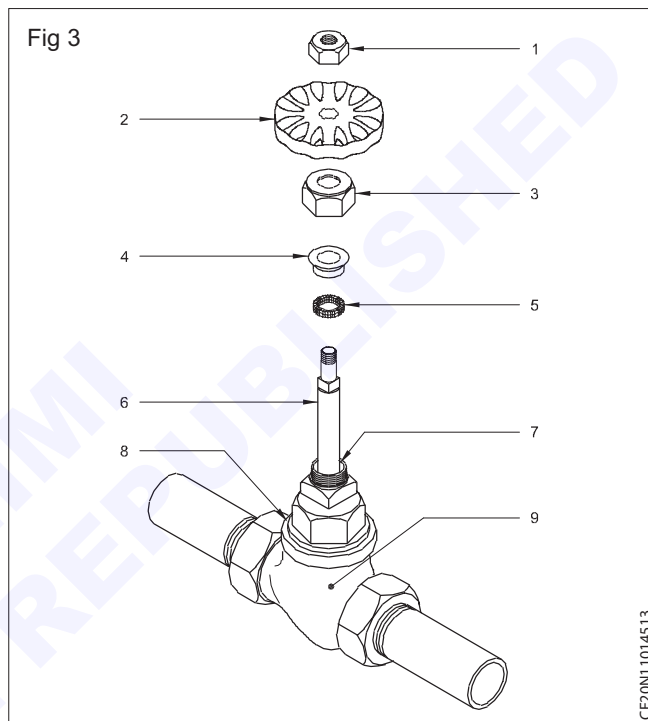
The gate-valve gets its name from the gate-like disc that slides across the path of the flow. This valve provides an unobstructed waterway when fully open. This feature makes the gate-valve useful in large piping installations. It is best suited for main supply lines and pump-lines. It should not be used to regulate flow. It should either be fully opened or completely closed.

It is one of the most common valves found in a water distribution system. (Figs 1 & 2)



Parts of a gate-valve (Fig 3)

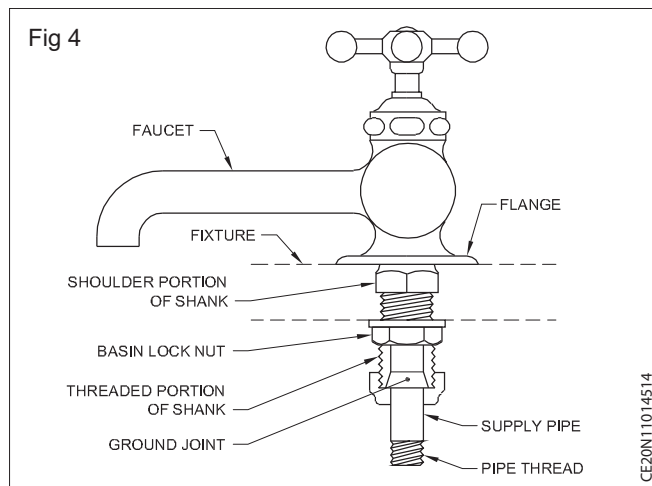
- 1 Hand wheel nut
- 2 Hand wheel
- 3 Gland nut
- 4 Stuffing gland
- 5 Packing
- 6 Shaft or spindle
- 7 Stuffing box
- 8 Bonnet
- 9 Gate - valve body



Defect	Cause	Remedy
Water flow from around the stuffing box screw	Gland nut is loose. The packing in the stuffing box is defective	Tighten the gland nut Renew packing with asbestos hemp and water pump grease
Valve is hard to turn on or turn off Spindle is bent	Stuffing box packing is dry spindle is bent	Tighten the gland nut
Spindle rotates continuously and the gate valve does not close	Spindle thread is worn out badly	Replace the worn-out part

Repairing practice of pillar cocks

Pillar tape (Fig 4)



It is generally of chromium plated brass. Pillar taps of other materials are also available in market. The size is designated by the nominal bore of pipe outlet to which the tap is to be fitted. The weight of CP brass pillar tap of 15mm and 20mm are 650gm and 1175 gm respectively. Pillar tap should withstand an internally applied hydraulic pressure of 20 kg/sq.cm.

Repair of water supply fitting-Stopcock

Stopcock is similar in construction to a bibcock except that it is placed in the pipeline.

The defects commonly encountered during the functioning of stopcock, their causes and remedial measures to be taken are listed below.

Defect	Cause	Remedy
Water drippings stopcock even after it is firmly closed	Worn out defective washer Accumulation of grit, dust, or other foreign matter	Replace washer Remove the foreign matter
	Defective stop cock seat	Reseat stop cock
Water flows from around the spindle or stuffing box screw	Gland nut is loose The packing in the stuffing box is defective	Tighten the gland nut. Replace the packing.
It is difficult to turn on or turn off the cock	Stuffing box packing is dry Spindle bent	Renew packing. Replace cock
Spindle slips down continuously when the cock is turned.	Spindle thread worn out badly	Replace the stopcock

Distribution of storage water, different type of valves and tanks

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

- explain distribution of storage water
- state the types of tanks.

There are two systems of water supply.

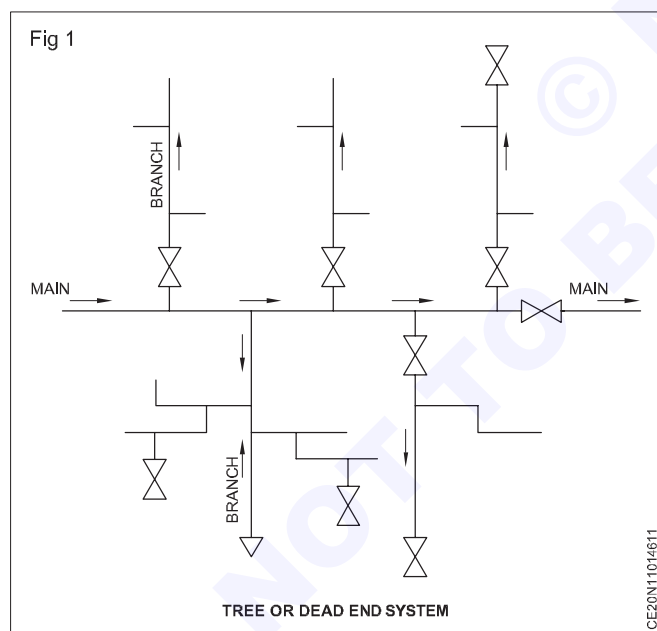
- 1 Continuous
- 2 Intermittent

In the continuous supply system, water is available to consumers throughout the days. In the intermittent supply system, water is supplied during fixed hours and for the remaining period the supply is shut off.

The water supply distribution systems are laid in the following forms.

- 1 Tree or dead end system
- 2 Circle or ring system
- 3 Grid iron system
- 4 Radial system

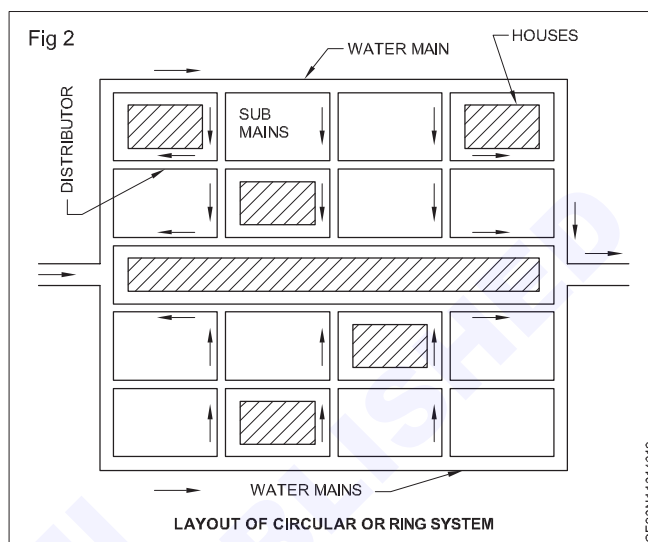
Tree or dead end system: In this system the main line is laid along the main road. Branch lines are taken in many places along the road and there are many dead ends in the system. (Fig 1)



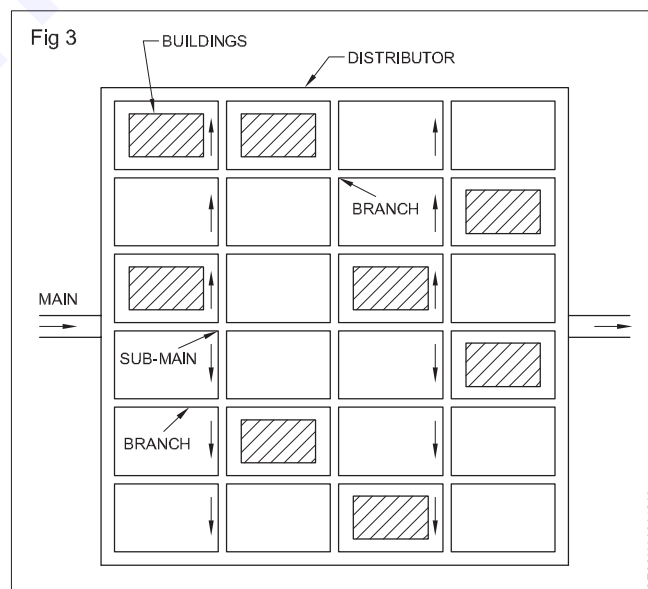
This system is suitable for towns growing irregularly.

Circle or ring system: Each locality of a town is divided into square or circular blocks and water lines are laid around the circumference of the square or circle. The branches, sub mains are laid along the inner roads. (Fig 2)

This system is suitable for towns having well planned roads. This system involves many valves and more pipe length but the design of pipe is easier.



Grid iron system: In this system water mains and branches are laid in rectangles (Fig 3). The lines are so interconnected so that in case of repair at any point, the water is available from other direction. There are no dead ends and water is kept in good circulation. It is the most widely used system and is best suited for planned cities with road of rectangular pattern.

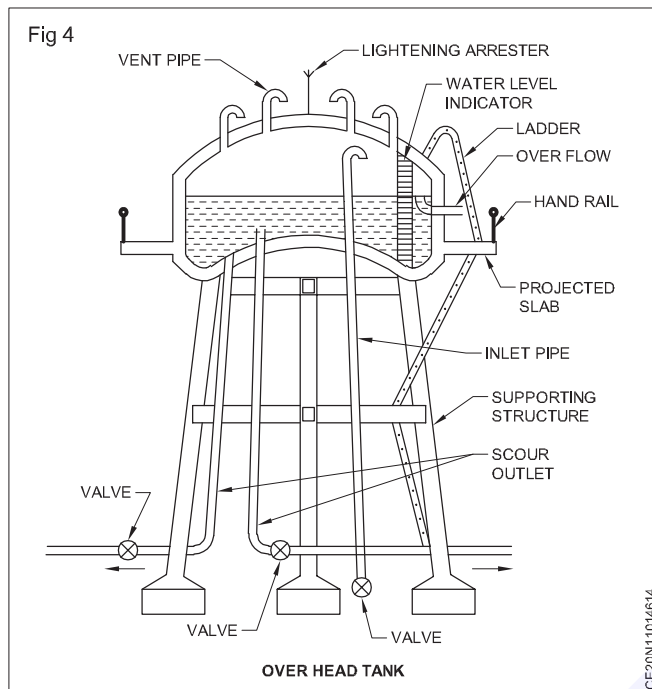


Radial system: In this system the supply lines are laid radially from the middle. It gives quick service. This system is suitable for towns with a radial layout. The design of pipe sizes is also easy.

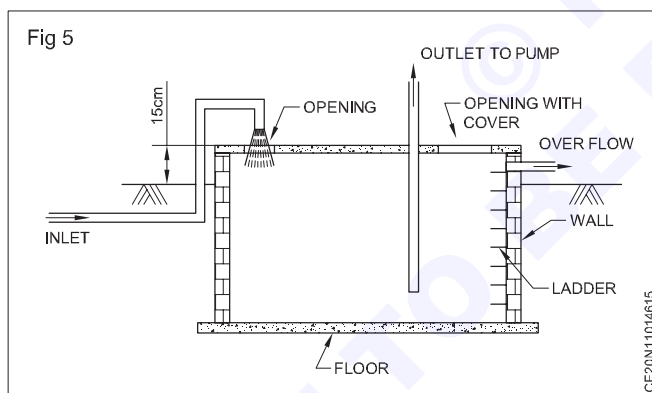
Tank: Shape of tank to be as decided by architects. Size of tank is decided considering the storage capacity and the required free board. It is preferable to

have a cantilever projection like a balcony with hand rail of 90cm height to facilitate inspections. An inspection hole and cover.

Storage tanks for water supply: Storage tanks for water can be either at ground level, below ground level or at elevated position. (Fig 4)



Pipes and valves: 5 pipes are provided in an elevated tank for different purposes. These pipes are named based on the purpose of its use (Fig 5)



- Inlet pipe
- Outlet pipe
- Overflow pipe
- Score pipe
- Ventilation pipe

Inlet pipe are terminating above the storage level and fitted with a control valve and non return valve. Outlet pipes are generally fixed at the opposite side of inlet and at 50mm above the tank bottom level and is fitted with a control valve. Drain pipe (scour) is fixed at the bottom level of tank and it should be taken 1m beyond the foundation area of tank and fitted with a valve. It is fitted for cleaning the tank and dewatering. Over flow pipes are fitted at the full supply level and it also to be taken away from tank area. Ventilating pipes is fixed at top of tank for fresh air inlet.

Ladder: A ladder is required for carrying out inspection and maintenance at outside and a small ladder inside.

Water level indicator: In order to find out the water level tank from ground, a water level indicator is required. It consists of a scale.

Lightening arrestor: It is provided to protect the structure from lightening. If the tank is constructed over airports etc. necessary red lights are to be fixed at top.

Domestic storage tank

Rotational moulded polyethylene water storage tanks. It shall confirm to IS12701. (Fig 6)

Installation and fittings: The flat base of the tank shall be fully supported over its whole bottom area on a durable rigid flat and level platform sufficiently strong to stand without deflection the weight of the tank when fully filled with water. Depending upon the capacity and location tanks may be suitably anchored.

For inlet, outlet and other connections fully threaded GI, HDPE or PVC connections with hexagonal check nuts and washers on either side of the tank wall shall be provided. Holes for threaded connections shall be drilled and not punched. Pipes entering or leaving the tank shall be provided with unions and suitably supported on a firm base to avoid damage to the tank walls.

Manhole lid: The lid shall rest evenly and fit over the rim of the manhole so as to prevent the ingress of any foreign matter into the tank. The lid shall be provided with suitable arrangement for locking it with the tank.

Sump: Sump is constructed below the ground to store water. It consists of bed, masonry/concrete walls, inlet, outlet, over flow pipes. Top of sump shall be 150mm above the formation ground level so that rain water should not enter. Sump also be cleaned once in six months.

The storage tanks are either in P.V.C. or Brick work or R.C.C. with a capacity of 1000 to 2000 lit. These are installed on a pedestal/platform; height about 1 m from ground level. Water is filled daily in the tank from water source through pipes. Inlet, Vent pipe, manhole is provided as usual in the tank. Number of taps are provided at the foot of the tank as per the requirement of area. This system is very useful both in city & village areas. Periodical maintenance should be done once in three or four months. This system is used where the water demand is somewhat less.

Cleaning and maintenance of storage tank

Storage tank must be cleaned at periodical intervals. If it's not carried out, water may contain due to bacteria, fungus and sedimentation and it is not advisable to usage.

Pipe line may get rust, scaling formation.

Every three months periodically check the water storage tank

- Check the water inlet and outlet pipe line's and outside wall if any damages.
- Tank must be closed tight to avoid entry of sun light.
- Must be provided with overflow pipe/automatic control valve.

Fig 6



CE20N11014616

Different types of valves and uses

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

- state the different types of valves and uses.

Valve

In water works practice to control the flow of water, to regulate pressure, to release or to admit air, to prevent flow of water in opposite direction and for many other purposes valves are required.

Sluice valve: The sluice valves are made from grey cast iron. The valves are used in a pipe line for controlling or stopping flow of water. These valves are operated in underground chamber, and are open or closed through gearing. (Fig 1)

Pressure relief valve: These valve relieve high pressure in pipe lines (Fig 2) such type of valve which is intended to release excessive pressure that may build up in a closed pipe.

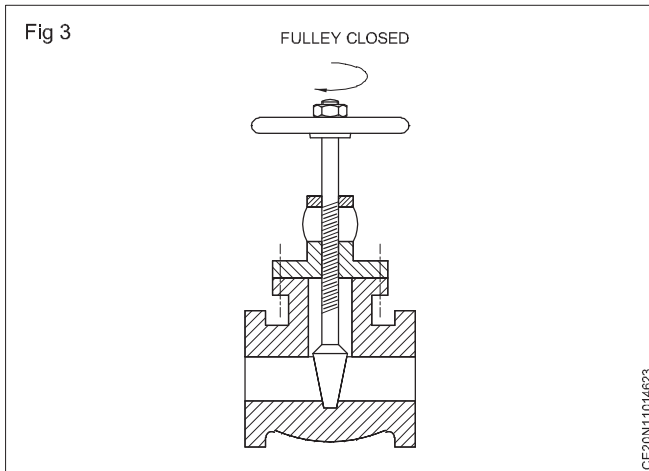
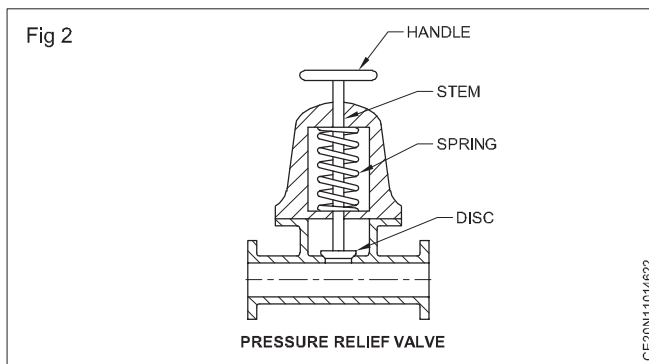
Gate-valve (Fig 3) (or) Main valve

The gate-valve gets its name from the gate-like disc that slides across the path of the flow. This valve provides an unobstructed waterway when fully open. This feature makes the gate-valve useful in large piping installations. It is best suited for main supply lines and pump-lines. It should not be used to regulate flow. It should either be fully opened or completely closed.

Fig 1



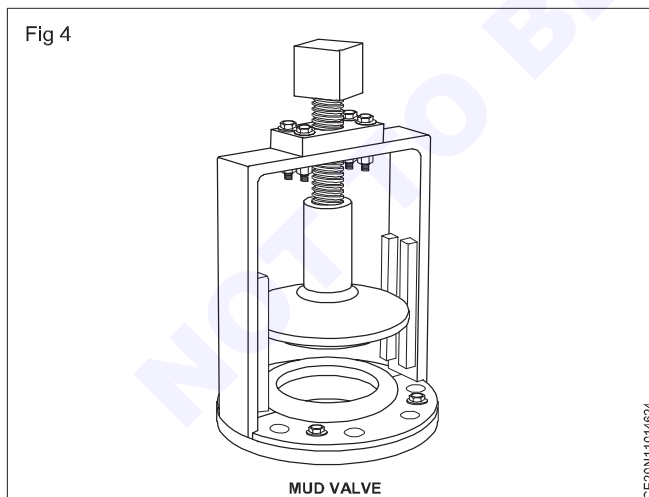
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It is one of the most common valves found in a water distribution system.

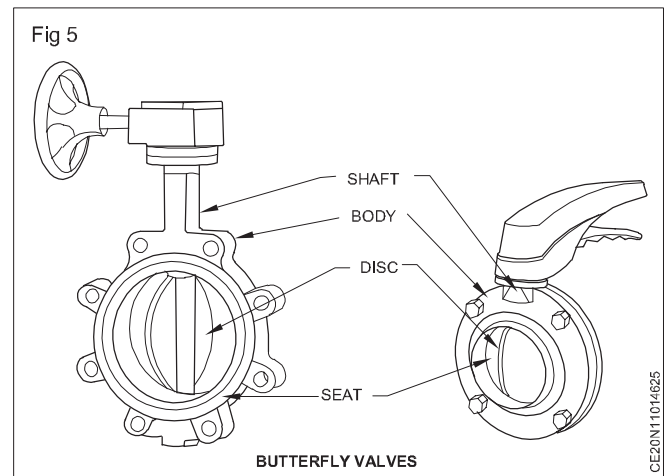
Mud valve

This valve is shown in Fig 4. It is used for removing water and mud or sludge from the bottom of the reservoir. It is a very simple type of valve. This valve is fitted at the bottom of reservoirs. It consists of a circular disc which when on lifted from the seat, mud or sludge is drained off from the tank.



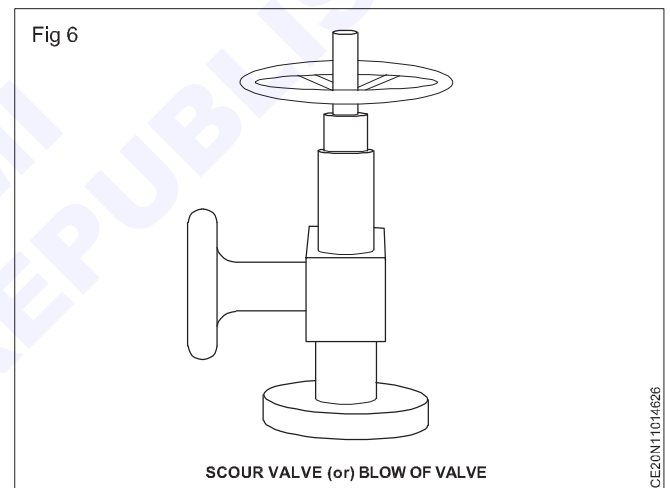
Butterfly valve

- This type of Value is now - a - days so familiar.
- It is fixed in the water line to arrest (or) to Control the flow of water (Fig 5)
- Due to its design maintenance is so easy.

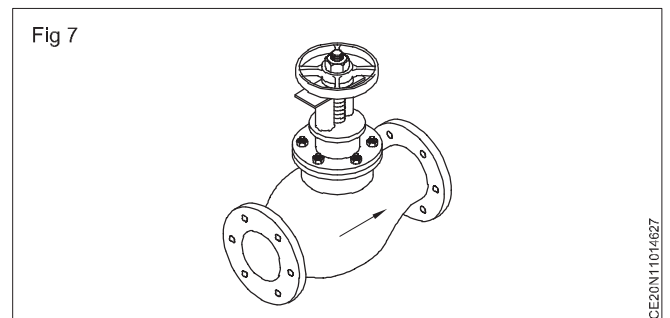


Scour valve (or) blow off valve (Fig 6)

- 1 These are similar to blow off valves and operated by hand
- 2 It is placed at dead ends or lowest point in the mains
- 3 They are provided to remove the sand and silt deposited in the pipe line.

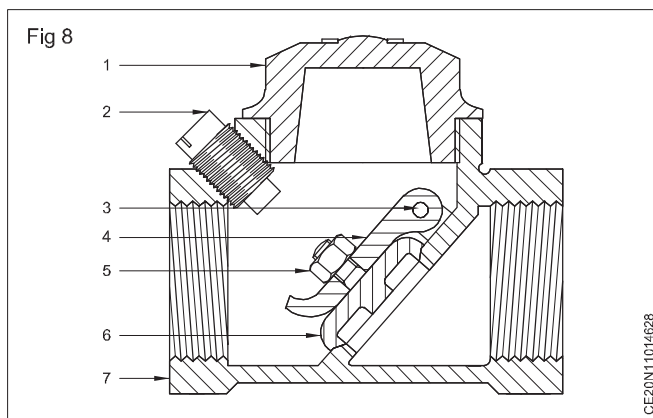


Wheel valve (or) branch valve (or) globe valve (Fig 7): Globe valves are widely used in most piping systems for controlling air, steam and water. (Fig 7)



Non-return valve/check valve

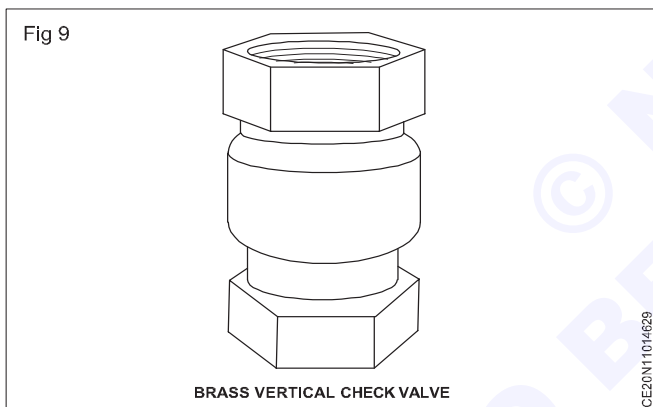
Non-return valve: Water supply piping systems are used several mechanical devices to control and regulate the fluids and gases flowing through them. (Fig 8)



The swing check valve consists of the following parts. (Fig 8)

- 1 Cap
- 2 Stop plug
- 3 Hinge pin
- 4 Hinge
- 5 Disc hinge nut
- 6 Disc
- 7 Body

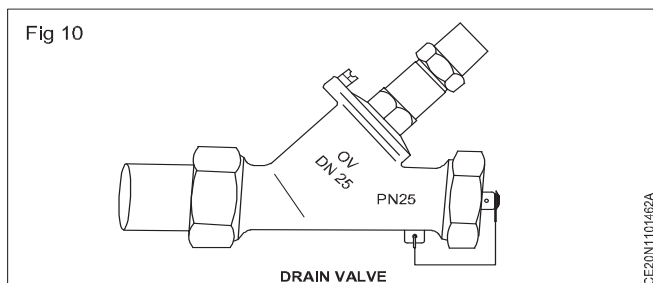
Brass vertical check valve (Fig 9)



- Check Value Vertical:
- This type of value is fixed in vertical position. (Fig 9)
- To be fixed with arrow mark direction.
- Arrest backflow allow water in one direction only.
- Especially used in Drinking water hand pump.

Drain valve (Fig 10)

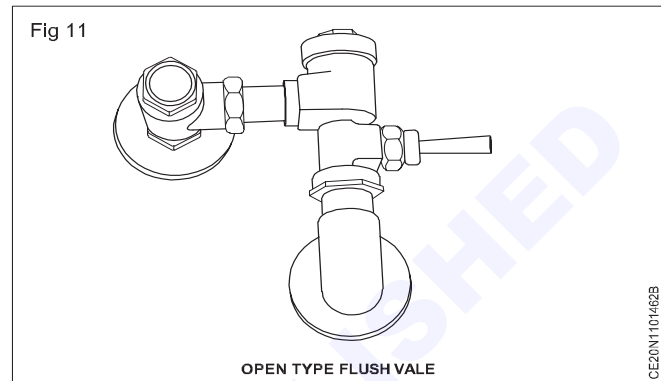
- Drain values are used is compressed air system.



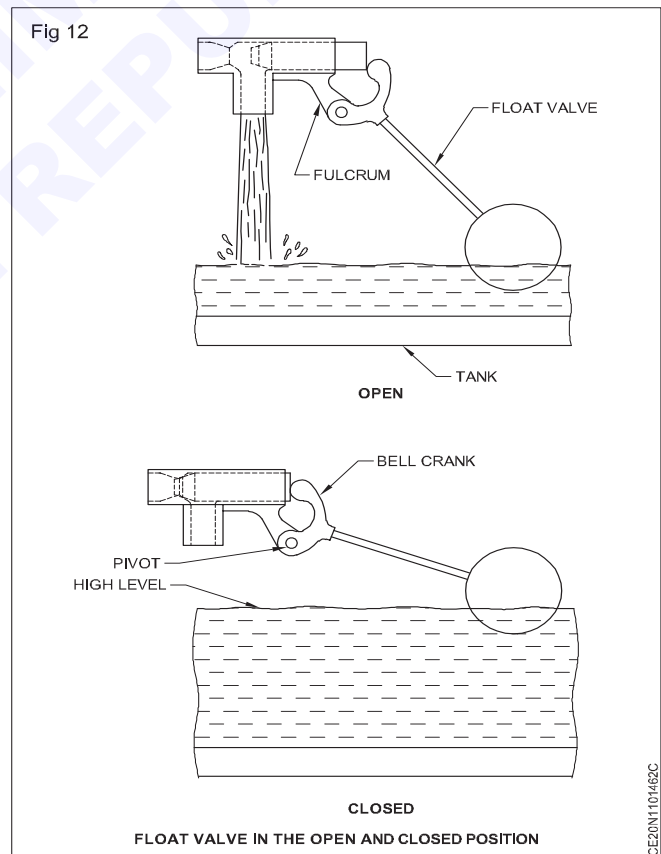
- These are used to remove slurries to drain from the system
- Also used to drain liquid or gas to be drained from the hot water system.
- Helps to prevent the formation of corrosion and erosion.

Flush valve: Flush valve is non-automatic type of valve. It is widely used in the water supply system for flushing Bowls. (Fig 11)

Flush valves are made of brass/CP brass.

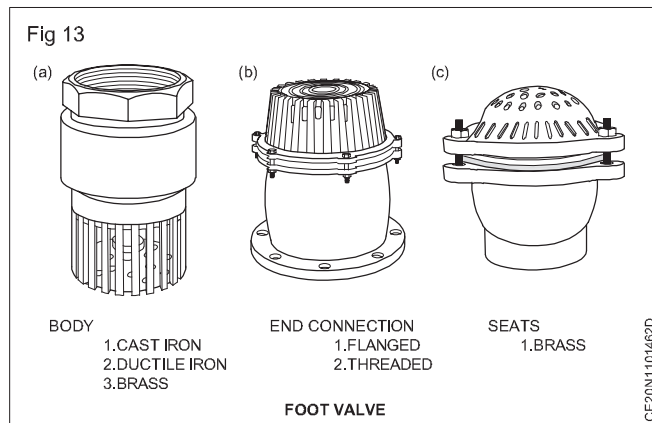


Float valve: Float valve is automatic type of valve used in the flushing cisterns of closets and in water storage tanks. (Fig 12)



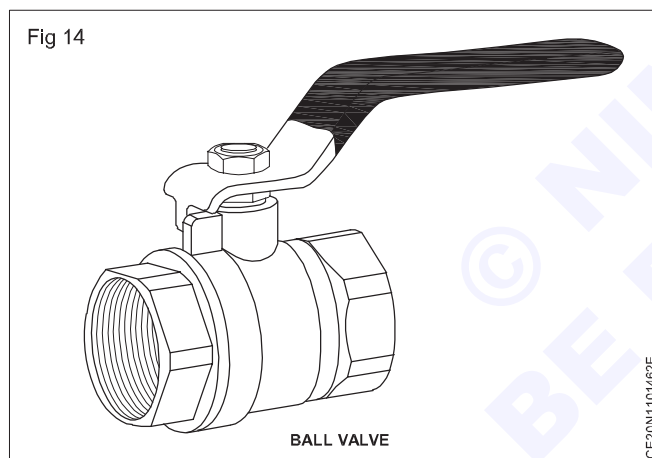
Function of float valve: The function of a float valve is to shut off the water supply to the tank, when the water level reaches a pre-determined level.

Foot valve (Fig 13)



- 1 These foot valves are used in the pump set suction line. (Fig a, b & c)
- 2 These valves are essential to maintain the water level in the suction line.
- 3 Strainers are used to prevent dust, silt, leaves and other foreign substances entering the suction line.
- 4 If pump runs without water flow strainer gets blocked should be cleaned.

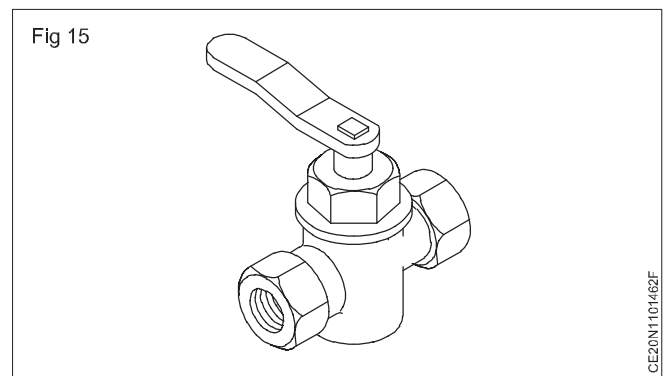
Ball valve (Fig 14)



- 1 Ball valves are used in water supply lines by builders.
- 2 These valves are now a days so familiar for its simple operation.
- 3 This functions like plug valve.
- 4 Made of Brass, PVC, UPVC.
- 5 Consists of Lever Handle, Lock nut with washer, Spherical with through hole in centre, Teflon 'o' rings.
- 6 Handle perpendicular to pipe line means close.

Plug-cocks: Plug-cocks are suitable for high pressure applications. A parallel, tapered or spherical plug, pierced with a hole equal in area to the bore of the pipe, is turned in the body to permit or prevent flow from one side of the plug to the other. (Fig 15)

Fig 15

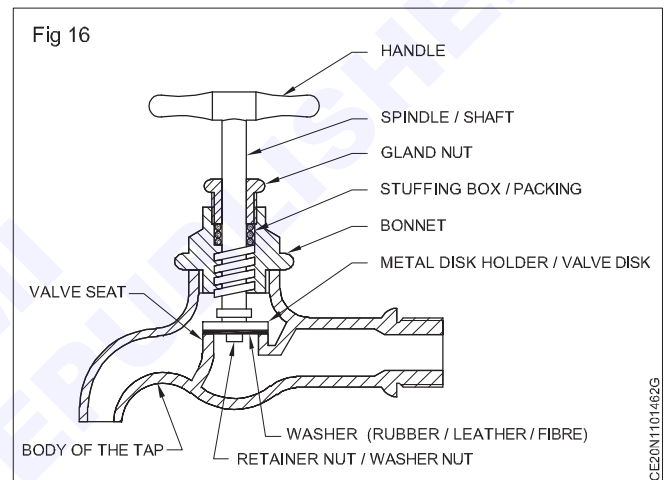


Types of cocks

1 Bib cock (or) stop tap (Fig 16)

A Bib cock is a valve with suitable means of connection, for insertion in a pipe line for controlling or stopping the flow.

Fig 16

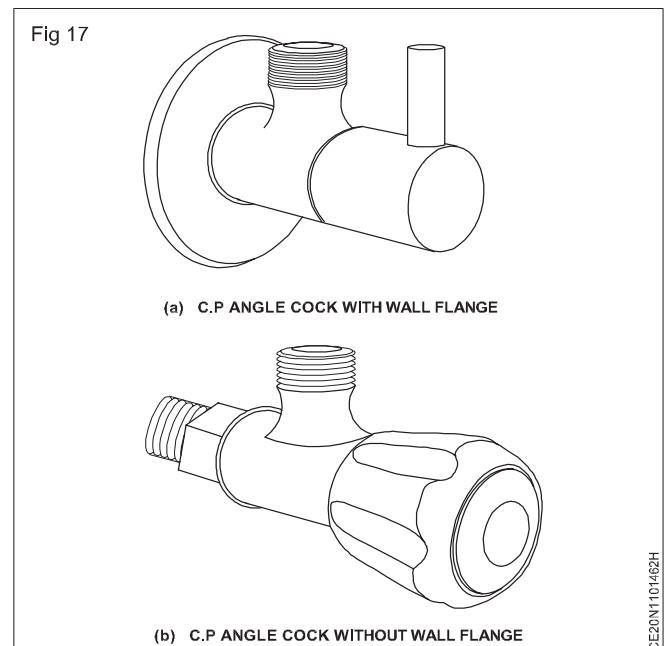


C.P. Angle cock (Fig 17)

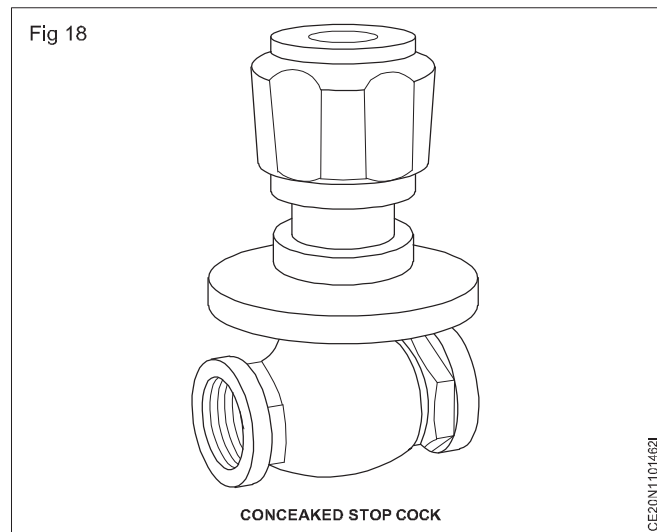
This valve is so essential to provide inlet connection to all sanitary fittings like flush tanks, wash basin, Health faucet

Also - for the inlet of geyser, washing machine etc.,

Fig 17

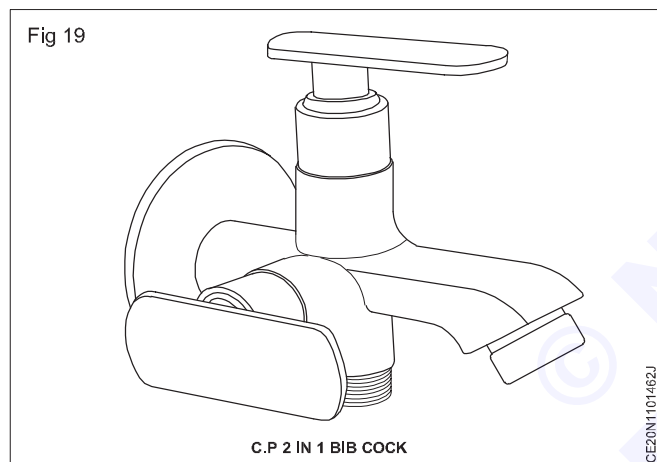


Concealed stop cock (Fig 18)



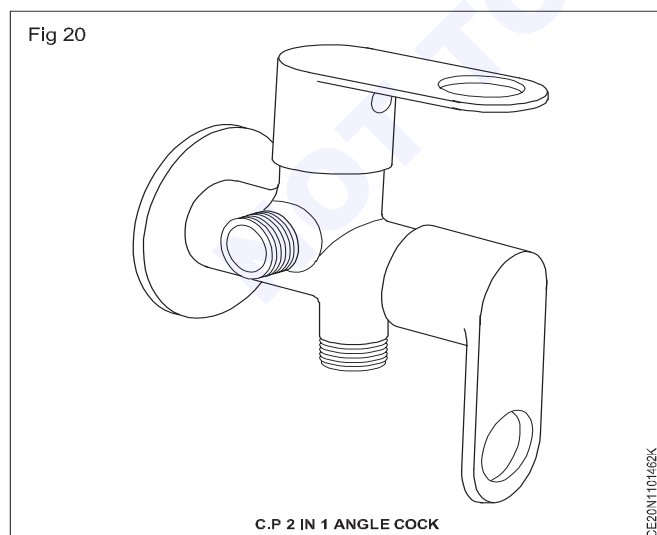
This cock is used in between pipelines.
Generally used in concealed shower connection.

C.P 2 in 1 Bibcock (Fig 19)



This type of tap is used for double purpose
Used in bathroom and toilets

C.P. 2 in 1 Angle cock (Fig 20)

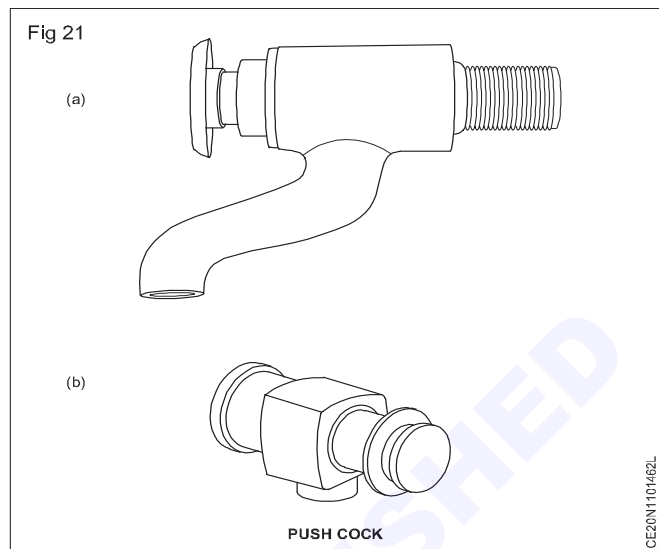


This 2 in 1 angle cock is used for Geyser outlet connection

Used to get two hot water outlet with single Geyser for two Bathrooms

Also used in health faucet and cistern in European water closet.

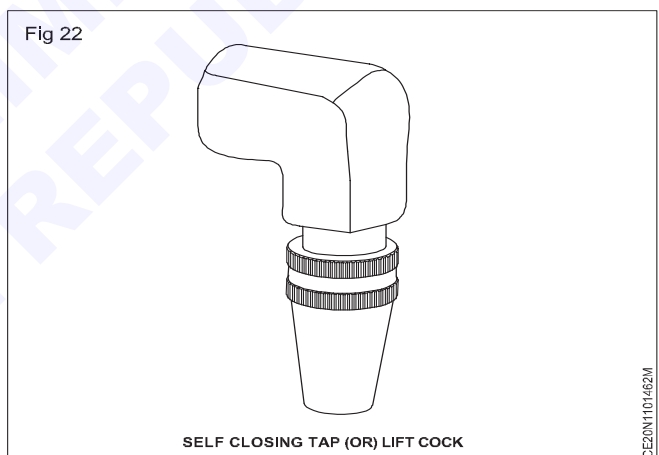
Push cock (Fig 21)



This tap belongs to auto closed type.

Used for drinking water connection

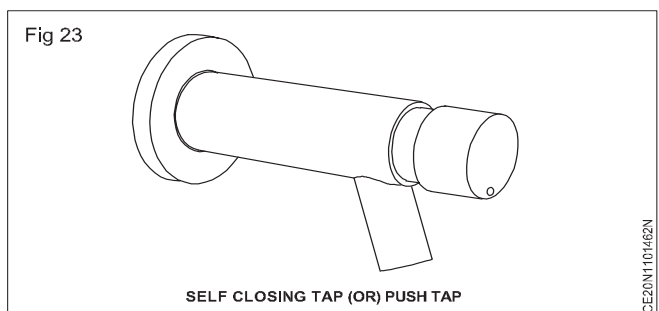
Set closing tap (or) Lift cock (Fig 22)



This tap belongs to auto closed type.

Used in drinking water fountains, water coolers and in public drinking water provision

Self-closing Tap cock (or) push cock (Fig 23)



This type of tap functions by pushing the head

Belongs to automatic closing type

After pushing automatically closed due to spring.

3D Coordinate systems to aid in the construction of 3D objects and knowledge short cut key board commands

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

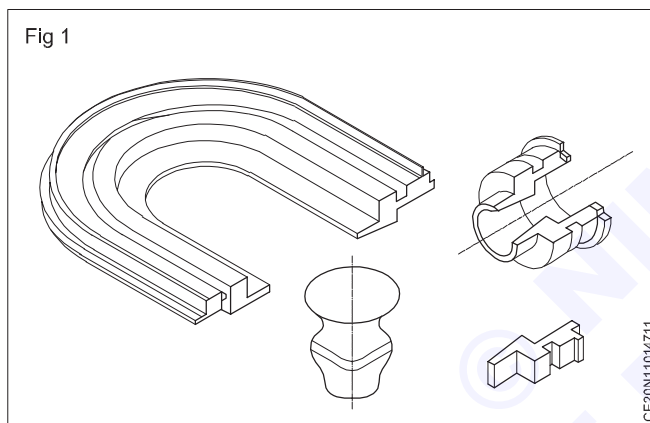
- describe solid modeling
- describe surface modeling and construction plane commands.

Introduction

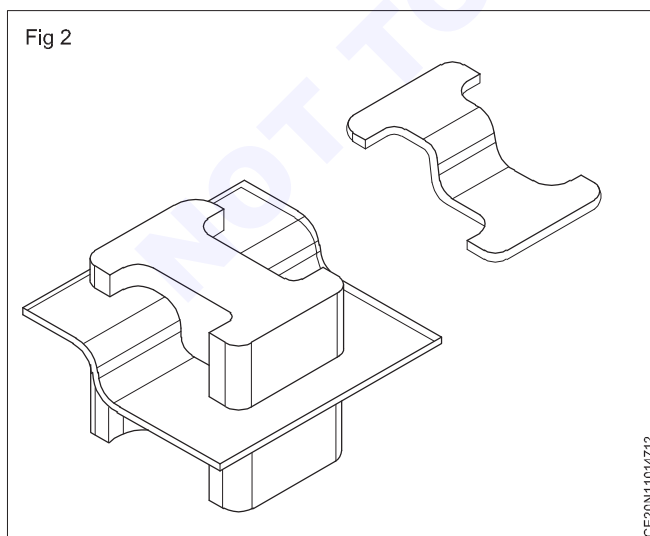
Auto CAD 3D modeling allows you to create drawings using solid, surface, and mesh objects.

Solid modeling (Fig 1)

A solid model is a volume that represents a 3D object, and has properties such as mass, center of gravity, and moments of inertia. You can create 3D solids from primitive solids such as cones boxes, cylinders, and pyramids, or by extruding, revolving, sweeping, or lofting closed 2D objects as shown.

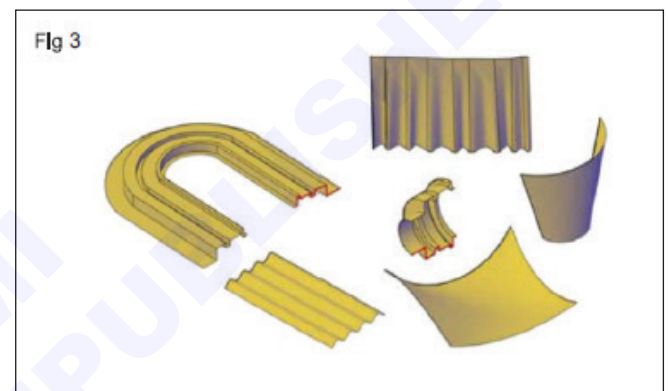


You can also combine 3D solids using Boolean operations such as union, subtract, and intersect. The illustration below shows two solids that were extruded from closed poly lines, and then combined by intersecting them. (Fig 2)



Surface modeling (Fig 3)

A surface model is a thin shell that does not have mass or volume. Auto CAD offers two types of surfaces: procedural and NURBS. Use procedural surfaces to take advantage of associative modeling, and use NURBS surfaces to take advantage of sculpting with control vertices.



Construction planes: In addition, you can save and restore named construction planes and import named construction planes from another rhino file.

Coordinate input, elevator mode, object snaps, and other cursor constraints allow the cursor to move away from the construction plane.

- Construction plane behavior in the viewports is controlled by the standard and universal options. With the standard option, the construction plane of each viewport is independent from all of the other constructions planes. With the Universal option, the behavior of the construction planes in the viewports is linked. Set these in Modeling Aids Options.
- The construction plane is infinite. The array of lines lying on a specified portion of the construction plane in the viewport is the grid. The grid is a visual reference only. The size, spacing, and color of the grid lines can be changed.
- The X and Y axis of the construction plane are shown on the grid in color by default. The visibility and color of the grid axis can be changed.
- Custom construction planes can be named and saved in the 3dm document, they can be restored in any viewport using the Named C Plane command.

Construction plane commands

C Plane

Set the construction plane in the active viewport.

Copy C plane settings to all

Match all viewports' grid and snap settings to the specified viewport.

Copy C plane to all

Match all viewports, construction planes to the specified viewport.

M Plane

Set up a relationship between a construction plane and an object.

Shortcut	PC	Mac
Bold	Ctrl +B	Command + B
Italic	Ctrl + I	Command + I
Underline	Ctrl +U	Command +U
Select All	Ctrl + A	Command + A
Redo	Ctrl + Y	Command + Y
	Ctrl+Shift+Z	(Command+Shift+Z)
Undo	Ctrl + Z	Command + Z
Header 1	Alt+shift+1	Ctrl + Alt + 1
Header 2	Alt+shift+2	Ctrl + Alt + 2
Header 3	Alt+shift+3	Ctrl + Alt + 3
Header 4	Alt+shift+4	Ctrl + Alt + 4
Header 5	Alt+shift+5	Ctrl + Alt + 5
Header 6	Alt+shift+6	Ctrl + Alt + 6
Paragraph	Alt+shift+7	Ctrl + Alt + 7
Div	Alt+shift+8	Ctrl + Alt + 8
Address	Alt+shift+9	Ctrl + Alt + 9
Focus to menu bar	Alt+F9	Alt+F9
Focus to toolbar	Alt+F10	Alt+F10
Focus to (element path)	Alt+F11	Alt+F11

Named C plane.

Manage the named construction planes list.

Universal construction plane.

Link the viewport origin and position.

Shortcut keys ABCs

Shortcut keys help provide an easier and usually quicker method of navigating and executing commands in computer software programs. Shortcut keys are commonly accessed by using the alt key (On IBM compatible computers), command key (on Apple

computers), Ctrl key, or shift key in conjunction with another key. The de facto standard for listing a shortcut is listing the modifier key, a plus symbol, and another key. In other words, "Ctrl +S" is telling you to press and hold the Ctrl key, and then press the S key too.

You can also find the shortcut keys to their most popular program by looking for underlined letters in their menus. For example, the image to the right has an underline on the "F" in file, which menus. You can press the Alt key and then the "F" key to access the File menu. Some programs require the user to press and hold Alt to see the underlined characters.

In the same image above, you can see that some of the common features, such as open (Ctrl+ O) and save (Ctrl + S), have shortcut keys assigned to them. As you begin to memorize shortcut keys, you'll notice that many applications share the same shortcut keys. We have a list of the most commonly shared ones in the basic PC shortcut keys section.

Tip: Users outside the United states or who have a foreign copy of Microsoft Windows or a Microsoft application may not be able to use all of the below shortcut keys.

Basic PC shortcut keys

Below is a list of some of the most commonly used basic shortcut keys that work with almost all IBM compatible computers and software programs. It is highly recommended that all users keep a good reference of these shortcut keys or try to memorize them. Doing so will dramatically increase your productivity.

Tip: Besides the special character shortcuts listed here, some special characters are also located on the number keys (below the F1-F12 Keys). You can enter these special characters by pressing the Shift key and the number key that has the special character listed on it.

Shortcut keys	description
Alt + F	File menu options in current program
Alt + E	Edit options in current program
Alt + Tab	Switch between open programs
F1	Universal help in almost every Windows program
F2	Rename a selected file
F5	Refresh the current program window
Ctrl + N	Create a new, blank document in some software programs
Ctrl + O	Open a file in current software program
Ctrl + A	Select all text.
Ctrl + B	Change selected text to be bold
Ctrl +I	Change selected text to be in Italics

Ctrl + U	Change selected text to be underlined
Ctrl + F	Open find window for current document or window.
Ctrl + S	Save current document file.
Ctrl + X	Cut selected item
Shift + Del	Cut selected item.
Ctrl + C	Copy selected item.
Ctrl + Ins	Copy selected item
Ctrl + Y	Redo last action
Ctrl + K	Insert hyperlink for selected text
Ctrl + P	Print the current page or document
Home	Goes to beginning of current line
Ctrl + Home	Goes to beginning of document
End	Goes to end of current line
Ctrl + End	Goes to end of document.
Shift + Home	Highlights from current position to beginning of line.
Shift + End	Highlights from current position to end of line
Ctrl + Left Arrow	Moves one word to the left at a time
Ctrl + Right Arrow	Moves one word to the right at time
Ctrl + Esc	Opens the START menu
Ctrl + Shift + Esc	Opens windows task manager
Alt + F4	Close the currently active program
Alt + Enter	Open the properties for the selected item (file, folder, shortcut, etc.)

PC shortcut keys for special characters

Many special characters can be created using keyboard shortcuts, below are some of the more common and popular special characters and the keyboard shortcuts to create them.

Shortcut keys	description
Alt + 0224	à
Alt + 0232	è
Alt + 0236	ì
Alt + 0242	ò
Alt + 0241	ñ
Alt + 0228	ä
Alt + 0246	ö
Alt + 0252	ü
Alt + 0248	ø
Alt + 0223	ß
Alt + 0198	Æ
Alt + 0231	ç
Alt + 0191	¿
Alt + 0176	° (degree symbol)
Alt + 0177	± (plus/minus symbol)
Alt + 0153	™
Alt + 0169	©
Alt + 0174	®
Alt + 0128	€ (Euro currency)
Alt + 0162	¢ (Cent symbol)
Alt+0163	£ (British pound currency)
Alt+ 0165	¥ (Japanese yen currency)
Focus to contextual toolbar	Ctrl + Shift + E Command + E
Insert Link	Ctrl + K Command + K
Toggle Full screen	Ctrl + Shift + F Command + Shift + F
Save	Ctrl + S Command + S
Find	Ctrl + F+ Query Command + F+Query