DRAUGHTSMAN CIVIL

NSQF (LEVEL - 5)

3rd Semester

TRADE THEORY

SECTOR: Construction

Directorate General of Training

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

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

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FOREWORD

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

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Draughtsman Civil 3rd Semester Trade Theory NSQF Level - 5 in Construction Sector under Semester Pattern.** The NSQF Level - 5 Trade Theory 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 - 5 trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 5 the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

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

Jai Hind

RAJESH AGGARWAL
Director General/ Addl. Secretary
Ministry of Skill Development & Entrepreneurship,
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PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of the Federal Republic of Germany. The prime objective of this institute is to develop and provide instructional materials for various trades as per the prescribed syllabi (NSQF LEVEL - 5) under the Craftsman and Apprenticeship Training Schemes.

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

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

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.

R. P. DHINGRA
EXECUTIVE DIRECTOR

Chennai - 600 032

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisations to bring out this Instructional Material **(Trade Theory)** for the trade of **Draughtsman Civil** (NSQF LEVEL - 5) under **Construction** Sector for ITIs.

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

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

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

INTRODUCTION

Trade Theory

The manual of trade theory consists of theoretical information for the third semester course of the Draughtsman Civil under NSQF - Level 5. 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 correlation is maintained to help the trainees to develop the perceptional capabilities for performing the skills.

Module 1 - Building drawings

Module 2 - Computer aided drafting

Module 3 - 3D modeling in CAD

Module 4 - Parks and playgrounds

Module 5 - Reinforced cement concrete structure

Module 6 - Steel stuctures

Module 7 - House drainge

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

It will be preferable to teach/learn trade theory connected to each exercise at least one class before performing the related skill 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.

Trade Practical

The trade practical manual is intended to be used in practical workshop /Hall. It consists of a series of practical exercises to be completed by the trainees during the second semester course of **Draughtsman Civil** under **NSQF Level - 5** Syllabus, which is supplemented and supported by instructions / informatics to assist in performing the exercises. These exercises are designed to ensure that all the skills in prescribed syllabus are covered.

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

CONTENTS

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

- **Make drill jig and produce components on drilling machine by using jigs and check for correctness.**
- **Plan, dismantle, repair and assemble different damaged mechanical components used for power transmission and check functionality of mechanical components like pulley, gear, keys, jigs and shafts.**
- **Identify, dismantle, replace and assemble different pneumatics and hydraulics components like compressor, pressure gauge, filter, regulator, lubricator, valves and actuators.**
- **Construct circuit of pneumatics and hydraulics observing standard operating procedure and safety aspect.**
- **Plan and perform basic day to day preventive maintenance, repairing and check functionality of drilling machine, power saw and lathe.**
- **Plan, erect simple machine and test mechanical tool accuracy of drilling machine, power saw and lathe.**

SYLLABUS FOR DRAUGHTSMAN CIVIL

Third Semester **Duration: Six Month**

Week No.	Ref. Learning Outcome	Professional Knowledge (Trade Theory) with Indicative hours	Professional Skills (Trade Practical) Building:-
53-54	Draw single storied Building site plan layout.	Drawing details of:- 91. Single storied residential house with attached bath of both pitched and flat roof. (12 hrs) 92. Making plan, elevation, and section with aid of line diagrams of the building. (26 hrs) 93. Layout and detailing of residential building. (06 hrs) 94. Create a drawing of building showing set backs. (06 hrs) 95. Showing layout plan and key plan. (06 hrs)	• Principle of planning • Objectives & importance. • Function& responsibility. • Orientation. • Local building Bye-Laws as per ISI code. • Lay out plan & key plan. • Submitted in composition of drawing. • Provisions for safety. • Requirement of green belt and land.
55-56	Create objects on CAD workspace using Toolbars, Commands, Menus, formatting layer and style.	Computer practice:- 96. Function of keys and practice of basic commands. (06 hrs) 97. Use of elementary commands by CAD toolbar. (06 hrs) 98. Creation of objects in different layers on CAD workspace. (10 hrs) 99. Plotting of drawing from CAD. (02 hr) 100.2D drafting of flash door, panel door, window, hand railing, wash basin, sewerage pipe joints, etc. (20 hrs) 101.Preparing Library folder by creating blocks of the above items. (12 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.
57-58	Draw a sanction plan of double storied flat roof residential building by using CAD.	Building Drawing (Residential) Prepare:- 102.Plan, section and elevation of buildings with specifications for the given line drawing to suitable Scale. (32 hrs) 103. A Reading room with R.C.C flat roof. (06 hrs) 104.A House single storeyed residential building with	Building Planning:- • Economy & orientation. • Provision for lighting and ventilation. • Provision for drainage and sanitation. • Types of building. • Planning & designing of residential , public and commercial building.

59-60	Draw a sanction plan of double storied flat roof residential building by using CAD.	105. A residential building with double beded rooms with R.C.C. flat roof slab. (10 hrs.) 106.House with single bed and hall with partly tiled and partly R.C.C. flat roof slab. (12 hrs.) 107.Two roomed house with RCC slope roof with gable ends. (12 hrs.) 108. A House with fully tiled roof with hips and valleys. (10 hrs.) 109.Design and create a double storied residential building (3BHK) with Positioning layout of Furniture, Electrical appliances and plumbing / sanitary fittings. (12 hrs.)	Prefabricated Structure:- • Preparation. • Method of construction, assembling. • Advantages & disadvantages.
61	Create objects on 3D modeling concept in CAD.	3D modeling in CAD :- (28 hrs) 110.Create and use model space viewports. 111. Create a standard engineering layout. 112. Create and edit wireframe model. 113. Create and edit solid mesh and surface modeling. 114. Create and edit simple 2D regions and 3D solid models. 115. Generate 3D text and dimensions using a variety of 3D display techniques. 116. Render a 3D model with a variety of lights and materials.	3D modeling concept in CAD • 3D coordinate systems to aid in the construction of 3D objects • Knowledge of shortcut keyboard commands.
62-63	Prepare a drawing of public building detailing with roof, column by framed structure using CAD	Building Drawing (Public) Prepare:- 117. A Primary health center for rural area with R.C.C roof. (10 hrs.) 118. A Village Library building with R.C.C flat roof. (06 hrs.) 119. A small Restaurant building with R.C.C flat roof. (06 hrs.) 120. A Single storeyed School building with R.C.C flat roof. (10 hrs.) 121. A Small workshop with north light steel roof truss (6 to 10m Span) over R.C.C. Columns. (12 hrs.) 122. Service plans. (06 hrs) 123. A Bank building with R.C.C flat roof. (06 hrs)	• Parks & play ground- Types of recreation, landscaping. etc • Concepts of design of earthquake resisting buildings- requirements resistance , safety, flexible building elements, special requirements, base isolation techniques.

64-65	Prepare detailed drawing of RCC structures using CAD and prepare bar bending schedule.	Drawing details of RCC members with reinforcement:- 124.Rectangular beams(Single reinforced & Double reinforced). (17 hrs) 125. Lintel, chajjas & slabs. (12 hrs) 126.Stair - details of step. (17 hrs)	Reinforced cement concrete structure:- • Introduction to RCC uses. • Materials - proportions • Form work • Bar bending details as per IS Code. • Reinforced brick work.
66-68	Prepare detailed drawing of RCC structures using CAD and prepare bar bending schedule.	Draw Reinforced details of RCC members:- 127. Preparing bar-bending schedule. (12 hrs) 128. Details of one-way slab & two-way slab. (20 hrs) 129. T-beam, Inverted beam, cantilever, retaining wall, Lift well. (16 hrs) 130. Column with footing. (12 hrs) 131. Continuous columns showing disposition of reinforcement. (12 hrs) 132. RCC framed structure, portal frame, B.I.S. Code 456-2000, SP - 34 and its application. (12 hrs)	Materials used for RCC:- • Construction. • Selection of materials - coarse aggregate, fine aggregate, cement water and reinforcement. • Characteristics. • Method of mixing concrete - machine mixing and hand mixing. • Slump test. • Structure - columns, beams, slabs - one-way slab & twoway slab. • Innovative construction. • Safety against earthquake. • Grade of cement, steelbehaviour and test. • Bar-bending schedule. • Retaining wall. • R.C.C. Framed structure.
69-70	Draw the different types of steel sections, rivets and bolts using CAD. Draw the details of girders, roof trusses and steel stanchions using CAD	Drawing of different types of:- 133. Steel sections, rivet,bolts,etc. (16 hrs) 134. Section and elevation of girders. (12 hrs) 135. Structural Joints. (12 hrs) 136. Plate girders roof trusses, stanchion etc. (16 hrs)	Steel structures:- • Conmen forms of steel sections. • Structural fasteners , Joints. • Tension & compression member. • Classification, fabrication. • Construction details.
71-73	Preparethe detailed drawing showing the different types of sanitary fittings, arrangements of manholes, details of septic tank using CAD. Draw the details of rapid sand filter.	Public Health & Sanitation. 137. Drawings of showing various pipe joints for underground drainage. (12 hrs) 138. Types of sanitary fittings in multi-storeyed building. (12 hrs) 139. Manholes and septic tank. (16 hrs) 140. Water supply system. (10 hrs) 141. R.C.C square overhead tank	House drainage of building:- • Introduction. • Terms used in PHE. • Systems of sanitation. • System of house drainage. • plumbing, sanitary fittings, etc. • Types of sewer appurtenance. • Systems of plumbing. • Manholes & Septic tank. • Water treatment plant • Swerage treatment plant

		supported by four columns. (12 hrs) 142. Preparation of service plan (drainage plan) for isolated building & in sewer system. (10 hrs) 143. Drawings of toilet fixtures. (06 hrs) 144. Flow diagram of water treatment plant (WTP) and Swerage Treatment plant (STP). (06 hrs)	
74-75	Project work / on the job training Broad area :- (a) Draw residential building plan of single/ double storied building using CAD for Municipal/ approval (b) Prepare drawing of public building detailing with roof, structure etc. using CAD. (c) Prepare drawing of Bath/ Kitchen/ Reception Hall in details using Auto CAD 3D modeling with rendering.		
76-77	Revision		
78	Examination		

Note: -

1. Some of the sample project works (indicative only) are given against each semester.
2. Instructor may design their own project and also inputs from local industry may be taken for designing such new project.
3. The project should broadly cover maximum skills in the particular trade and must involve some problem solving skill.
4. If the instructor feels that for execution of specific project more time is required than he may plan accordingly to produce part/ sub-drawings in appropriate time i.e., may be in the previous semester or during execution of normal trade practical.
5. Drawings at weeks 1 to 54 are in traditional and from 55 to 99 weeks are in computer drafting.

Planning of building and orientation

Objectives : At the end of this lesson you shall be able to
- **introduction objectives and importance of building**
- **state principles of planning**
- **explain orientation of building**
- **state the functions and responsibility while planning**
- **documentation to be submitted In cooperation of drawing.**

Introduction

Food, shelter and clothing are the basic requirements of human being. By considering the sheltering aspects, the Civil Engineering play an inevitable role. Convenient branches of tree, suitable caves and huts of bamboo are a few examples of early means of sheltering.

Even in the modern era, adequate housing is a social impacting problem so planning of building is an intellectual task of modern civil engineering.

Building planning

Planning is the process of providing a safe, healthy, economic and hygienic atmosphere in and around of a builidng for the human habitation.

Plan of a builidng is the assembling or grouping and arranging of its component parts in a systematic manner and proper order so as to form a meaningful wholesome and homogeneous body with a compreshensive look out of meet its day to day functional purpose.

Object use and importance kept in mind while planning

- Planning should be according to the functional objects and requirements
- General scope and purpose of the building.
- Legality of ownership right, local rules and financial status etc. Considered.
- A double storied building providing same floor area that of a single storey is cheaper by about 15% to 20%
- Local bye laws and rules should be considered.
- Climatic conditions of the area should take under consideration.
- A square and circular plan is cheaper & compact
- Plan should be according to the shape of plot.
- Relationship between different rooms and their sizes should be considered.
- Availability of materials and methods.
- Topography of the plot.
- A square plan to cheaper than oblong. The area occupied by walls of a square building may be 15% to 25% less than a rectangular plan.
- A square plan makes a house compact. It makes the house cooler in summer season and warmer in window season. Since fewer walls are exposed. Hence a sequence plan is always preferred.

According to the planning acts the main objects of planning may be summarised in three words

1 Health.

2 Convenience.

3 Beauty.

1 Health: To create and promote healthy conditions and environment for all people.

2 Convenience: The object of convenience is meant in the form of various needs of the community such as social, economic, cultural and recreational amenities etc.

3 Beauty: To preserve the asthetics in the design of all elements of town and city plan, which included preservation of trees, ancient architectural buildings of cultural and historical importance and buildings of worship etc.

Principles of planning

The factors or principles which govern the theory of planning are detail as shown below.

1 Aspect.	2 Prospect.
3 Privacy.	4 Furniture requirement.
5 Roominess.	6 Grouping.
7 Circulation.	8 Santiation.
9 Flexibility.	10 Elegance.
11 Economy.	12 Practical considerations.

1 Aspect: The arrangement of doors and windows in external walls of a buildings which the occupants to receive and enjoy nature's gifts as sunshine, breeze and the beauty of landscape and at the same time protecting the inmates from the effects. The manner of arrangement of rooms or peculiarity of arrangement of doors and windows in the external walls of the building to draw maximum effect from sun and wind is termed as aspect. A room which receives light and air a particular direction is said to have aspect of that direction.

A building must be designed to suit the site with all its varying aspects. As not only provide comfort, but are a requisite from the hygienic point of view as well.

Each room of a residential building should have a particular aspect been certain rooms need morning sun and other rooms need less light.

Aspect is a very important consideration in the planning of a building. It influence the appearance of a building.

Aspects of different rooms of a residential building are as shown below.

Room	Recommended aspect	Influencing factor
Bed	NW-W-SW	To receive plentiful of breeze in summer,
Kitchen	E and rarely NE	To receive morning sun which is germicides. It purifies the air. It should be well illuminates and cool in afternoon.
Dininig	SE-S-SW	Proximity of kitchen. It should be cool.
Drawing	SE-S-SW-W N-NW	Adequate natural lighting during winter and obviate the sun during summer.
Store	NW-N-NE	Light from north being diffused and events distributed and cool. Dark and cool.

2 Prospect

Prospect is to enrich the outside view i.e., elevation or end-view created by prominent exposing the better constructed and better looking portions and at the same time concealing from the view any undesirable ones.

Prospect must not only make outer appearance attractive, but also maintain qualities such as comfort, cheerfulness, security, labour-saving and up-to -date ness, must also prove a good investment.

The outside appearance can be improved by attractive planning, providing by a windows and utilization of good landscape.

3 Privacy

Privacy is the screening provided for the individuals from the others different from seclusion. It is one of the important principles in the planning buildings of all types in general and residential buildings in particular. If there in respect of privacy, it is a deplorable fault which cannot be compensated on a host of other merits.

Privacy can be a privacy of sight as needed in bath rooms, water closet, urinals etc. or privacy of sound as needed in confidential discussions and in a room, or both privacy of sight and sound as required in a bed room.

Privacy is broadly classified as.

1 Internal privacy.

2 External privacy.

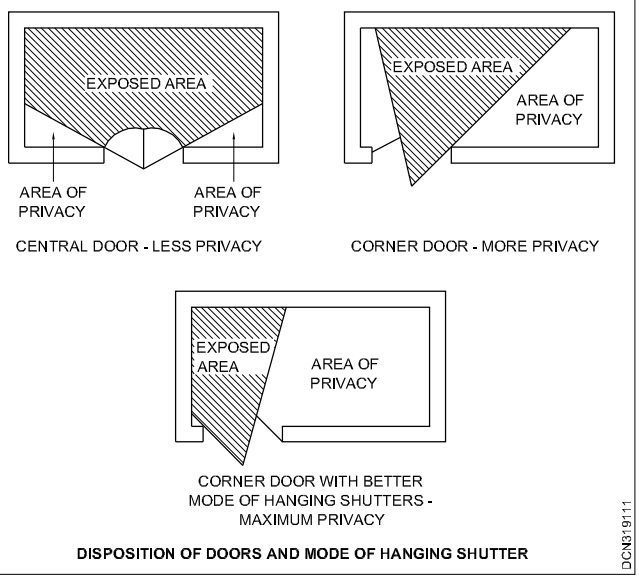
1 Internal Privacy. Internal privacy is the privacy within the building. It can be easily achieved by proper grouping of rooms as bed, dressing and toilet, kitchen and dining.

Useful planning of entrance and circulation space.

Better disposition of doors and windows and mode of their hangings.

locate the doors at one corner rather at the middle. The desirable ways of disposing and hanging shutters are illustrated in (Fig 1).

Fig 1



DISPOSITION OF DOORS AND MODE OF HANGING SHUTTER

Doors with single shutter offer more privacy only when they are kept closed.

Doors with two shutters offer better privacy as one shutter can be closed leaving the other open.

Internal privacy can be obtained by proper grouping of rooms and careful planning of circulation space.

2 External privacy

Privacy of the whole building with reference to the surrounding buildings and roads.

External privacy can be achieved by

i Having a compound wall to a height of 1.35m to1.5m.

ii Planting trees along the compound walls which acts as sound barriers and sight barriers as well.

iii Providing ground glass windows and ventilators. Venetians have the advantage of offering privacy as well as air circulation. Ground glass venetians offer light as well.

iv Providing screen walls, certain walls and dwarf wall on verandha.

v Planting creepers along the boundary fencing or growing shrubs.

4 Furniture requirement

One of the most important requirements of a building planner, is to know how is space is needed by each function in a particular building. The room sizes for particular function can be completed on the basis of permanent furniture to be and in that room as the furniture dimensions are standardized.

How much space is required for performing a particular activity is known through anthopanetric studies science Dimensions of furniture to be used in that room is also known The arranging furniture in that particular room keeping clearance for circulation, dimension can be finalized. Hence, while planning a building, furniture arrangement must be shown to justify the size of a room.

Rooms areas are not related only to furniture sizes, but also to their arrangement. A difference layout if arranged in the same space may not be equally efficient. Hence, planning of a room depends on the number of users and on its furniture and its alignment.

5 Roominess

It is the general feeling created after a room is well-furnished with all the furniture (as the beds inside a bed room)as a spacious and well-planned.

The room dimension should be such that the maximum use of a room having possible dimensions can be made. It means the accomplishment of economy at the same time avoiding cramping of the plan.

Some rooms may create the impression of being cramped with furniture, whereas may create a tunnel like feeling as we enter.

As square room has no advantage and a rectangular room of the same floor area gives a better out look.

A breadth to length ratio of 1:1.2 to 1:1.5 is desirable. When the length exceeds two times its breadth it creates a tunnel-like effect i.e., a feeling as when one is insaide a long tunnel or a railway compartment. Similarly height also plays an important role. A large room with less headroom will give very bad impression, and a small room with large ceiling height will produce a cavernous effect. Hence a room should have all proportional dimensions.

The utillity of space in a room can be increased by providing left and built in cupboards to accommodate furniture, especially furniture of an easy-folding nature.

6 Grouping

Grouping is the planning of two or more related rooms in proximity of each minimises the length of circulation and at the same time improved the comfort, privacy and convenience of the inmates of the house.

Grouping varies according to the type of a building. All public buildings should be designed taking into consideration the movement of persons from one unit to another without causing disturbance to the other units.

The shape of a building depends upon grouping of various individual units.

The following points are to be considered while planning residential buildings.

The dining room close to the kitchen permits an easy serving of dishes in the desirable state i.e., hot or cold. Further the odours and smoke of kitchen are kept off from other rooms, bed and drawing rooms in particular.

The bed room, toilet and dressing room may be grouped together for better privacy.

The bath room and water closet should be nearer to each other. This saves the length of the water supply pipe. Besides, these two rooms require water and storage vessels, when the supply is intermittent. They also collect waste water blended with the body wastes whose disposal is to be done in an hygienic manner. They are to be provided with doors of 650 mm to 750 mm in size and of single shutter. The lower half of the shutter is to be protected against spillage of water which causes severe damage to the shutter. Wooden shutters are decayed and steel shutters are corroded due to alternate wetting and drying. Bath water-closet and bathroom should be provided with a ventilator at a height of 1.8 m above the floor level to an outer wall. When the number of inmates is less than 5, it is desirable to its have a bath-cum-water-closet, but when the number exceeds 5, it is better to have two separate units provided side by side.

Kitchen should be nearer to the backyard and the doors and windows are so located that the housewife can have a free unobstructed sight of the children playing in the open space or in the drawing room.

If more than one bedroom is provided, they should have an easy access to the drawing and dining-rooms.

Staircase should be centrally located and easily accessible from all the rooms.

The water-closet should be away from dining-room and this is mainly to get privacy of sound and the psychological feeling of being away from the insanitary place.

7 Circulation

Circulation is the access into or out of a room. It is the internal movement inside a building and the area earmarked for it. It is the space used for getting comfortable communication from one room to another or from one floor to another.

The position of doors indicates the area of circulation which in turn controls privacy, comfort and convenience.

Circulation inside a house should be simple, systematic and short.

The sequential operations like the movements from kitchen to dining and the toilet control the provisions for circulation.

Circulation area should be straight, short, bright, lighted both day and night and well ventilated.

Circulation should neither affect the privacy of a room nor interfere with utility space.

Circulation in a building is of two types

1 Horizontal circulation.

2 Vertical circulation.

When the circulation is within the same floor, it is called horizontal circulation and when it is between different floors it is called vertical circulation.

1 Horizontal circulation: Horizontal circulation within a building is facilitated by verandahs, corridors, halls and lobbies.

Passages should never be narrow, dark, zigzag or winding. They should be tree from obstructions.

Window-shutters should never flung open into the passages particularly when people are passing over.

No stationary object is to be situated on a corridor or verandah.

Area of the horizontal circulation may constitute about 20% to 25% of the total plan area of a residential building.

i.e.. Circulation area/utility area =1/5 to 1/4

It may be more for public buildings where a room can be divided into two spaces, one a useful space and the other circulation space.

2 Vertical circulation: It is the movement from one floor to another in multi-storied building.

It is possible because of stairs, ramps (sloping slabs), elevators (lifts) and escalator (mobile stairs).

Stairs are quite common in small residential buildings. Lifts are a must when.

i Number of stories are more than three.

ii Number of users are many as in a public building.

iii Old people, children and sick people frequently move in and out as in the case of a hospital.

Lift is to be provided nearer to the stairs.

Stairs are to be provided with smooth hand-rail for easy ascent and descent.

Stairs are to be well ventilated both day and night. They should have a free and independent access from all rooms.

Ramps are common for the movement of heavy objects like cars going to upper floors in a multi-storied building.

Escalators have the virtues of both sairs and lifts, but they are a little slow as compared to lifts.

Sanitation

It is the provision and upkeep of the various components of a house to keep the inmates cheerful and free from disease.

The factors influencing sanitation are

1 Lighting. 2 Ventilation. 3 Cleanliness.

1 Lighting

It can be natural light as that obtained from the sun during the day or artificial one as that from a filamentous bulb or fluorescent light. Fluorescent light. Produces more illumination per unit of power consumed hence is cooler and produces a softer shadow.

Adequate illumination is essential in day to day activities to execute the tasks safely, comfortably and efficiently.

Good visibility is a must for accident prevention, comfortable watching and reading decoration, to reduce fatigue, avert confusion, present true colour and for efficient security.

Day lighting

Sun is the source of light.

Day light is preferred to artificial illumination.

Morning sun is pleasant and has vitamin D. It is the best tonic for rickets. Sun rays even diffused kill pathogenic bacteria and keep the vision clear. Natural light stimulates the blood. This simulation controls tuberculosis.

The intensity of illumination depends on

Latitude-Maximum on equator and reduces with increase in latitude (towards N)

Solar altitude-Increases with solar altitude (0° at sunrise or sunset and 90° at noon)

Sky factors Maximum when clear, least when cloudy.

Season-very bright in summer and less bright in winter.

Orientation of windows

Transmission factor (inversely proportional to shielding of light because of the trees, dark coloured glasses of Doors, Windows and Ventilators).

Reflection factor of walls, ceiling and flooring in White colour offers 100 reflection and black colour 0% reflection.

Day light factor = Incidental light + Reflected light, 1% day light factor =80 Lux.

Focussed or concentrated light may be required for some jobs like reading writing, whereas the light spread uniformly is needed for various other avocations.

Diffused light is preferred to direct light. Light from more than one source preferred to that from a single source.

Uniform lighting may not reveal good contrast. Hence, predominant light to direction and less intense light in other direction or directions will present better contrast.

Twinkling or glistering light can be appreciated, but not glare and dazzling light.

Glare harms the eye and may cause fatigue. One cannot see the details in glare.

All the rooms of a residential house except store room need a reasonable amount of illumination both day and night.

Stairs or for that matter any other flight of steps must be well-illuminated day and night to avoid confusion and accidents.

Drawing room and kitchen should be very well-illuminated. A relatively less amount of light may be sufficient in dining room, bed room and toilet. However in the dressing room light focussing arrangement should be provided about mirror to have a clear image revealing the true details.

A standard candle emits 4 lumens.

1 Lux = 1 lumen/m2.

Ventilation is replacement of state warm and odourous air within the room with fresh coal and odour free air.

i Supplies fresh cool air rich in oxygen,

ii drives out CO_2 and odourous gases,

iii Reduces humidity,

iv Expels smoke and other gases of combustion and

v Preserves heat balance of human body.

Extent of ventilation required depends on

1 **Climate:** Chill cold climate does not require any air exchanges. Hence windows are kept closed during chill winter nights.

In very hot climate outside hot air (greater than 37°C) the human body temperature of the day is never welcome to get into the room. Hence, windows are kept close during the daytime in summer.

Dry hot climate requires air exchanges only at night (when outdoor temperature is less than human body temperature).

Warm humid climate requires frequent air exchanges.

2 Purpose of the room

Residential house: Residential odourous rooms as toilet require a minimum 6 air changes per hour.

Kitchen which gives out steam, fumes, heat and odour requires a minimum of 6 air changes per hour when designed for 5 or less number of users.

All other habitable rooms including bedroom and drawing room need a minimum of 3 air changes per hour.

Public buildings: Less than 1 air change per hour is no ventilation at all.

In a place where neither heat nor any offensive odours are given out as a small class room or a small office room a minimum of 5 air changes per hour is required.

A kitchen of a restaurant needs a minimum of 12 air changes per hour. The ward of a hospital requires more than 12 air changes per hour.

It is a maximum of 60 air changes per hour in case of places which products odourous gases or excessive quantities of heat.

More than 60 air changes per hour need high velocities of wind greater than 1.5m which causes discomfort to the occupants of the room and hence is undesirable.

3 Number of occupants and the nature of occupancy: More is the number of occupants of the room, more ventilation is required.

Place	Characteristics of occupancy	Ventilation air m^3/h/person
Cinema theatre	Still watching with no activity	8.5
Office	Little physical action	17
Restaurant	Hot and odourous products	25
Bar	Quite odourous products	35
Gymnasium	Body strained, heat, sweat and body odours, exuded	85

Types of ventilation

1 Natural ventilation.

2 Mechanical Ventilation.

1 Natural Ventilation

It is the controlling of the movement of air within a room by providing openings as windows, ventilators and louvers, in the walls.

A single window (irrespective of its size) in a wall rarely serves the purpose of ventilation unless the door of the room is also kept open. Therefore for effective ventilation a minimum two windows to different walls is a must.

Width of window: In general more is the window area more is the ventilation. But when the total width of windows exceeds 66.67% of the total length of the wall any further increase has little influence on ventilation.

Window area should be a minimum of 10% of floor area for any habitable room while 15% to 20% is preferred for Bed and Drawing rooms. A value greater than 25% does not increase ventilation much.

A minimum sill level of 0.9 m is preferred for privacy as well as effective ventilation. Window top level at more than 2 m may not serve any useful purpose except where the headroom is more than 3.5 m.

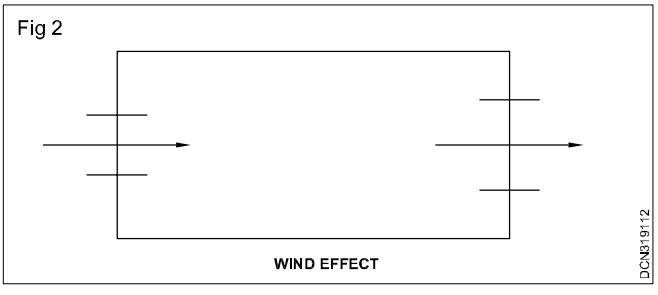
Number of windows: A wider window is preferred to 2 or more narrower windows on the same wall.

At least two windows on the opposite walls serve effective ventilation and windows on adjacent walls is the next preference.

A small window (ventilator or opening) is provided just below the roof slab of walls to expel hot air accumulated.

Operating forces in natural ventilation

1 **Wind effect:** Fig 2 Wind flows from a higher pressure to a lower pressure. It exerts positive pressure on the windward face and suction on the leeward face.



Narrow window openings on the windward side and broader ones on the leeward side cause good air flows into the room and keeps it cool.

Change of direction reduces the velocity of flow of air.

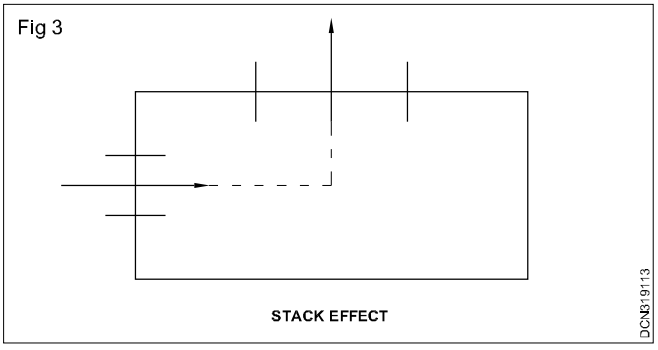
2 **Stack effect:** Fresh air shall be cool and heavy. As it becomes stale it gets warmed and becomes lighter. Hence, it is collected over cool air. Thus, coolest air shall be the densest and collected at the bottom while warm and light air shall be collected at the top.

If we provide an outlet (an opening, louver or ventilator) at a higher level i.e., just below the roof level, the warm air flows out sucking in cool free air at the floor level. This is known as stack effect which works because difference in temperature between inside and outside the room.

Stack effect increases with (Fig 3)

a Difference in temperature between outside and inside of the room. More is the difference more is ventilation;

b Difference in elevation between inlets and outlet. More is the different vigorous is the ventilation.



c Sizes of inlets and outlets. Bigger inlets and outlets cause greater stack effect Natural ventilation may not be adequate even in a small residential building.

a Variation of wind. The wind changes both velocity and direction from time to time and hence windward and leeward directions change accordingly.

b Less window area.

c Less head room and hence less stack effect.

d Hot climate as summer which requires frequent air changes.

In public places where the number of occupants of a room is more than 50 (fifty) and is designed at less than 10 cubic metres per person, forced air circulation may be necessary.

2 **Mechanical ventilation:** Besides providing circulatory fan to create air current different other methods are available.

i **Exhaust system:** It is sucking out of the warm, vitiated air collected nearest to the roof by means of propeller type of fans provided to the outer warm which in turn such fresh air into the room. It is better suited in kitchen Toilets and Laboratories giving out heat, odours and smoke.

ii **Plenum (supply) system:** It is the injection of pure air into the room through ducts forcing the vitiated air to leave through ventilators or other openings.

It is adopted in crowded gatherings as assembly halls, factories and templates of heavy rush.

Cleanliness: Dust harbours bacteria. Besides rendering the surface dull, it creates health problem Hence, the floor which receives most of the dust should be smooth, impervious non-absorbing and uniformly sloping so that it collects less dust and is easily cleanliness non-absorbing and uniformly sloping so that it collects less dust and is easily clean.

Dampness is the root cause of infection. Hence, walls and floors should be damp-proof.

Sanitary conveniences such as bath and water-closet should be so designed that the waste water drains off as quickly as possible. Their flooring should be smooth, impervious, non-absorbent, non-slippery and given proper slope for the quick drainage. Also their walls are to be finished with glazed tiles to a height of one metre above the floor level. The corners are preferably rounded off and this is for the quick drainage. Similarly wastewater generated in the kitchen must find a way out in hygienic manner.

Flexibility: Flexibility means that a room which is planned for one function be used for other so required.

In the case with which a room designated for a particular activity can accommodate the load temporarily or sometimes may have to supplement the activity of another room as the drawing room being used as a bed room for guests, kitchen as an additional dining room etc.

If the rooms are big enough (more than 15 sq m) and have a minimum width of 3m, then they are more flexible and even the activities of various rooms can be exchanged.

A bigger drawing room, a number of rooms and verandas, offer better flexibility.

Independent access to bath and toilet offer maximum flexibility.

Flexibility planning is very important for public and commercial buildings.

Elegance: Elegance is the grand architectural appearance of a building attained mainly owing to the elevation which in turn depends on the plan.

Selection of site for the building greatly affects the elegance. A building located a depression will always give depressed elegance, whereas that located on an elevated spot gives impressive appearance, and catch the attention of everyone.

Without elegance even a best-planned building may not have beauty whilst a poorly and building, if given a slight consideration on front portion may produce good elegance.

Also elegance depends on architecture, neighbourhood, conformity with nature, activity, adjoining buildings and their relative placement which governs the contrast.

A type of architecture which created a sensational feeling at one place may be miserable failure at another place because of lack of conformity with neighbourhood, environment and natural background.

A better elegance can be obtained by

1 Selecting superior building materials for facing such as polished stone-granite, marble or mosaic.

   Glass - either transparent or opaque , coloured or plain.

   Timber - polished teak or sun-glass.

   Paints and varnishes with proper contrast.

2 Providing projections like sunshades, balconies, canopies, porch with or without openings.

3 Providing bay windows, corner windows etc.

Aesthetics, utility and easy maintenance are to be considered while planning elevation. Dark pockets, dusty areas and elements depriving or privacy are to be avoided.

11 Economy: The building should have minimum floor area with maximum utility. It will reduce cost of construction and hence will be economical. Economy should not be achieved at the cost of strength, otherwise the useful life of a building will reduce only with proper planning and utility of space being maximized (passage being minimized), it should be achieved. Hence, economy may not be a principle planning but it is definitely a factor which affects planning.

Economy restricts the liberties of an architect on aesthetic development upon certain extent.

Economy can be achieved by implementing the following measures without affect the utility and strength of the structures.

1 Providing simple elevation.

2 Dispensing of porches, lobbies and balconies.

3 Reducing the storey height.

4 Reducing the number of steps of stairs by giving more rise to the steps.

5 By standardization of sizes of various components and materials.

The present trend of construction is towards simplicity. Simplicity and effect strength lend a lasting beauty and stability to a building.

12 Practical considerations

Besides all the principles of planning discussed, the following practical and should be kept in mind in the planning of a residential building.

1 Strength and stability coupled with convenience and comfort of the occupation should be the first consideration in planning.

2 In the years to come, a man perhaps has to add a wing or extend some part of the house. Provision for this should be made in the planning in the first instance so that some part already built may not be required to dismantle in future.

3 The elements of the building should be strong and capable of withstand the adverse effects of environmental factors that are likely to arise.

4 As far as possible, sizes of rooms should be kept large. Larger rooms can be shortened by providing movable partitions, but smaller rooms cannot be enlarge.

5 Life period of a building should be at least 50 years.

6 Money should not be spent unnecessarily for elaborate architectural pure like balconies, arches etc.

7 Use prefabricated elements for lintels, chajjas, steps etc. This measurement useful in effecting economy.

8 If all bedrooms are in the first floor, lifts should be provided for sick and old, at least one bedroom should be provided in the ground floor for the aged person

9 The number of doors and windows should be a minimum from the area and strength point of view.

Orientation of building (Fig 4, 5, 6, & 7)

Placing of different units of building with respect to the sun prevailing wind direction, rain, and topography of the locality is called orientation. Orientation means fixing the direction of the building in such a way that it derives maximum benefit from the sun, air and nature. Faulty housing condition cause poor health and spread of various types of diseases. Resistance to disease may be increased by living in fresh air and exposing the body to sun shine. Proper orientation of a house increases fresh air and sun shine in the house and decrease possibility of direct infection.

Building orientation is the practice of facing a building so as to maximize certain aspects of its surroundings, such as street appeal, to capture a scenic view, for drainage considerations, etc. With rising energy costs, it's becoming increasingly important for builders to orient buildings to capitalize on the Sun's free energy. For developers and builders, orienting a new home to take advantage of the warmth of the sun will increase the home's appeal and marketability. For homeowners, it will increase their indoor comfort and reduce their energy bills.

Hot dry climate

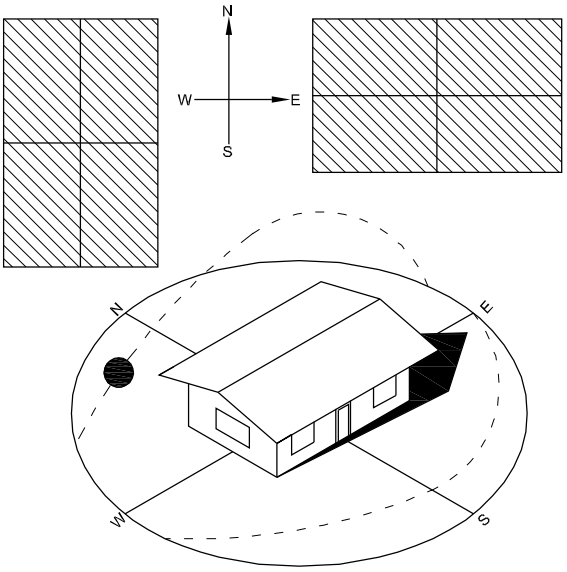
Describe conditions

1 Close layout and compact planning

2 Radiation barries on east & west

3 Smooth and reflective surface

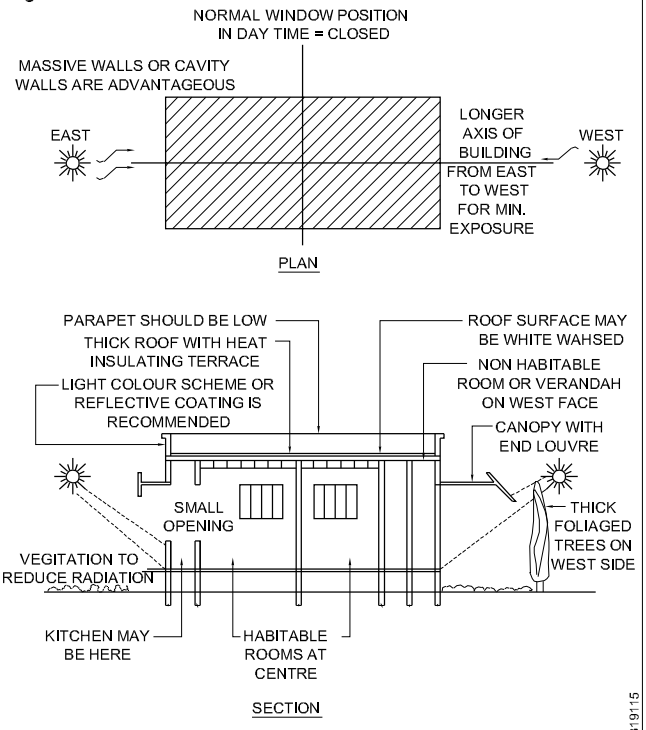
Fig 4



ORIENTATION OF BUILDING

DCN19114

Fig 5



ORIENTATION OF BUILDING

DCN19115

4 Roofs with heat insulation

5 Adoption of evaporative cooling system

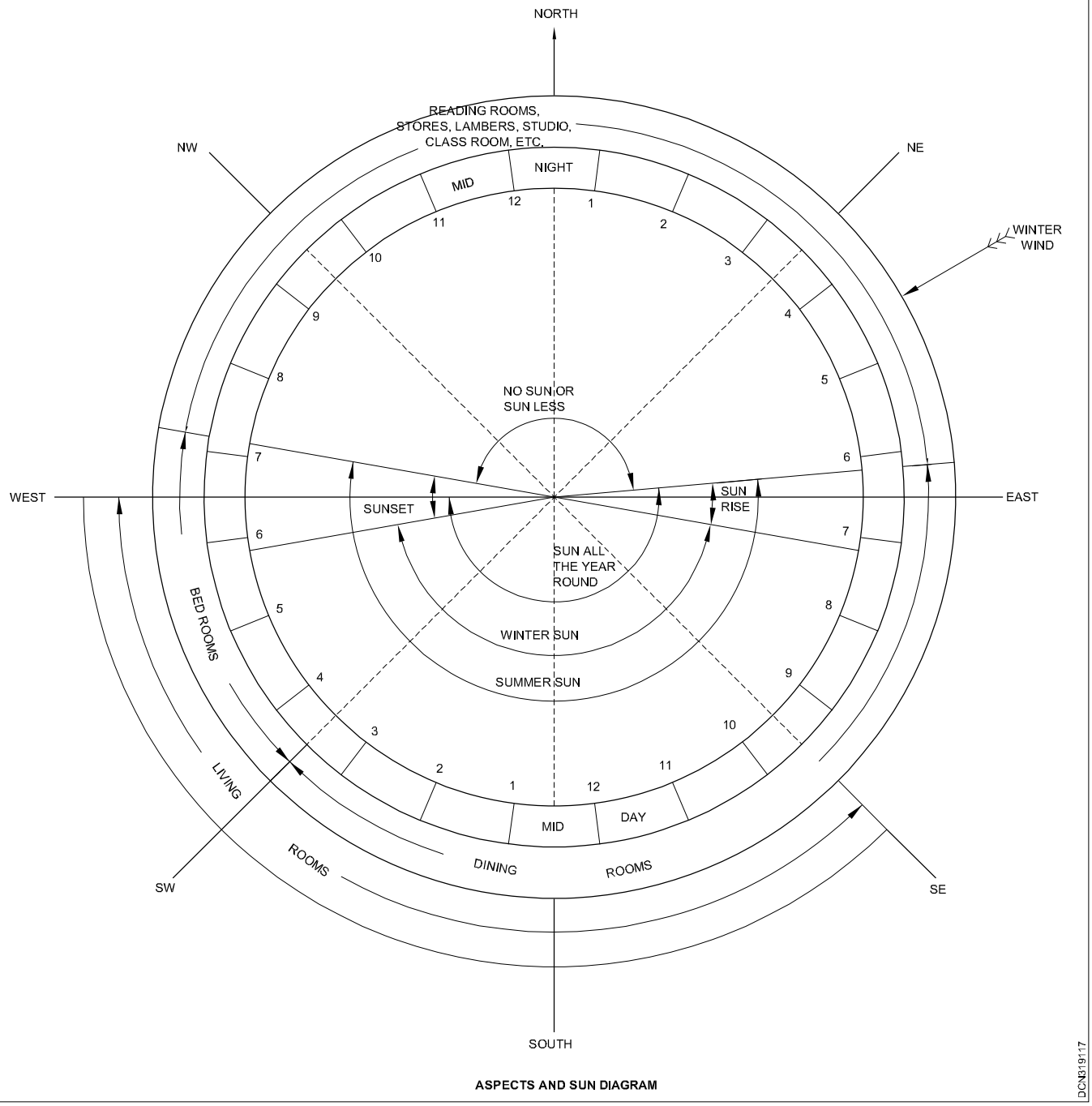
6 Avoding stone slab pavings around the buildings

7 Developing vegitation around the building

8 Providing ventilated false ceilings

9 Internal coutryard

Fig 7



ASPECTS AND SUN DIAGRAM

Suggestions for good orientation of the building

1 **Cross ventilation:** Sufficient number of window, doors and ventilation.

2 **Damp proof course:** To keep away walls from damp, it is desirable to provide DPC at suitable level.

3 **Placing of walls:** Exposing less area of walls to the sun rays will assist in maintaining comfortable temperature.

4 **Projection:** In the form of balconies, verandas, etc are provided on East and west sides.

5 **Roof:** R.C.C flat roofs should be provided with weathering and pitched roofs should contain valley gutters, overhang eaves etc. For drawing rain-water.

6 **Treatment of ground:** Plantation of grass, trees vegetation etc. To reduce the temperature inside the building.

7 **Wind direction:** For enjoying the natural breeze.

Planning of rooms

It is a unit design for the residence of human beings on a permanent basis.

Every unit will have its own identify depending on the site conditions, kinds of occupants, standards of accommodation required, size of family, financial condition etc.

Usual requirement

Living room

Bed room

Kitchen

Bath & W.C.

Bed room: Should be of adequate size to accommodate the furniture including space for movement and other requirements (dressing, cupboard, w.c.etc) and should be adequately ventilated.

Main factors, privacy, location requires careful and better planning.

Bath and water closet: The practice for modern building is to provide bathing space and W.C., wash basin, mirror etc. In a single unit of toilet only.

It should be so arranged that an economical layout of water supply, drainage and electric connection developers.

Dining room: Its main function will be taken meals and refreshments, therefore, should be easily serviceable from the kitchen and immediately approachable from the drawing room.

Drawing room: It is meant for receiving guest also used for various purpose,

- Occasions in the family.
- Office discussions.
- Occupational work.
- Library reading, etc

Therefore, it should be located very near to the entrance with adequate size and easily approachable to the common toilet, dining room, front verandah and staircase.

Garage: It is for the vehicle to be parked in enclosed space.

Kitchen: one of the important unit of the building it is the preparation of food for family.

A nicely designed and well-equipped kitchen afford great comfort and convenience to the family life, social status, etc of the persons occupying the building.

The location should be such that an overall view of the whole building is obtained,

Easily approachable to the entrance, drawing room, dining room, and washing place.

Suitably combined with stone.

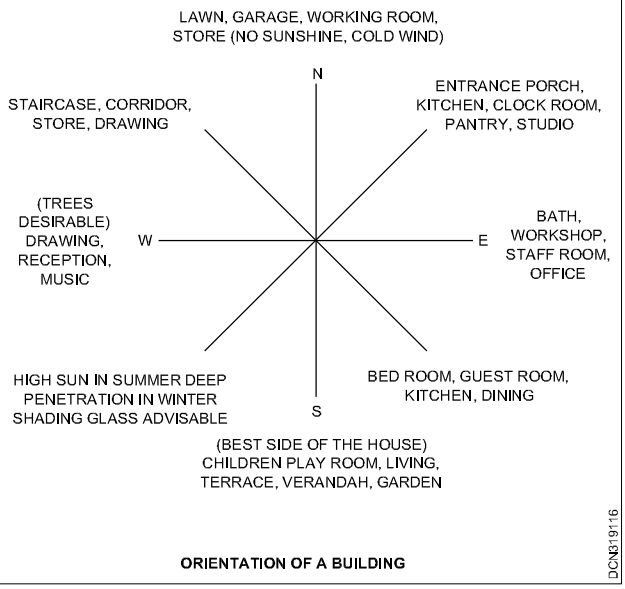
It should allow private working.

Should be on the opposite side of breeze or wind direction to avoid smell spreading into other rooms.

Living room: Similar to drawing room.

Open spaces: To grant air, light and ventilation to the rooms also serves for storage, washing, clothes cleaning utensil etc. Open spaces becomes necessary.

Fig 6



ORIENTATION OF A BUILDING

Passages: It is to avoid undue attack on the privacy or utility of any rooms.

Stairs: The purpose of giving access to different floor of a building the location, required good and careful consideration for adequately lighted and properly ventilated.

Store: If necessary it may accommodated.

Verandah: Essential in the entrance to avoid direct entry of unknown person and back/rear side to protect the rooms directly from the sun sets.

Function and responsibility while planning

1 Selection of proper size.
   - Plot-shape size and natural slope.
   - Width and type of road in frontage.
   - Position of plot with respect to sun and wind.

2 No. of occupants and their profession.

3 Financial capability of owner

4 Requirements of room

5 Provision of garage, porch etc

6 Feasibility of basement/first floor

7 Provision of internal/external staircase

8 Feasibility of future expansion

9 Soil and sub soil particular

10 Sub soil water level.

Residential building an overview

1 Portico (Fig 8)

It is a space provided for packing vehichles. The location of portico may be provided near the entrance or easy accessible space from the road. The size of the portico

is sufficient to park the new generation vehicles, without any discomfort to usage.

Fig 8

2 Sit out (Fig 9)

It is the welcome space for the inmates and it can also treated as a waiting space for visions. It is used for recreation in the morning and evening times.

Fig 9

3 Living (Fig 10)

As far as a residential building is considered living room is the most important room because three fourth of the day of inmates is consumed by this room. So it should be sized and furnished accordingly.

Fig 10

4 Pooja room

It is the space for worship and it should be located at an area free from all sorts of disturbance.

5 Dining (Fig 11)

Dining room is situated near by kitchen and drawing room with maximum ventilation. It should be furnished with photos with delicious food. Rooms like bed room toilet etc. Can have direct access from dining room.

Fig 11

6 Bed room (Fig 12)

Bed room is the most important room in a residential building and it is located with sufficient privacy and space of a habitable.

Fig 12

7 Kitchen (Fig 13)

It is a hygienic space provided for preparing food. It is normally placed at the rear side of the building. It should be placed accordingly fumes from kitchen should not enter the other parts of the building and falling of sunlight in the morning where foods are prepared.

Fig 13

8 Work area (Fig 14)

It is the utility area provided adjacent to the kitchen.

Fig 14

9 Store (Fig 15)

This room should be located close to the kitchen with sufficient storing facilities.

Fig 15

10 Bath room (Fig 16)

It is the room provided for bathing. Bath room may be separated as dry and wet areas and water closet and wash basin may be provided at dry areas. Flooring materials may have anti skip properties.

11 Study Room (Fig 17)

It is an area provided for learning and reading. Space should be provided for keeping books in a systematic manner and it is located in an area with fewer disturbances.

12 Entertainment Room

Area provided for placing home theatre and music systems for entertainment.

Fig 16

Fig 17

Fig 18

13 Stair case (Fig 18)

It is located such that easy accessible from all parts of the building with standard size and with good ventilation.

14 Balcony (Fig 19)

It is an open space provided in the upper floor seen from below for gathering.

Fig 19

Details

EWC with cistern : 1 no

Wash basin with counter top 730 x 500mm with mirror

Storage shelf : 500 x 500mm

Instant glysor : 1 no

Shower facility with mixing valves

Semi polished stone slab flooring

Room size : 160 x 200mm.

1In general for different type of plots for residential houses the minimum covered

Area i.e. area on which the building can be constructed is given below.

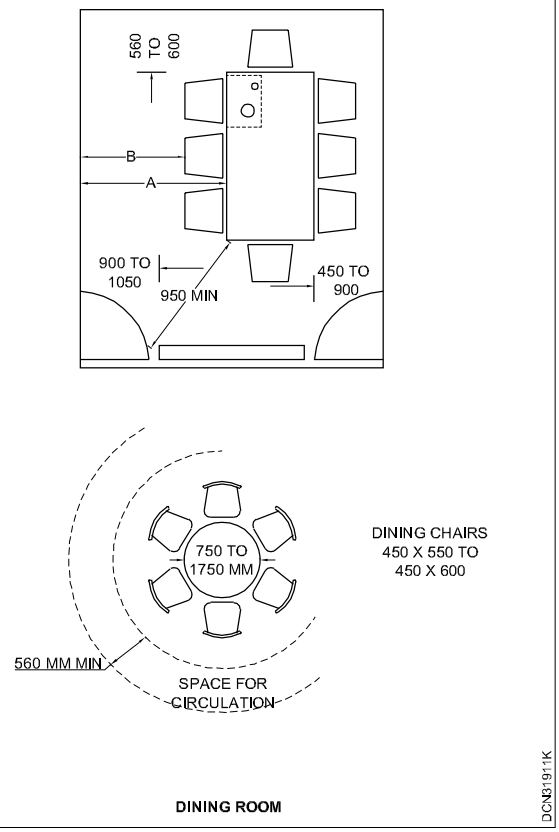
Type of plot	Area of plot	Permissible covered area
A Type	More than 1000 sq.m	33% of site area
B Type	501 sq.m to 1000 sq.m	40% of site area
C Type	201 sq.m to 1000 sq.m	50% of site area
D Type	Upto 200 sq.m	60% of site area

2 A standard residential houses should have drawing or living room, dining room, bed room, guest room, kitchen, store, Bathroom, water closet, front and rear verandah and a staircase if the building in double storeyed. (Fig 20 to 23)

3 If considerable formality is not observed in a family, the drawing room, dining room, may be combined and the two may be isolated by a sliding curtain and the whole room can be utilized on some special occasions.

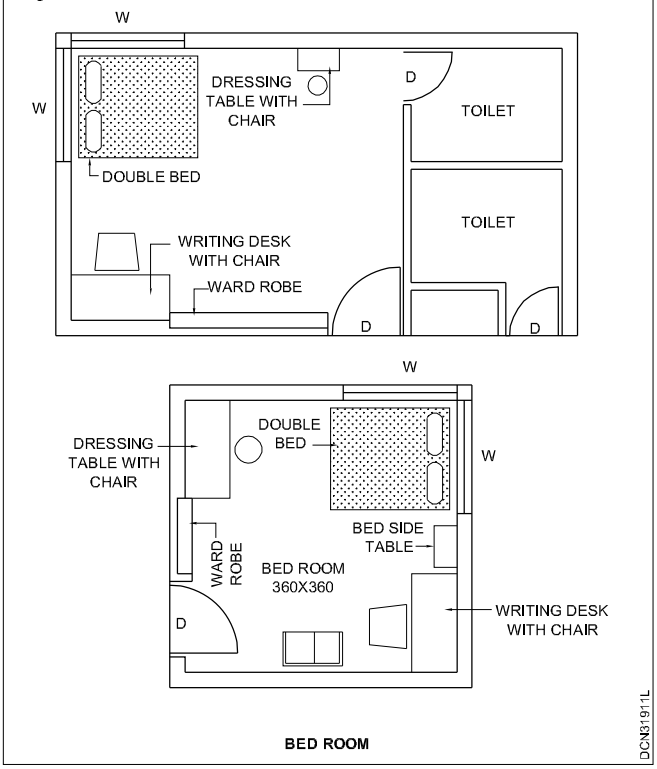
If the house belongs to a professor or an Advocate a study room should also be provided.

Fig 20



DINING ROOM

Fig 21



BED ROOM

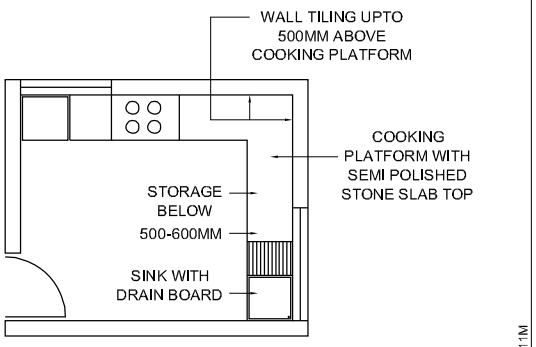
Design steps

The following step by step procedure is suggested for the beginner in order to evolve a reasonably acceptable building design.

Step 1. If the owner gives his needs in clear terms that is ideal. But often the designer has to ask leading questions and extract his needs.

Step 2. Analyze the space needs as listed and estimate the floor area of a building. An increase of 20-25 percent of this area may be assumed for wall space and lobbies and the gross built-up area of the floor may be certain spaces all together and/or by reducing the area under each space.

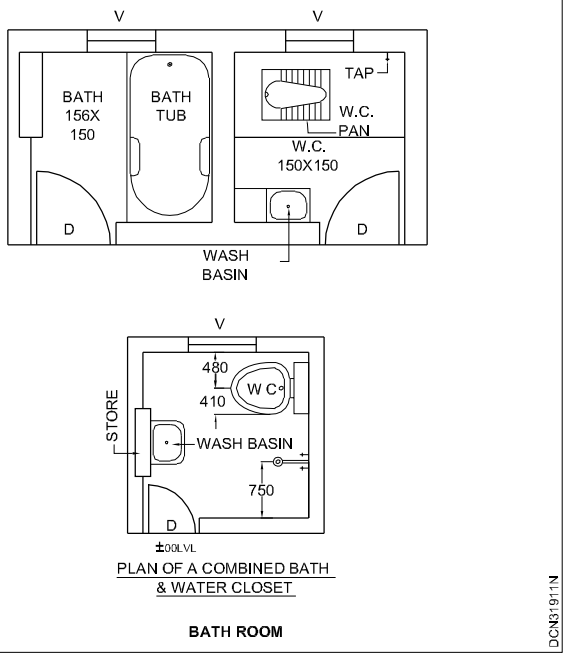
Fig 22



Step 3. Analyze the site in detail with respect to its dimensions, existing trees, and restrictions for building by ground slopes, adjoining development access north direction, wind direction, and view. A map showing the possible area for the building.

Step 4. Organize the plan of the building considering the pattern suggested the site structure plan and relative position of different rooms. This is done by a flexible bubble diagram in which each room is represented by a bubble close to that having good proximity requirement.

Fig 23



Step 5. The line plan can now be developed into a fully dimension floor plans, section to explain the constructions and elevation to show the overall front views of the finished building.

The site plan is now finalized by incorporating the final plan in the site and showing other detail to suitable scale.

Vastu shatra (Fig 24)

Vastu is an attempt towards finding aesthetic design solutions. Most of the clients wished to incorporate vastu principles in the construction and decorations of their houses. Therefore, vastu principles have today become the house rather than an exception. Instead of being considered as constraints, these principles are taken as underlying guide lines for aesthetic solutions to design problems.

Documents to be submitted cooperation with drawing :

The following are the documents to be submitted to the authority for the permit:

i Owner's notice to the authority of his intention for development or construction and the request for the permit.

ii Proof of ownership of the site.

iii Key plan of the site showing the boundaries and the location of the site with respect to the neighbourhood landmark to a scale not less the 1:10000.

iv Subdivision/Layout plan, where applicable, drawn to a scale of not less than 1:500.

a Location of existing and proposed roads, drains, sewers, electric lines, public facilities, North direction etc.,

b Dimensions of each plot in relation to the access road in the development together with a table indicating the size, area and use of all plots, and

c A statement indicating the area under different uses such as roads, open spaces, playgrounds, reservoir, schools, shopping, and public places along with their percentages of the total area.

v Site plan to scale not less than 1:1000.

a Boundaries and positions of the plot in relation to the main street, North direction etc. And physical features such as wells, rocks, trees in the site.

b All existing and proposed buildings in the site with details of access, set back etc., and

c Particulars of development immediately outside the plot and other particulars as prescribed by the local authority.

vi Building plan indicating plans, elevations and sections of the proposed building drawn to a scale of 1;100 which shall include,

a All floor plans showing size and use of rooms, openings, positions of staircases, W.C., bath, sink etc. Including a terrace plan indicating roof slopes and drainage.

b All street elevations and sectional drawings indicating construction details from foundation to roof, vertical heights and a sectional view through the staircase.

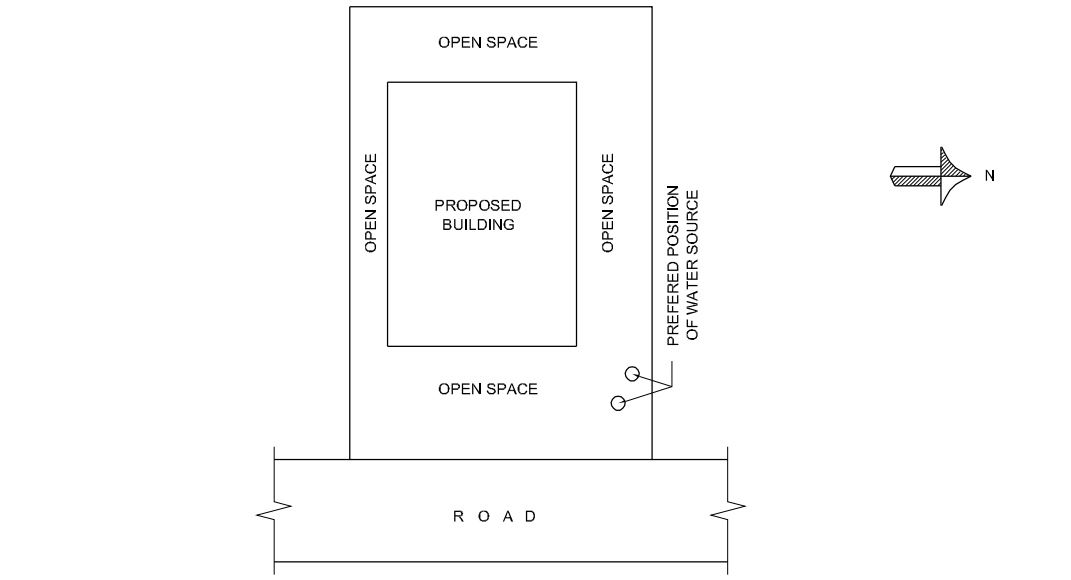
c Location and details of common lobbies, chutes, ramps, lift, and electric control room, water storage tanks. Fire fighting installations, first aid etc. For multistoreyed buildings.

vii Service plan showing all locations and details of water supply and sewage disposal systems, plumbing details, electrical connections and other building services as applicable.

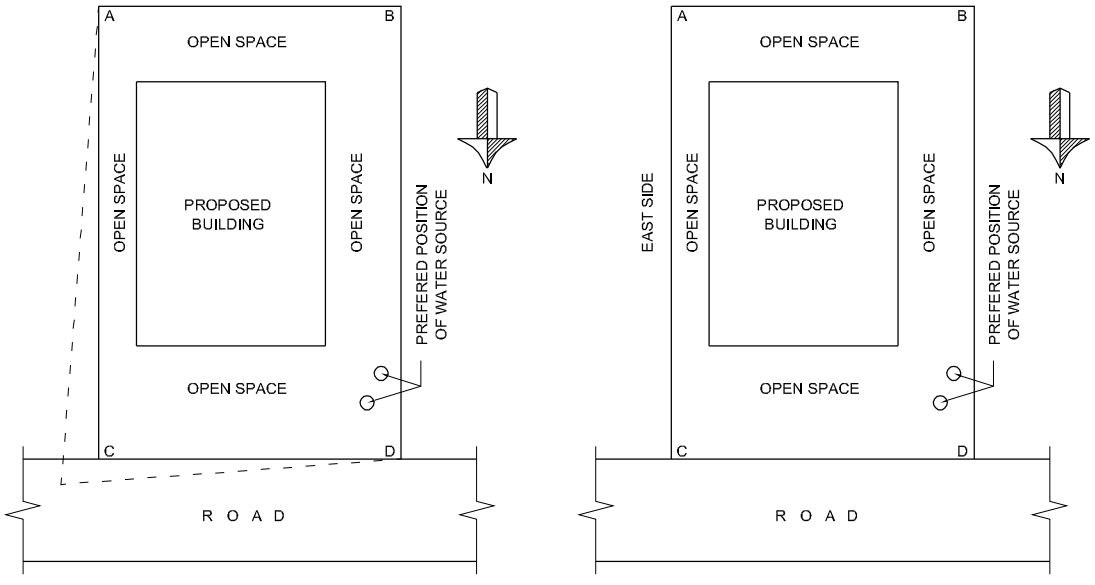
viii A certificate from the designer to the effect that the work shall be carried out in accordance with the sanctioned plans and specifications under his supervision.

Of these, the key plan is extracted from the village survey map or town map. Sub division plan is required only for development permit of large area with layout of different buildings or uses. It is prepared as per control rules for development. The site plan, building plan and the service plan are needed for building permit to show that location and design features of the building are according to the general building requirements as given in the codes or rules.

Fig 24



A. POSITION OF WATER SOURCE



B. SHAPE OF A PLOT

ENSURE THAT ANGLE AT A, B, D IS NOT LESS THAN 90° ANGLE AT A, D MORE THAN 90° IS PREFERABLE.

C. OPEN SPACES AROUND A BUILDING

OPEN SPACE ON EAST SIDE SHOULD BE MORE THAN THAT ON WEST SIDE. SIMILARLY, OPEN SPACE ON NORTHERN SIDE SHOULD BE MORE THAN THAT ON SOUTHERN SIDE.

VASTHU SHASTRA

DCN31911O

Local building bye-laws as per I.S code

Objectives : At the end of this lesson, you shall be able to
- **describe the different types of building**
- **define the term related to bye-laws**
- **explain requirements of building as per NBC**
- **explain requirement of building as per local bye-laws.**

Introduction

Building is a structure that is built with three parts, foundation, superstructure and roof. Building means any structure whatever be the purpose and whatever materials used for construction includes foundation plinth, walls, floors, chimney, plumbing and building services, verandas, balconies etc .

Fig 1

Types of building

Occupancy classification

All buildings can be classified in one of the following groups:

Group A: Residential

Group B: Educational

Group C: Institutional

Group D: Assembly

Group E: Business

Group F: Mercantile (Includes both retail and wholesale stores)

Group G: Industrial (Includes low, moderate and high fire hazard)

Group H: Storage

Group I: Hazardous

A Brief description of the various classes of buildings is as follows:

Group A: Residential buildings

These include any building in which sleeping accommodation is provided for normal residential purposes, with or without cooking or dining or both facilities, except any building classified under group C.

a Subdivision A-1. Lodging or rooming houses. These include any building or group of buildings under the same management, in which separate sleeping accommodation for a total of not more than 40 persons (beds) on transient or permanent basis, with or without dining facilities, but without cooking facilities for individuals, is provided. This includes inns, clubs, motels and guest houses.

A lodging or rooming house shall be classified as a dwelling in subdivision A-2 if no room in any of its private dwelling units is rented to more than three persons.

b Subdivision A-2. One-or two - family private dwellings. These include any private dwelling which is occupied by members of one or two families and has a total sleeping accommodation for not more than 20 persons.

If rooms in a private dwelling are rented to outsiders, these shall be for accommodating not more than three persons per room.

If sleeping accommodation for more than 20 persons is provided in any one residential building, it shall be classified as a building in subdivision A-1, A-3 or A-4 as the case may be.

c Subdivision A-3. Dormitories. These include any building in which group sleeping accommodation is provided, with or without dining facilities, for persons who are not members of the same family, in one room or a series of closely associated rooms under joint occupancy and single management, For example, school and college dormitories, student's hostels and military barracks.

d Subdivision A-4. Apartment houses (flats). These include any building or structure in which living quarters are provided for three or more families, living independently of each other and with independent cooking facilities, for example, apartment houses, and mansions.

e Subdivision A-5. Hotels. These include any building or group of buildings under single management, in which sleeping accommodation is provided with or without dining facilities, for hotels classified up to 4 star category.

f Subdivision A-6. Hotels star. These include the hotels duly approved by the concerned authorities as Five star and above hotels.

Group B: Educational Buildings

These include any building used for school, college other training institutions for day-care purposes involving assembly for instruction, education or recreation for not less than 20 students.

a Subdivision B-1. (schools upto senior secondary level). This includes any building or group of buildings under single management for students not less than 20 in number.

b Subdivision B-2. (all others/training institutions). This includes any building or group of buildings under single management used for students not less than 100 in number.

Group C: Institutional buildings

This includes any building or part thereof, which is used for purposes, such as medical or other treatment or care of persons suffering from physical or mental illness, disease or infirmity; care of infants, convalescents or aged persons and for penal or correctional detention in which the liberty of the inmates is restricted. Institutional buildings ordinarily provide sleeping accommodation for the occupants.

a Subdivision C-1: (hospitals and sanatoria). This subdivision includes any building or a group of buildings under single management, which is used for housing persons suffering from physical limitation because of health or age, for example, hospitals, infirmaries, sanatoria and nursing homes.

b Subdivision C-2: (custodial institutions). This subdivision includes any building or a group of buildings under singe management, which is used for custody and care of persons, such as children, convalescents and the aged, for example, homes for the aged and infirm, convalescent homes and orphanages.

c Subdivision C-3: (penal and metal institutions).This subdivision includes any building or a group of buildings under single managements, which is used for housing persons under restraint, or who are detained for penal or corrective purpose, in which the liberty of the inmates is restricted, for example, jails, prisons, mental hospitals, mental sanatoria and reformatories.

Group D: Assembly building

These include any building or part of a building, Where groups of people congregate or gather for amusement, recreation, social, religious, patriotic, civil, travel and similar purposes, for example, theatres, motion picture houses, assembly halls, auditoria, exhibition halls, museums, skating rinks, gymnasiums, restaurants, places of worship, dance halls, club rooms, passenger stations and terminals of air, surface and marine public transportation services, recreation piers and stadia, etc.

a Subdivision D-1: This subdivision includes any building primarily meant by theatrical or operatic performances and exhibitions and which has a raised stage, proscenium curtain, fixed or portable scenery or scenery loft, lights, motion picture booth, Mechanical appliances or other theatrical accessories and equipment and which is provided with fixed seats for over 1000 persons.

b Subdivision D-2: This subdivision includes any building primarily meant for use as described for subdivision D-1, but with fixed seats up to 1000 persons.

c Subdivision D-3: This subdivision includes any building, its lobbies, rooms and other spaces connected thereto, primarily intended for assembly of people, but which has no theatrical stage or theatrical and/or cinematographic accessories and has accommodation for 300 persons or more. For example, dance halls, night clubs, halls for incidental picture shows, dramatic, theatrical or educational presentation, lectures or other similar purposes, having no theatrical stage except a raised platform and used without permanent seating arrangement; art galleries, exhibition halls, community halls, marriage halls, places of worship, museums, lecture halls, passenger terminals; and heritage and archaeological monuments.

d Subdivision D-4: This subdivision includes any building, primarily intended for use as described in subdivision D-3, but with accommodation for less than 300 persons with no permanent seating arrangement.

e Subdivision D-5: This subdivision includes any building or structure permanent or temporary meant for assembly of people not covered by subdivisions D-1 to D-4,for example, grandstands, stadia amusement park structures, reviewing stands and circus tents.

f Subdivision D-6: This includes any building for assembly of people provided with multiple services/ facilities like shopping, cinema theatres and restaurants, for example, multiplexes.

d Subdivision D-7: Any building or structure permanent or temporary meant for assembly of people not covered by D-1 to D-6. For example, underground or elevated railways.

Group E: Business Buildings

These include any building or part of a building which is used for transaction or business more than covered by Group F) for keeping of accounts and records and similar purposes, professional establishments, service facilities, etc. City halls, town halls, court houses and libraries classified in this group so far as the principal function of these is transaction of people business and keeping of books and record.

Business building are further subdivided as follows

a Subdivision E-1: Offices, banks, professional establishments, like offices of architecture engineers, doctors, lawyers and police stations.

b Subdivision E-2: Laboratories,research establishments, libraries and test houses.

c Subdivision E-3: Computer installations.

d Subdivision E-4: Telephone exchanges.

e Subdivision E-5: Broadcasting stations and T.V. Stations.

Group F: Mercantile buildings

These include any building or part of a building, which is used as shops, stores, market, for display and sale of merchandise, either wholesale or retail.

Mercantile buildings shall be further sub classified as follows

Subdivision F-1: Shops, stores, departmental stores, markets with area up to 500 m^2.

Subdivision F-2: Shops, centres, departmental stores, markets with are more than 500 m^2 .

Subdivision F-3: Underground shopping centres.

Storage and service facilities incidental to the sale of merchandise and located in the same building shall be included under this group.

Group G: Industrial buildings

These include any building or part of a building or structure, in which products or materials of all kinds and properties are fabricated, assembled, manufactured or processed. For example, assembly plants, laboratories, dry cleaning plants, power plants, pumping stations, smoke houses, laundries, gas plants, refineries, dairies and saw - mills, etc.

The hazard of occupancy shall be the relative danger of the start and spread of fire, the danger of smoke or gases generated the danger of explosion or other occurrence potentially endangering the lives and safety of the occupants of the buildings.

a Subdivision G-1: (Buildings used for low hazard industries): This subdivision includes any building in which the contents are of such low combustibility and the industrial processes or operations conducted therein are of such a nature that there are no possibilities for any self- propagating fire to occur and the only consequent danger to life and property may arise from panic, fumes or smoke, or fire from some external source.

b Subdivision G-2: (Buildings used for moderate hazard industries): This subdivision includes any building in which the contents or industrial processes of operations conducted therein are liable to give rise to a fire which will burn with moderate rapidity and give off a considerable volume of smoke, but from which neither toxic fumes nor explosions are to be feared in the event of a fire.

c Subdivision G-3: (Buildings used for high hazard industries): This subdivision includes any building in which the contents or industrial processes or operations conducted therein are liable to give rise to a fire which will burn with extreme rapidly or from which poisonous fumes or explosions are to be feared in the event or a fire.

Group H: Storage buildings

These include any building or part of a building used primarily for the storage or sheltering (including servicing, Processing or repairs incidental to storage) of goods, wares or merchandise (except those that involve highly combustible or explosive products or materials) vehicles or animals. For example, warehouses, cold storages, freight depots, transit sheds, storehouses, truck and marine terminals, garages, hangars (other than aircraft repair hangars), grain elevators, barns and stables.

Storage properties are characterized by the presence of relatively small number of persons in preposition to the area. Any new use which increases the number of occupants to a figure of the new use. For example, hangars used for assembly purposes, warehouses used for office purposes, garage buildings used for manufacturing.

Group 1: Hazardous buildings

These include any building or part of a building which is used for the storage, handling, manufacture of processing of highly combustible or explosive materials or products which are liable to burn with extreme rapidity and /or which

may produce poisonous fumes or explosions; for storage, handling, manufacturing or processing which involve highly corrosive, toxic or noxious alkalies, acids or other liquids or chemicals producing flame, fumes and explosive, poisonous,irritant or corrosive gases; and for storage, handling or processing of any material producing explosive mixtures of dust which result in the division of matter into fine particles subject to spontaneous ignition. Examples of buildings of this class are those buildings which are used for:

a Storage, under pressure of more than 0.1 N/mm^2 and in quantities exceeding 70 m^3 ,of acetylene, hydrogen, illuminating and natural gases, ammonia, chlorine, phosgene, sulphur dioxide, carbon dioxide, methyl oxide and all gases subject to explosion, fume or toxic hazard, cryogenic gases, etc.

b Storage and handling of hazardous and highly flammable liquids, liquefiable gases like LPG, rocket propellants, etc

c Storage and handling of hazardous and highly flammable of explosive materials, (other than liquids) and

d Manufacture of artificial flowers, synthetic leather, ammunition, explosives and fireworks.

Introduction to building bye-laws

For a planned development of towns and cities, planning authorities of the area lay down certain norms for construction of buildings which are known as "BUILDING BYE - LAWS"

For provisions and requirement for safe and stable design, methods of construction and sufficiency of materials in structures and regulations for maintenance of equipments, use and occupancy of all structures and premises, these rules may be helpful.

Terminology related to bye-laws

Abut: A building is said to be abut on the street, when the outer face of any of its (external) walls is on the street boundary.

Alley: Alley means a secondary public thoroughfare which affords a mean of access to the abutting properly.

Alteration: A change from one occupancy to another or a structural change such as an addition to the area or height or removal of the part of the building or any change to the structure.

Balcony: Balcony shall mean a cantilevered horizontal projection from the wall of building without any vertical support and having a balustrade or railing not exceeding one metre in height and intended for human use.

Barsati: It means a habitable space on the roof of the building with/without toilet facilities.

Basement/cellar: It means the lower storey of the building below or partly below the ground level.

Building line: Building line is also known as set back or front building line. It is a line parallel to the plot boundaries beyond which no construction work is permitted. The distance is taken from the centre line of the road and building line.

Type of road	Building line
Village road	9.0 m.
Other district road	9.0 m.
Major district road	15.0 m.
National & state highway	30.0 m.

Cabin: A non residential enclosure constructed of non load bearing partitions.

Canopy: Cantilever projection known as canopy of size limit 4.5 m long and 2.4m width will not be considered as covered area.

Carpet area: Carpet area means usable floor area excluding staircase, lift and walls.

Carpet area = total floor area - circulation area

Carpet area of an office building is 60% to 70% of plinth area

Carpet area of residential building is 50% to 65 % of plinth area

For framed multi storied building the area occupied by wall is 5% to 10% of plinth area.

For ordinary building without frame the area occupied by walls may be 10% to 15% of plinth area.

Circulation area: It is floor area of veranda, passage, corridor, balconies, entrance hall, staircase etc, which are used for movement of persons using the building. It may be divided into two parts.

a Horizontal circulation area: Horizontal circulation area is area of veranda, passages, corridor, porch, etc which are required for horizontal movement of the users, it may be 10% - 15% of plinth area of building.

b Vertical circulation area: It is the area or space occupied by stair cases, lift and the entrance hall adjacent to them which are required for vertical movement of the users, it may be 4% - 5% of plinth area.

Cooking alcove: A cooking space having direct access from main room without any intermediate.

Court yard: Court yard shall mean an area open to sky within the boundary of a plot, which is enclosed of partially enclosed by building. parapet of railing may be provided all around the court yard. It provided access to light air and rain water inside the building It may be at ground floor level.

Covered area: Covered area means ground area covered by the building at the ground level.

The maximum covered area of the building of different classes shall be governed by the following.

1 In a bazaar or market area the covered area shall not exceed 75% of the area of the site. Provided that sufficient off street parking facilities for loading and unloading of vehicles are available.

2 In an industrial area, the covered area shall not exceed 60% of the site area.

3 In residential area, the covered area shall be as given in table.

4 In the case of building of mixed class, the covered area shall be determined by the rules pertaining to the particular class for which the particular floor is used or intended to be used.

Table - Covered area

Area of plot	Maximum permissible covered area
1 Less than 200 sqm (or 240 sq.yd)	60% of the site area on the ground and first floor and nothing on the second floor except a " barsati" not exceeding 25% of the ground floor.
2 200sqm. To 500 sqm. (or 240 sq.yd. to 600 sq.yd)	50% of the site area or 150 sqm (180 sq.yd.) whichever is more.
3 501 sqm. To 1000 sqm. (or 601 sq.yd.to 1200 sq.yd.)	40% of the site area or 250 sqm. (or 300 sq.yd.) whichever is more.
4 More than 1000 sqm.(1200 sq.yd)	33 1/2 % of the site area or 400 sqm.(480 sq.yd) whichever is more.

Cross wall: An internal wall built into an external wall.

Damp proof cours: Damp proof course means a course consisting of some appropriate water proofing material provided to prevent penetration of dampness.

Dead load: Dead load means the weight of all permanent stationary construction, becoming a part of structure.

Drainage: Drainage means the removal of any liquid by a system constructed for the purpose.

Detached building: A building whose roofs and walls are independent of any other building with open spaces on all sides as specified.

Development of land: Development of land means any material change on the use of land intended for sale or construction of any structure.

Development plan: Development plan means a general planning scheme for the local area as a whole or any detailed planning scheme for any specified area.

Floor area: Floor area means the built up area of a building at any floor level. To get floor area, the area of wall shall be deducted from the plinth area. It includes all room veranda, corridor, entrance hall,dining hall, kitchen, store, bath, latrine, etc.

Floor area = Plinth area- area occupied by walls.

Floor area ratio: It means the quotient obtained by dividing the floor area of all floors by the area of the plot and multiplied by hundred.

$$F.A.R. = \frac{\text{Total floor area of all floors}}{\text{Total plot area}} \times 100$$

Assume :- Total plot area = 100 sqm.

Total floor area at ground floor = 60.00 sqm.

Floor area at first floor = 60.00 sqm.

Floor area at second floor = 30.00 sqm.

Total floor area = 150.00 sqm.

(Ground floor + first floor + second floor)

$$F.A.R. = \frac{150}{100} \times 100 = 150$$

Floor space index :- It is the ratio of built up area allowed to the plot area available.

$$F.S.I = \frac{\text{Builtup area allowed}}{\text{Plot area available}}$$

Built up area = floor area at ground level + 20% of floor area for walls = 60 sqm + 12 sqm = 72 sqm.

$$F.S.I. = \frac{72}{100} 0.72$$

Footing: The offset portions of a foundation to provide a greater bearing area.

Foundation: "Foundation" means the part of a structure which is below the lower most floor and which provides support for the super- structure and transmits the loads to the ground below.

Frontage: It means side or part of a side of a plot which abuts on a street.

Front yard: Means an open space extending laterally along the front side (entrance side) of a building and formatting part of the plot.

Gallery: Means an intermediate floor or platfrom projecting from a wall or an auditorium or a hall providing extra floor area, additional seating accommodation, etc.

Garage: A building or outhouse used for the storage of vehicles.

Ground floor: The storey of a building to which there is an entrance from the outside of the adjacent ground or street.

Habitable room: It means a room having windows and doors of size not less than one tenth of the floor area of the room and bath room.

Head room: Head room means the clear vertical distance measured from the finished floor surface to the finished ceiling surface.

Height of building: Height of building means vertical distance measured in the case of flat roofs from the average level of the ground arround and contiguous to the building to the terrace of the last livable floor of the building.

Height of the room: It means the vertical distance between the floor and the lowest point on the ceiling.

Jhamp: A downward, vertical or sloping projection hanging below any horizontal projection like balcony, canopy, verandas, passage etc, to provide protection from direct sun and rain.

Jhot: A strip of land permanently left open for drainage purposes not to be used as an access way and is not a street or to be included as a part of setbacks.

Katra or chawl: A Building so constructed as to be suitable for letting in separate tenements each consisting of a single room, or two rooms, but not more than two rooms, and with common sanitary arrangements.

Key plan: It is a plan to a scale of not less than one in 10,000 (1:10,000) It shell be submitted along with the application for a development/building permit It gives the boundary location of the site w.r.t. neighborhood.

Ledge: A shelf like projection supported in any manner what so ever, except by means of vertical support, within a room itself but not having, projection wider than 0.75m.

Lift well: It means the unobstructed enclosure provided for the vertical movement of the lift car(s) and any counterweight (s) including the lift pit and the space for top clearance.

Live load: It means all loads except dead load that may be imposed on structure.

Loft: A residual space in a pitched roof or any similar residual space, above normal floor level, which may be constructed for storage purpose.

Mezzanine floor: An intermediate floor in any story over-hanging and overlooking a floor beneath.

Open space: Means an area forming integral part of the plot left open to the sky.

Open space around builidng: The national building code of our country has recommended following open space around building of varying heights.

Parking space: Means an area enclosed or un closed, sufficient in size to park vehicles, together with a driveway connecting the parking space with a street or alley.

Party wall: Shall mean a common wall partly constructed on the plot of land and partly on an adjoining plot and serving both structurally.

Parapet: Means a wall not more than 1.2m in height built along the edge of a room or a floor.

Pathway: An approach constructed with materials, such as bricks, Murrum, concrete, stone, asphalt or the like.

Pilaster: A pier forming part of a wall partially projecting there and bonded there to.

Plinth: The portion of a structure between the surface of the surrounding ground and the surface of the floor first above the ground.

Plinth area: Plinth area means the area of the building at plinth level, it is the built up covered area measured at the floor level of basement or any storey. This is calculated by taking external dimension of the building at floor level excluding plinth offset.

Plinth height: Shall mean the height of the ground floor above the street level of the centre of the adjoin street.

Plinth level: Plinth level shall mean the level of the ground floor of a building.

Depth of plot: Depth of plot means the mean horizontal distance between the front and rear plot boundaries.

Porch: A covered surface supported on pillars or otherwise for the purpose of pedestrian or vehicles to approach a building.

Description of building	Front space (width in m.)	Side space (width in m.)	Back space (width in m.)	Remarks
1 Building having height less than 10.0m	3.0 In no case less than 1.8	3.0	3.0 In no case less than 1.8	Minimum building line 7.5m.
2 Building having height more than 10.0m and less than	3.0+A	3.0+A	3.0+A	The value of a is 1 m. for every 3m. 10m. height of building.
3 Building having height more than 25.0m and less than 30.0m	10.0	10.0	10.0	
4 Building having height more	10.0+B	10.0+B	10.0+B	The value of B is 1m. for every 5m. yond 30m height of building.

Rain water pipe: A pipe or drain situated wholly above the ground and used for carrying water directly from roof surface of elevated court yard or other open surface.

Road: Road means any highway, street, lane, pathway, alley., stairway, passageway, carriage way, footway, or bridge, whether a through fare or not, over which the public have a right of passage or access uninterruptedly, for a specified period.

Road line: The line defining the side limits of a road.

Row housing: A row of houses with only front, rear and interior open spaces.

Sanctioned plan: It means the set of drawing and statements submitted under these rules in connection with a building and duly approved and sanctioned by the authority.

Semi detached building: A building detached on three sides with open space.

Sewage drain: A drain used or constructed to be used for conveying solid or liquid waste matter, excremental or otherwise to a sewer.

Site: Site means a parcel (piece) of land enclosed by definite boundaries.

Site double frontage : A site having a frontage on two streets other than corner plot.

Site plan: The site plan shall be drawn to a scale of not less than 1:400 provided that when circumstances are such as to make a smaller scale necessary or sufficient, the plan may with the constant of the authority be drawn to a scale of 1:800. It shall be fully dimensioned and shall show.

1 The boundaries of the plot and of any continuous land belonging to the owner thereof including the revenue survey particulars in full.

2 The position of the site in relation to the neighbouring street (s) and its main access.

3 The name of such street(s), if any.

4 All existing structure standing on, over or under the plot.

5 All existing streets of footpaths within the plot.

6 The layout of street or foot paths within, adjoining or terminating at the site, existing or proposed to be widened or newly aligned.

7 The purposed plot subdivision, if any, and the area and uses of each subdivision thereof

8 The access to each plot sub division, if any.

9 The layout of any service road or foot paths and public parking space proposed or existing, if any.

10 The area and location of any land within the plot that is not proposed to be developed or redeveloped.

11 The area and location of any land that is proposed to be reclaimed.

12 North direction is related to the site.

Stair covered: Stair covered means cabin like structure with a covering roof over a staircase and its landing built to enclose only the stairs for the purpose of providing protection from weather/and not used for human habitation.

Sunshade: It means a sloppy or horizontal structural overhang usually provided over opening an external walls to provide protection from sun and rain.

Stall: Stall means any temporary structure other than a hut used solely for the display and side sale of goods.

Storage: A space where goods of any kind or nature are stored.

Storey: Storey means any portion of a building included between the surface of any floor and the surface of the floor next above it, or if there be no floor above it, then the space between any floor and the ceiling next above it.

Street line: Street line means the line defining the side limits of a street.

Street level: Street level means the level at the centre line of the street.

Verandah: Veranda means a covered area with at least one side open to the outside with the exception of a parapet, trellis, jolly or grill work on the open side.

Vertical exit: A vertical exit is a means of exit used for ascension or descension between two or more levels including stairways, smoke- proof towers, ramps, and fire escapes.

Yard: An open space at ground level between a building and the adjoining boundary lines of the plot un occupied and unobstructed except by encroachments or structures specifically permitted by these by laws on the same plot with a building.

Yard front: Yard front means an open space extending laterally along the front side (main entrance side) of a building and forming part of the plot.

Yard rear: Yard rear means the utility open space extending laterally along the rear side of the plot and forming part of the plot.

Yard side: Yard side means an open space extending laterally between any side of a building of the plot facing that side other than front and rear/utility yard and forming part of the plot.

Building plan: The plan, elevation and sections of buildings accompanying the application shall be accurately drawn to a scale of not less than 1:100.

1 Include floor plan of all floors together with the covered area, accessory buildings and basement floor. It indicates clearly size of rooms, position of stair cases, ramps and lift well.

2 Show the use or occupancy of all parts of the building.

3 Show the exact position of services like water closet, sink, bath etc.

4 Include sectional drawing, showing clearly the size of footings, thickness of basement, wall construction, size and spacing of framing members, etc.

5 Show street elevations.

6 Include terrace plan indicating the drainage, and slope of the roof.

7 Specify total floor area of building.

Service plan: Service plan shall be drawn to the same scale as the building plan. It shall include plans and sections of private water supply and sewage disposal systems.

General site & building requirements

1 No land development/redevelopment shall be made and / or no building shall be constructed on any plot, on any part of which there is deposited before, excrete or other offensive matter.

2 No land development /redevelopment shall be made and /or no building shall be constructed on a plot which comprises or includes pit, quarry, and other similar excavation.

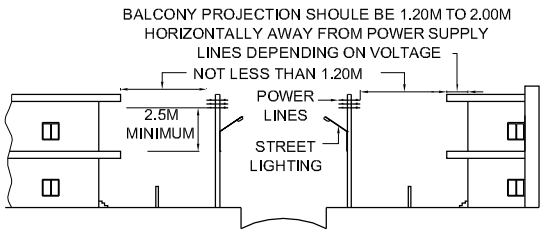
3 No development/redevelopment shall be made and /or no building shall be erected on a plot liable to flood or on a slope forming an angle of more than 45° with horizontal, or on soil un suitable for percolation, or in sandy beds.

4 Any land development/redevelopment or building construction or reconstruction in any area modified by the government of India. As a regulation zone under the environment (protection)act. 1986 (29 of 1986).

Distance from power supply mains (Fig 2)

The distance between any accessible part of the building and the electric supply mains should be between 1.2 m. to 2.0 m horizontally and 2.50 m to 3.70 m. vertically depending upon the voltage of power supply lines. This is necessary to avoid mishaps like electrocuting of children playing in the balcony adjacent to the electric supply mains. House wife or servants drying wet clothes on the open terraces, loss of property and lives due to fall of supply mains of building etc.

Fig 2



MINIMUM DISTANCE FROM ELECTRIC SUPPLY MAINS

Voltage of electric lines	Minimum distances	
	Vertical	Horizontal
1 Low medium	2.5m	1.2m
2 High voltage lines	3.7m	1.2m
Up to 11000 v(11kv)		
11000-33000 v(11kv-33kv)	3.7m.	2.0 m.
Above 33000 v(33kv)	3.7m.+	2.0 m.+
	o.s.m for for every addl 33000 volt	0.3 m for every addl 33000 volt

For voltage lines beyond 33 kv add 0.3 m to the above horizontal and vertical distance for every additional 33 kv and part there of.

Minimum distance between central line of a street and building

The minimum distance between the central line of street an building other than compound wall or fence or outdoor display structure shall be 5.0 m and that between plot boundary abutting the street and building shall be 3.0 m.

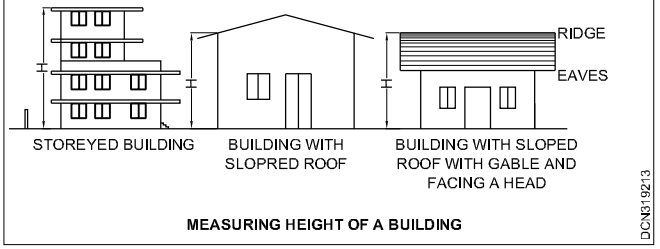
Prohibition for constructin abutting public roads

No person shall construct any building other than compound wall within 3.0 m from plot boundary abutting national highway, state highway or other road provided that open ramps or bridges or step with or without parapet or railing permitted as access from the street to the building within that 3.0 m and cornice or roof with protection had not exceeding 75.0cm shall be permitted with in that 3.0m.

Area and height limitations: The limitations of area and height of different occupancy classes are achieved by spacifying the floor area ratio (FAR) (Fig 3)

ACCESS:1 The clear width of access to a building from the street shall be the following:

Fig 3



MEASURING HEIGHT OF A BUILDING

Building	Individual occupancy	Multiple occupancy
Single storey building	1.2 m	3.6 m
Two storey building	2.0 m	5.0 m

Height of building

a The maximum height of the building shall not exceed 1.5 times width of the street abutting the plot plus 1.5 times the width of the yard.

b If the building abuts two or more streets of different width,then the building shall be deemed to face upon the street that has greeter width and the height of the building shall be regulated by the width of that street.

Sl.No	Building use of occupancy	Maximum permissible coverage percentage of plot area	Maximum permisible F.A.R.
1	Residential	50	1.5
2	Special residential	50	1.5
3	Educational (medical)	30	1.2
4	Institutional(medical)	25	1.0
5	Assembly	40	0.7
6	Governmental or semi public business	30	1.5
7	Mercantile(commercial)	60	2.0
8	Industrial	40	1.2
9	Storage	70	2.0
10	Hazardous	25	0.7

Occupancy: All buildings whether existing or proposed shall be classified as: GROUP A1: Residential [Normal residential purpose] GROUP A2:- Special residential [Lodging or rooming, hotels exceeding 150 sq. m floor area]

GROUP B : Educational

GROUP C : Medical/Hospital

GROUP D : Assembly

GROUP E : Office/ Business [Governmental or semi public business]

GROUP F : Mercantile

GROUP G1 : Industrial

GROUP G2 : Small Industrial

GROUP H : Storage

GROUP I : Hazardous

Parts of building

Foundation: Minimum depth of 60cm

Plinth :- Every plinth shall have a minimum height of

- 30 cm above the level of abutting street.
- 45 cm above the surrounding ground.

Habitable room: The carpet area of habitable room shall not be less than 9.5 sq.m. and a width not less than 2.4m. The average height shall not be less than 2.75m from the surface of floor to the lowest point of the ceiling or false ceiling.

Kitchen: The carpet area of a kitchen or any other room used as kitchen shall not be less than 5.0 sq m and its width shall not be less than 1.8m. The average height of kitchen measured from floor to the ceiling shall not be less than 2.75m there is a seperate store area of kitchen reduced to 4.5m^2.

Bath room and latrines: The area of a bath room shall not be less than 1.8 sq m. with either side not less than 1.2m. The carpet area of latrine shall not be less than 1.1 sq.m. with one side not less than 0.9m. provided that the area of combined bathroom latrine shall not be less than 2.8 sqm with one side not less than 1.2m.

Height of bathroom and for latrine measured from floor to the ceiling shall not be less than 2.1 m.

Mezzanine floor: The floor area of mezzanine floor shall not exceed area of the main floor or room accmmodating the mezzanine floor. The head room measured from the surface of the floor to any point underside of the mezzanine floor shall not be less than 2.2m.

Roof: The rise of Mangalore tile roof shall neither be more than half the span nor be less than one third the span.

Corrugated galvanized iron sheet, asbestos cement sheet roof: Rise shall be less than one fifth of the span.

Trussed roof: The rise of trussed roof shall not be less than either 1/5 th of the span or 11-20 degree whichever is greater.

Floors: Every kitchen, bathroom / latrine shall be provided with impermeable floor with a suitable slope towards the drain.

Stair case: In any building exceeding four storeys (including basement or sunken floor) every floor area above and below plinth shall have at least two staircases, one of which may be external stairway.

1 The minimum width of stair shall not be less than 0.75m. for single family residential occupancy and 1.20m. for buildings of other occupancies. (As per NBC 1.00M for dwelling and 0.75m for row house)

2 Width of tread without nosing shall not be less than 25 centimetre for internal stair in the case of residential buildings and 30cm in the case of other buildings.

3 Height of riser shall not exceed 19 cm. In case of residential buildings & 15cm, in case of other buildings.

4 Height of hand rail shall not be less than 80 cm.

Industrial occupancies open space: All building with built up area exceeding 75 square meter or the power used exceeds 30 H.P and/or the number of workers exceed 20 shall have open space not less than those prescribed below.

Open space	Value
Front yard	7.50 Mt.
Side yard on either side	3.00 Mt.
Rear yard	7.50 Mt.

Size of work room: All work rooms in buildings under this occupancy shall be provided with in a carpet area, not less than 3.4 sqm.

Height of work room: The minimum height of work room shall depend up on the type of industry. The height of any work rooms shall not be less than 2.6m, measured from the floor level to the lowest point in the ceiling.

Height of other ancillary rooms: Height of office laboratory, entrance hall, canteen, cloak room, etc. shall not be less than 3.0m.

In the case of store room and toilet, the height shall not be less than 2.4m.

Disposal of trade wastes and effluents

1 In a case of a factory where the internal drainage system is proposed to be connect to the public sewerage system, prior approval of the arrangements shall be obtained from the pollution board and water and drainage authority.

2 The industrial sewage effluents if proposed to be discharged into nearby water bodies such as river, lakes, canals or sea, the dilution of such waste shall be such that the water bodies, area not polluted.

Rat-proofing of building: Every building or part thereof designed or intended for the handling or storage of foodstuffs shall conform to the requirements specified below.

1 Every such building unless supported on posts shall have continuous foundation from at least 60 cm. below ground level to at least 15 cm above ground level.

2 All opening is such foundation or floors, windows and drains and all junctions between foundation and walls of the building shall be effectively rat-proofed. They are securely covered with rat-proof screening or grillage.

Sanitation requirement: Sanitation facilities shall be provided as stipulated below

a One water closet for the first 50 males or part thereof and two water closets for the first 50 females.

b One urinal for every 100 males.

c Drinking water foundation shall be provided at the rate of one for every 100 persons or part there of.

d Washing facilities shall be provided at the rate of one for 50 persons or part there of.

Hazardous occupancy

Open space: There shall be minimum open space of 10 m all round for the hazardous occupancy.

Petrol filling station: The location of petrol filling stations and its layout shall be approved by the authority in consultation.

Traffic terminal stations: The location of traffic terminal stations like municipal bus stand, inter-stand, bus, terminals railway station and air ports shall be decided by the authority of consultation.

Sanitation requirements: The sanitation requirements for bus or train station and airports shall be as stated in table, below. Two non service type latrine one each for males and females and one non service type urinal for males.

1 **Wash basin:** At the following rates:

   a Domestic airports: minimum of 2 each for males and females.

   b International airport : 10 for 200 persons

2 **Shower stall:** With wash basin

   a 4 stall each in the females and males toilets in the transit/departure lounge.

   b 4 stall each in the females and males toilets in the main concourse.

Tele communication towers.

1 The base of the tower or poles shall have minimum 3 meters distance from the plot boundary abutting the road whether it is proposed on land or over a building, even if the building is having less than 3 meters distance.

2 Distance from other boundaries of the plot to the base of the telecommunication tower or pole structure or accessory rooms shall be minimum 1.20 meters.

Assessary rooms.

1 The cabin may be made with any material but the area of such cabin shall not exceed 15 sq.m.

2 Installation of electricity generator may be allowed if the generator is covered with insulated sound- proof cabin.

Protective wall.

1 Every tower erected on the ground and through which electric power is transmitted or passed shall be provided with protective wall or grill at a distance of one mater from any point of the base.

2 The wall or grill shall have a minimum of 1.20m, height and shall be kept under lock and key, if provided with door.

Warning light and specifications

1 Every telecommunication tower shall have one light (ANL) each at 40 meters and 70 metres height from the ground level.

2 Every telecommunication tower shall be painted with international orange and international white colours alternatively starting with international orange at the top.

Educational institutional (Medical) government or semi public business occupancies

In the case of educational institutional (medical) Government or semi public business occupancies, provision of Rule 14 to 31 shall apply, subject to the modifications specified below.

1 **Plot requirements:** All plot sub Division and building and layout shall be approved by the chief town planner.

2 **Usage of plot:** The usage of plots proposed for development/redevelopment or for construction of any building shall be governed by provisions contained in the detailed town planning scheme prepared for the locality.

3 **Open space:** All buildings with floor area exceeding 75sq.mt, shall have open space not less than those prescribed below:

Open space	Value
Front Yard	7.50 Mt.
Side yard on either side	8.00 Mt.
Rear yard	7.50 Mt.

4 **Habitable Rrooms:** The carpet area of any habitable room shall not be less than 9.50 m^2 with width not less than 3 meters.

5 **Kitchen, store, record room, laundry etc:** The width of kitchen, store, record room, and laundry etc, shall not be less than 2.4 meters. The head room shall not be less than 2.4 meters at any point from the floor.

6 **Corridor, veranda, and passage way:** The clear width of any corridor, veranda, and passage way shall not be less than 1.5 meters.

7 **Circulation area:** Horizontal circulation shall not be less than 12% of the floor area. The area occupied by vertical circulation space such as lift, ramp and stair cases shall not be less than 4% of the floor area.

8 **Assembly occupancies:** In the case of assembly occupancies open spaces shall be as given below.

Requirements of assembly spaces

a Any room in a building under assembly occupancy shall have clear height of not less than 4m for the assembly area. Provided that the clear head room beneath or above the mezzanine or balcony shall not be less than 3 m.

Provided also that the head room shall not be less than 2.4 m in air conditioned rooms, the height of store room, toilets and cellar rooms shall not be less than 2.4 m

b Balconies or galleries or mezzanines shall be restricted to 25% of the total accommodation of assembly hall area and the maximum slope of the balcony or gallery or mezzanine shall not exceed 35°.

Ventilation: The standard of ventilation shall be 28 m^3 fresh air per seat per hour.

Fire protection

a Every such building shall be constructed of the fire resistant material throughout.

b Every place of assembly with a capacity of up to 600 persons shall have minimum of two separate exits as remote from each other as practicable.

Provided that where the capacity ranges from 601 to 1001 persons, such place of assembly shall have minimum of two separate exits as remote from each other as practicable, with each exit of not less than 2 unit width.

Provided further that where the capacity range over 1001 person, such place of assembly shall have minimum of four separate exits as remote from each other as practicable.

c When more than one auditorium or assembly hall is housed in the same building the exit requirements and fire escape provisions for each of the 2 units shall be mutually exclusive but shall be complimentary.

Mercantile (commercial) occupancies

Size of a shop: Every shop unit shall have a carpet area not less than 15 m^2 with a width not less than 3 meter. Provided that in case of stalls in markets the carpet area of such stall shall not be less than 5.0 m^2 with a width not less than 2.0 meter.

Extent of built up area	Nature of open space	Dimension
1 Built up area exceeding 100 sq.m but below 400 sq.m	Front yard side yard (each) Rear yard	7.5m 3.0m 3.0m
2 Built up area exceeding 400sq.m but below 800 sq.m	Front yard side yard(each) Rear yard	10.5m 4.5m 3.0m
3 Built up area exceeding 800 sq.m	Front yard side yard(each) Rear yard	12.0m 6.0m 3.0m

Submitted in composition of drawing

Objectives : At the end of this lesson you shall be able to
- **describe sanitary requirement and area of building**
- **describe plan section and elevation**
- **explain site plan layout plan and building plan detail**
- **explain first stage planning clearance**
- **describe second stage for building permit clearance .**

Introduction

1 **Side yard:** Every building of two or more stories in area zoned for commercial purpose in the development plan for the town or city or detailed town planning scheme for the locality and abutting on public street not less than 7 m width, may not provide any side yard.

Provided that in case any window/ventilator or such other opening envisaged on any side of the building, the building shall have a clear side space of 1.5 m on that side.

2 **Rear yard:** The rear yard shall not be less than 1.5 meter.

3 **Covered path ways:** All stalls in public market shall be provided with a covered access passage of not less than 1.8 m width.

4 **Fish and meat stalls:** Fish and meat stalls in a public market shall invariably be provided with flies proof enclosure. The access passage in these stalls shall have minimum width of 2 meter.

5 **Sanitation requirements:** Sanitation facilities to be provided for occupants in the group shall be as stipulated in table below.

Sanitataion requirements for shops/commercial buildings

Sl. No	Fitments	For personal
1.	Water closet	One for every 25 persons or part thereof exceeding 15 (including employees and customers). For female 1 per every 15 persons of or part thereof exceeding 10.
2.	Drinking water	One for every 100 persons with a minimum of one for each floor.
3.	Wash basin	One for every 100 persons or part thereof.
4.	Urinals	Nil up to 6 persons 1 for 7-20 persons 2 for 21-45 persons 3 for 46-70 persons 4 for 71-100 persons For 101-200 persons @ of 3% For over 200 persons @ 2.5%
5.	Cleaner's sink	One for floor minimum preferably in or adjacent to toilets.

Building in small plot: Building under residential or commercial occupancy can be constructed in small plot not exceeding 125sqm of area.

i **No of floors to be limited** - The number of floors allowed shall be three

ii Conditions regarding set back

1 The minimum distance between the plot boundary abutting any street other than National highway, state highway, district road, and other roads and the building shall be 2m.

2 Any one side shall have minimum of 90 cm and other side shall have minimum of 60cm.

3 The rear side shall have an average of 1m set back with minimum 0.50m.

Row buildings

The number of dwelling units in a row building shall not exceed ten.

Plot area: The area of plot for one unit shall not exceed 85sq.mt.

Distance from street: The minimum distance between the plot boundary abutting any street other than NH,SH,DR,OR, shall be 1.5m

Maximum floors: The maximum number of floors permitted shall be 2 with a staircase room.

Wells: The site plan should show the position and dimension of well and all existing and proposed buildings and structures in the land within 7.5m radius from that well.

Set back

1 The set back from any street shall be as that required for a building

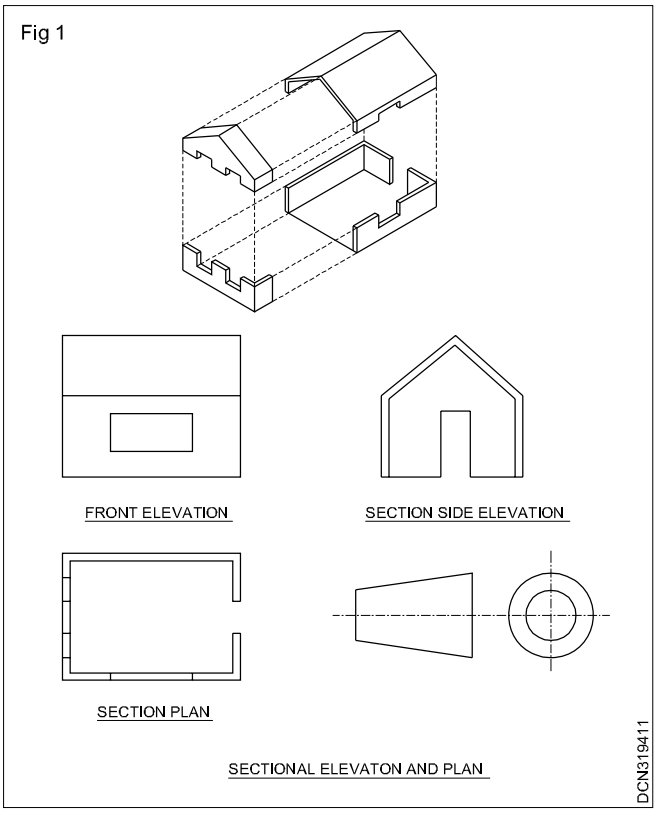
2 There shall be 1.5m set back from other boundaries

3 No leach pit, sock pit, refuse fit, earth closet or septic tank shall be allowed or made within a distance of 7.5m radius from any existing well and 1.2m distance from plot boundaries.

4 Well and surrounding:- The well shall be protected with brick wall with minimum 1m height.

Plans, Sections and Elevations of building (Fig 1)

Three kinds of drawings are commonly used to illustrate buildings. They are plans, sections and elevations. All of these are drawn directly from measurements of the



building, so they are more straightforward to do than perspective drawings. Always the buildings are drawn in first angle projections as shown.

Plan: A plan drawing shows what you would see if you sliced through the building horizontaly, lifted off the top part and looked down. The “cut” is usually made just above the level of the window sills. A separate plan is usually made for each storey of the buildings. Any soild part of the building which is cut through can be coloured with shading or hatching. This is shown on the walls in the drawing.

Sub divisional / layout plan: In the case of development work, the notice shall be accompanied by the sub-division/ layout plan which shall be drawn on a scale of not less than 1:500 containing the following”.

a Scale used and north point.

b The location of all proposed and existing roads with their existing/proposed/prescribed widths within the land.

c Dimensions of plot along with buildings lines showing the setbacks with dimensions within each plot.

d The location of drains, sewers, public facilities and service and electrical lines etc.

e Table indicating size, area and use of all the plots in the sub-divisional /layout plan.

f A statement indicating the total area of all the site, area utilized under roads, open spaces for parks, playgrounds, recreation spaces for parks, playgrounds recreation spaces and development plan reservations, schools, shopping and other public places alongwith their percentage with reference to the total area of the site propoed to be subdivided and

g In case of plots which are subdivided in built up area in addition to the above, the means of access to the sub-division from existing streets.

h the width of the street (if any) in front and of the street (if any) at the side or near the buildings

i the direction of north point relative to the plan of the buildings

j any physical features, such as wells, drains, etc and

k such other particulars as may be prescribed by the Authority.

Building plan and details

The plan of the buildings and elevations and sections accompanying the notice shall be drawn to a scale of 1:100. The plans and details shall

a include floor plans of all floors together with the covered area clearly indicating the size and spacings of all framing members and sizes of rooms and the position of staircases, ramps and lift wells.

b show the use or occupancy of all parts of the buildings.

c show exact location of essential services, for example, WC, sink, bath and the like.

d include at least one section through the staricase.

e include the structural arrangements with appropriate sections showing type/arrangements of footings, foundations, basement walls, structural load bearings walls, columns and beams, walls and arrangements/ spacing of framing memebrs, floor slabs and roof slabs with the material used for the same.

f show all street elevations.

g give dimensions of the projected portions beyond the permissible building line.

h include terrace plan indicating the drainage and the slope of the roof and

i give indications of the north point relative to the plan.

The requirement of 1:100 is permitted to be flexible for specific details needed for further illustration and also for drawings for these in electronic form.

Building plan for multi-storeyed/special buildings.

For all multi-storeyed buildings which are 15 m or more in height and for special buildings like educational, assembly institutional, industrial, storage and hazards and mixed occupancies with any of the aforesaid occupancies having covered area more than 500m^2, the building sanction shall be done in two stages.

Stage 1. First stage for planning clearance

The following additional information shall be furnished/ indicated in the building plan.

a Access fire applicances/ vehicles with details of vehicular turning circle and clear motorable accessway around the building.

b Size (width) of main and alternative staircases along with balcony approach, corridor, ventilated lobby approach.

c location and details of lift encloures.

d location and size of fire lift.

e smoke stop lobby/door, where provided

f refuse chutes, refuse, chamber, service duct, etc.

g vehicular parking spaces.

h refuse area, if any.

i details of buildings services - Air-conditioning system with position of fire dampers, mechanical ventilation system, electrical services, boilers, gas pipes etc.

j details of exits including provisin of ramps, etc, for hospitals and special risks.

k location of generator, transformer and switchgear room.

l smoke exhauster system if any.

m details of fire alarm system network.

n location of centralized control, connecting all fire alarm systems, built-in-fire protection arrangements and public address system, etc.

o location and dimension of static water storage tank and pump room along with fire service inlets for mobile pump and water storage tank.

p location and details of fixed fire protection installations such as sprinklers, wet risers, hose-reels, trenchers, etc and.

q location and details of first-aid fire fighting equipment/ installations.

Second stage for building permit clearance

After obtaining the sancation for planning (Stage 1) from the Authority a complete set of structural plans, sections, details and design calculation duly signed by engineer/ structural engineer along with the complete set of details duly approved in stage 1 shall be submitted. The building plans/details shall be deemed sanctioned for the commencement of construction only after obtaining the permit for stage 2 from the authority.

Lighting and ventilation.

Aggregate area of opening for lighting and ventilation excluding doors shall not be less than

1/10 of the floor area for dry hot climates.

1/6 of the floor area for wet hot climates.

1/8 of the area for intermediate climates.

1/12 of the floor area for cold climates.

No portion of the room shall be assumed to be lighted if it is more than 7.5m from the opening. The windows shall open in to external air or to an open verandah of width not more than 3m. The openings in kitchen shall be increased by the 25% of the above value.

Provision of safety

Objectives : At the end of this lesson you shall be able to
- **introduction to fire protection**
- **general fire safety requirements for buildings**
- **fire resistant construction**
- **fire alarms.**

Introduction to fire protection engineering

Fire engineering is the application of science and engineering principles to protect people, property, and their environments from the harmful and destructive effects of fire and smoke. It encompasses fire protection engineering which focuses on fire detection, suppression and mitigation and fire safety engineering which focuses on human behaviour and maintaining a tenable environment for evacuation from a fire. In the United States fire protection engineering is often used to include fire safety engineering.

The discipline of the engineering includes, but is not exclusive to:

Fire detection - fire alarm systems and brigade call systems.

Active fire protection - fire suppression systems.

Passive fire protection - fire and smoke barriers, space separation.

Smoke control and management.

Escape facilities - Emergency exits, Fire lifts etc.

Building design, layout, and space planning.

Fire prevention programs.

Fire dynamics and fire modelling.

Human behaviour during fire events.

Risk analysis, including economic factors.

Wildfire management

Fire protection engineers identify risks and design safeguards that aid in preventing, controlling, and mitigating the effects of fires. Fire engineers assist architects, building owners and developers in evaluating buildings'life safety and property protection goals. Fire engineers are also employed as fire investigators, including such very large scale cases as the analysis of the collapse of the Word Trade Centers. NASA uses fire engineers in its space program to help improve safety. Fire engineers are also employed to provide 3rd party review for performance based fire engineering solutions submitted in support of local building regulation submitted in support of local building regulation applications.

Categories of active fire protection

Fire suppression

Fire can be controlled or extinguished, either manually (fire fighting) or automatically. Manual includes the use of a fire extinguisher or a Standpipe system. Automatic means can include a fire sprinkler system, a gaseous clean agent, or fire fighting foam system. Automatic suppression systems would usually be found in large commercial kitchens or other high -risk areas.

Sprinkler systems

Fire sprinkler systems are installed in all types of buildings, commercial and residential. They are usually located at ceiling level and are connected to a reliable water source, most commonly city water. A typical sprinkler system operates when heat at the site of a fire causes a glass component in the sprinkler head to fail, thereby releasing the water from the sprinkler head. This means that only the sprinkler head at the fire location operates - not all the sprinklers on a floor or in a building. Sprinkler systems help to reduce the growth of a fire, thereby increasing life safety and limiting structural damage.

Fire detection

Fire is detected either by locating the smoke, flame or heat, and an alarm is sounded to enable emergence evacuation as well as to dispatch the local fire department. An introduction to fire detection and suppression can be found here. Where a detection system is activated, it can be programmed to carry out other actions. These include de-energising magnetic hold open devices on fire doors and opening servo- actuated vents in stairways.

Hypoxic air fire prevention

Fire can be prevented by hypoxic air. Hypoxic air fire prevention systems, also known as oxygen reduction systems are new automatic fire prevention systems that reduce permanently the oxygen concentration inside the protected volumes so that ignition or fire spreading cannot occur. Unlike traditional fire suppression systems that usually extinguish fire after it is detected, hypoxic air is able to prevent fires. At lower attitudes hypoxic air is safe to breathe for healthy individuals.

Construction and maintenance

All AFP systems are required to be installed and maintained in accordance with strict guidelines in order

to maintain compliance with the local building code and the fire code.

AFP works alongside modern architectural designs and construction materials and fire safety education to prevent, retard, and suppress structural fires.

General fire safety requirements for buildings

In order that the fire hazards (i.e. personal hazard, internal hazard and exposure hazards) are minimised, IS: 1641-1960 recommends that the buildings shall conform to the following general requirements:

1 All buildings and particularly buildings having more than one storey shall be provided with liberally designed and safe fire-proof exits or escapes.

2 The exits shall be so placed that they are always immediately accessible and each is capable of taking all the persons on that floor as alternative escape routes may be rendered unusable and/or unsafe due to fire.

3 Escape routes shall be well-ventilated as persons using the escapes are likely to be overcome by smoke and/ or fumes which may enter from the fire.

4 Fire - proof doors shall conform rigidly to the fire safety requirements.

5 Where fire-resisting doors are employed as cut - off or fire breaks, they shall be maintained in good working order so that they may be readily opened to allow quick escape of persons trapped in that section of the building, and also, when necessary, prompt rescue work can be expeditiously carried out.

6 Electrical and/or mechanical lifts, while reliable under normal conditions may not always be relied on for escape purposes in the event of a fire, as the electrical supply to the building itself may be cut- off or otherwise interrupted, or those relying on mechanical drive may not have the driving power available.

7 Lift shafts and stairways invariably serve as flues or tunnels thus increasing the fire by increased drought and their design shall be such as to reduce or avoid this possibility and consequent spread of fire.

8 False ceiling, either for sound effects or air-conditioning or other similar purpose shall be so constructed as to prevent either total or early collapse in the event of fire so that persons underneath are not fatally trapped before they have the time to reach the exits; this shall apply to cinemas, and other public or private buildings where many people congregate.

9 To a lesser extent, the provisions of clause (8) above shall apply to single - storey buildings which may be used for residence or an equivalent occupancy. Whatever be the class or purpose of the building, the design and construction shall embody the fire retardant features for ceilings and/or roofs.

10 Floors. Floors are required to withstand the effects of fire for the full period stated for the particular grading. The design and construction of floors shall be of such a standard that shall obviate any replacement, partial or otherwise, because experience shows that certain types of construction stand up satisfactorily against collapse and suffer when may first be considered as negligible damage, but in practice later involves complete stripping down and either total or major replacement. This consideration shall also be applied to other elements of structure where necessary.

11 Roofs. Roof for the various fire-grades of the buildings shall be designed and constructed to withstand the effect of fire for the maximum period for the particular grading, and this requires concrete or equivalent construction. It is, however, important that maximum endurance is provided for as stated in para 9.

12 Basements. Where basements are necessary for a building and where such basements are used for storage, provision shall be made for the escape of any heat arising due to fire and for liberating and smoke which may be caused. It is essential that fire resistance of the basement shall conform to the highest order and all columns for supporting the upper structures shall have a grading not less than laid down in types 1 to 3.

13 Smoke extraction from basements. The following requirements shall be provided for smoke extraction

a Unobstructed smoke extracts having direct communication with the open air shall be provided in or adjoining the external walls and in positions easily accessible for firemen in an emergency.

b The area of smoke extracts shall be distributed, as far as possible, around the perimeter to encourage flow of smoke and gases where it is impracticable to provide a few large extracts, for example, not less than 3 m^2 in area, a number of small extracts having the same gross area shall be provided.

c Converse to the smoke extracts shall, where practicable, be provided in the stall board and/or pavement lights at pavement level, and be constructed of light cast iron frame or other construction which may be readily broken by fire-men in emergency. The covers shall be suitably marked.

d Where they pass through fire resisting separations, smoke extracts shall in all cases be completely separated from other compartments in the building by enclosures of the appropriate grade of fire resistance. In other cases, steel metal ducts may be provided.

e Where these are sub-basements, the position of the smoke extracts from subbasements and basements shall be suitably indicated and distinguished on the external faces of the building.

Fire resistant construction

In a fire resistant construction, the design should be such that the components can withstand fire as an integral member of structure, for the desired period. We shall

Consider the construction of the following components:

1 Walls and columns.

2 Floors and roofs.

3 Wall openings.

4 Escape elements.

5 Strong room construction.

1 Walls and columns

The following points should be observed for making walls and columns fire-resistant:

i Masonry walls and columns should be made of thicker section so that these can resist fire for a longer time, and can also act as barrier against spread of fore to the adjoining areas.

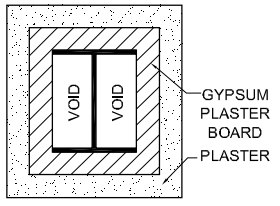
ii In the case of solid load-bearing walls, bricks should be preferred to stones.

iii If walls are to be made of stones, granite and lime stone should be avoided.

iv In the case of building with framed structure, R.C.C should be preferred to steel.

v If steel is used for the framed structure, the steel structural components should be properly enclosed or embedded into concrete, terracotta, brick, gypsum plaster board, or any other suitable material, as illustrated in (Fig 1).

Fig 1

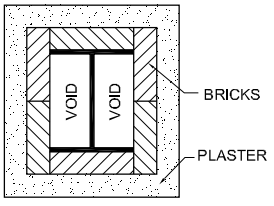


PROTECTION OF STEEL COMPONENTS

DCN319511

vi If the frame work is of R.C.C., thicker cover should be used so that the members can resist fire for a longer time. It is recommended to use 40 to 50 mm cover for columns, 35 to 40 mm cover for beams and long span slabs and 25 mm for short span slabs (Fig 2).

Fig 2



PROTECTION OF STEEL COMPONENTS

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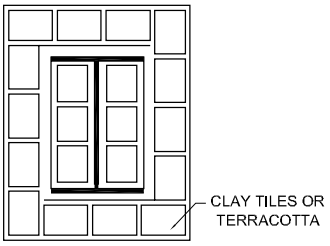
vii Partition walls should be of fire-resistant materials such as R.C.C., reinforced brick work, hollow concrete blocks, burnt clay tiles, reinforced glass, and asbestos cement boards (Fig 3).

Fig 3



PROTECTION OF STEEL COMPONENTS

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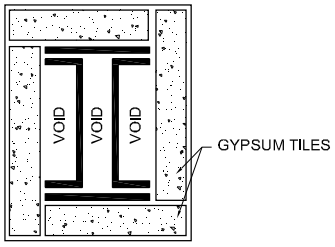
viii Cavity wall construction has better fire resistance.

ix All walls, whether load bearing or non-load bearing, should be plastered with fire-resistive mortar (Fig 4)

Fig 4



PROTECTION OF STEEL COMPONENTS

DCN319514

2 Floors and roofs

The following points are note-worthy for fire-resistant floors and roofs:

i For better fire resistance, slab roof is preferred to sloping or pitched roofs.

ii If it is essential to provide sloping roof, trusses should either be of R.C.C. or of protected rigid steel with fire proof covering.

iii For better fire resistance, the floor should be either of R.C.C. or of hollow tiled ribbed floor or of concrete jack arch floor with steel joists embedded in concrete.

iv If floor is made of timber, thicker joists at a greater spacing should be used, and fire stops or barriers should be provided at suitable interval.

v The flooring materials like concrete tiles, ceramic tiles, bricks etc. Are more suitable for fire resistance.

vi If cast iron, wrought iron, cork carpet, rubber tiles etc. Are to be used, these should be protected by a covering of insulating materials like ceramic tiles, plaster, terracotta, bricks etc.

vii Ceiling, directly suspended from floor joists should be of fire resistant materials like asbestos cement boards, fibre boards, metal lath with plaster etc.

3 Wall openings

i From the point of view of fire spread, openings in the walls should be a bare minimum.

ii Openings serve means of escape. Hence these should be properly protected by suitable arrangements, in case of fire.

iii Doors and windows should be made of steel. Fire resistant doors can be obtained by fixing steel plates to both the sides of the door.

iv Wire-glass panels are preferred for windows.

v Rolling shutter doors should be used for garages, go downs, shops etc.

vi In case of timber doors, minimum thickness of door leaf should be 4 cm. And that of door frame as 8 to 10 cm.

vii All escape doors should be such as to provide free circulation to the persons in passages, lobbies, corridors, stairs etc., and should be made of fire proofing material.

4 Escape elements

i All escape elements, such as stair cases, corridors, lobbies, entrances etc. Should be constructed of fire resistant materials.

ii These escape elements should be well separated from the rest of the building.

iii Doors to these escapes should be fire proof.

iv Staircases should be located next to the outer wall and should be accessible from any floor in the direction of flow towards the exits from the building.

v Five proof doors to the emergency stair cases should be fixed in such a way as to make them close from inside only.

vi The lift shafts connecting various floors should be surrounded with the enclosure walls of fire-resisting materials.

vii Lift shafts should be vented from top to permit escape of smoke and hot gases.

viii An emergency ladder should be provided in the fire resisting building. This ladder should be at least 90 cm wide, constructed of fire-resistant materials.

ix All escape routes over roofs should be protected with railings, balustrades or parapets not less than one metre in height.

5 Strong room construction

A strong room construction is found to be useful in case of safe deposit vaults in banks. Following are the important features of construction:

i The walls, floors and ceilings of a strong room are made of at least 30cm thick cement concrete. If thin R.C.C. walls are used, they should be have covering of bricks or terra-cotta and then suitably plastered with fire-resistant plaster.

ii Doors and windows are well anchored to concrete walls by large number of steel hold fasteners longer in length.

iii Doors and windows should be fire-proof. It is preferable to have double fire-proof door.

iv Windows and ventilators should be covered by special grills made of 20 mm steel square bars. These grills should be well fixed to concrete walls by means of long steel hold fasteners.

Fire alarms

Fire alarms are installed to give an alarm and to call for assistance in event of fire. The fire alarms give enough time to the occupants to reach to a safe place.

Fire alarms can be either manual or automatic

1 Manual alarms

These are of a hand-bell type or similar other sounding device, which can emit distinctive sound when struck. These are sounded by watchmen and the occupants are there by warned to have safe exit in shortest possible time. Manually operated alarms shall be provided near all main exits and in the natural path of escape from fire, at readily accessible points which are not likely to be obstructed.

2 Automatic alarms

These alarms start sounding automatically in the event of fire. It is used in large industrial buildings which may remain unoccupied during night. The automatic fire alarm sends alarm to the nearest control point. The system can also perform the function of sending message to the nearest fire brigade station.

Fire extinguishing equipments

Each building should have suitable fire extinguishing arrangements, depending upon the importance of the building and the associated fire hazards. Following are usual equipments required for fire extinction.

Manual fire extinguishing equipment

These devices are useful for extinguishing fire as soon as it starts. They are not so useful when once the fire has spread. Under this category comes the portable extinguishers of carbon - dioxide type or foam generation type etc. The discharge from a portable fire extinguisher lasts only for a short duration of 20 to 120 seconds. In some cases, especially in small buildings buckets of water, sand and asbestos blanket may be kept ready at all times to extinguish fire. These buckets are installed at convenient locations for taking care of fire of minor size.

Fire hydrants

These fire hydrants are provided on a ring main of 150 mm dia. In the ground around the building periphery. The ring main gets water from underground tank with pressure, so that available pressure at each hydrant is of the order of about 3.5 to 4 kg/cm2.

Wet riser system

The system consists of providing 100 to 150 mm dia. Vertical G.I pipes (risers) at suitable locations in the building. A fire pump is used to feed water from underground tank to these pipes, to ensure a pressure of 3 kg/cm2 at uppermost out let.

Automatic Sprinkler system

This arrangement is adopted for important structures like textile mills, paper mills etc. The system consists of a net work of pipes 20 mm dia. Fixed to the ceiling of the room. These pipes are spaced at 3m centre to centre. Heat actuated sprinkler heads are fixed to these pipes at regular interval. The pipes get supply from a header. Each sprinkler head is provided with fusible plug. In the event of fire, the fusible plug in the sprinkler nearest to the wire melts due to rise of temperature, and water gushes out of the sprinkler head. The fire is thus brought under control in a short period.

Requirement of green belt and land

Objectives : At the end of this lesson you shall be able to
- **describe green belt land and its purposes**
- **explain environmental low for green belts developments.**

What is Green Belt Land and its purpose.

Green belt land refers to an area that is kept in reserve for an open space, most often around larger cities. The main purpose of the green belt policy is to protect the land around larger urban centers from urban sprawl, and maintain the designated area for forestry and agriculture as well as to provide habitat to wildlife.

Green belt offers a number of benefits for both urban and rural population. By preventing the urban sprawl, it helps protect agricultural activities and the unique character of rural communities, urban population, on the other hand, is provided an access to an open space which offers opportunities for outdoor activities and an access to clean air.

Areas that are designated as green belt must not be built upon because green belt is defined as an open space, however, that does not mean that no buildings can be erected in green belt. Buildings for agricultural uses and sanitation facilities, for instance, are usually allowed. In some cases, it is also possible to change the use of land in green belt and even gain permission for structures that are officially not allowed in green belt. However, such cases are very rare and the local authorities grant permission only if no suitable site for the building can be found in the urban centre or outside the green belt and there is an accessible business electricity source.

Are there any regulations or environmental law for green belts development in India?

Environmental protection has been considered as an important domain for industrial and other developmental activities in India. Ministry of Environment & Forests (MOEF) has taken several policy initiatives and promoted integration of environmental concerns in developmental projects. One such promoted integration of environmental impact Assessment (EIA) of developmental projects issued in 1994 and further revised notification in year 2006 under the provisions of Environment (protection) Act., 1986. EIA notifications from here. EIA guidance manual for building. Construction, townships and area development projects proactively talks about the importance of green belts in such projects. Environmental guidelines for Industries developed by MOEF, suggest that the industries must care about the surrounding environment and minimize the adverse impacts of industrial operations in the immediate neighborhood as well as distant places. Therefore, these guidelines mandate project owners to maintain the certain distances by the industries from the areas like ecologically sensitive areas, costal areas, flood plain of the Riverside systems, transport/communication system and major settlements,

In addition, these guidelines also mandate that economic and social factors have to be recognized and assessed while cutting industry. Following are the key points that all industries need to follow while moving ahead with the establishment of manufacturing/processing unit in certain areas. These are.

1 No forest land shall be converted into non-forest activity for the sustenance of the industry (reference, forest conservation act, 1980)

2 No prime agricultural and shall be converted into industrial site.

3 Within the acquired site the industry must locate itself at the lowest location to remain obscured from general sight.

4 Land acquired shall be sufficiently large to provide space for appropriate treatment of waste water still left for treatment after maximum possible reuse and recycle. Reclaimed (treated) wastewater shall be used to raise green belt and to create waster body for aesthetics, recreation and if possible for aquaculture. The green belt shall be ½ km Wide around the battery limit of the industry. For industry having odour problem it shall be a kilometer wide.

5 The green belt between two adjoining large scale industries shall be one kilometer.

6 Enough space should be provided for storage of solid wastes so that these could be available for possible reuse.

7 Lay out and form of the industry that may come up in the area must conform to the landscape of the area without affecting to scenic features of that place.

8 Associated township of the industry must be created at a space having physiographic barrier between the industry and the township.

9 Each industry is required to maintain three ambient air quality measuring stations within 120 degree angle between stations.

Environment Management plan (EMP) prepared by MOEF mandates that community buildings and townships should build 1-1.5 kilometer of green belt. This is suggested to restrict air and noise pollution in the vicinity.

As per the National forest policy, 1988 (NFP), It is necessary to encourage the planting of trees alongside of roads railway lines, rivers and streams and canals, and on other unutilized lands under state/corporate, institutional or private ownership. NFP give emphasis on the green belt development. It says - green belts should be raised in urban/industrial areas as well as in arid tracts. Such a programmed will help to check erosion and desertification as well as improve the microclimate (reference).

As per the stipulations of MOEF, green belt is to be provided all around the power station boundary by planting trees and the total green area including landscaping area will be 1/3 (about 33%) of the plant area. This will include Lay down area which will be later on converted into green area. (Report on the land requirement of thermal power stations by CEA)

In India, there is no exclusive green belt regulation/policy. However, under the purview of other regulations such as Environmental Guidelines for Industries, Environment Management plan, National Forest policy, Forest Conservation Act, etc, certain percentage of land designated for green belts is recommended for deferent categories of industrial projects. Expansion of agricultural, urban and industrial activities are causing additional burden on natural resources. Industrial development is causing severe health hazards due the exceeded level of pollution. Green belt not restrict environmental pollution but it helps to maintain the ecological balance of the region.

Introduction of CAD

Objectives : At the end of this lesson you shall be able to
- **define the computer and CAD**
- **describe history of computer.**

Introduction

Computer are increase singly of a becoming a part of everyday life computers calculates our electricity and telephone bill find its useful applications in the field up medicine and medication assists various business organization system to keep their accounts and other basic jobs up to date its also provides the facility of plying games and surfing over the internet so as to gain to information on different filed into days time.

Definition

Computer are an electronic devices which are used to perform arithmetic and logic operation at a very high speed. The application of computers in different fields and areas is successful and economically justified.

A brief history of computers and software

The first computers were developed in the 1950s, shortly after the transistor was invented. In the mid 1960 s general Motors, Boeing and IBM began developing CAD programs, but the development was slowed by the high cost of computer hardware and programming.

In 1971, Ted Hoff developed the first microprocessor. All circuitry of the central processing unit (CPU) was now on one chip. This started the era of the personal computer (PC). In the 1980s, additional improvements to the microprocessor changed the mainframe computers to powerful desktop models.

Of course, computer software was advancing along with the computer hardware. CAD started as a simple drafting tool and has now evolved into a powerful design tool. CAD has progressed from two-dimensional (2-D) to three dimensional (3-D), to surface modelling and to solid modelling with animation. Each generation has become more powerful and more user friendly.

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.

Enlarging or reducing diagrams

CADD allows you to enlarge or reduce diagrams in a convenient manner. To enlarge or reduce diagrams, you need to select the objects and enter a scale factor. The scale factor determines by how much the diagrams are to be reduced or enlarged. (illustrated with fig. In CAD PRIMER)

Mainframe computers have a lot of data processing power and their size is quite big. A single mainframe computer performs all the data processing and is accessed via terminals connected to it. Minicomputers are smaller versions of mainframe computers. Microcomputers (PCs0 are the desktop or laptop computers of today and are used for individual computing needs.

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 CADD. (This topic is further described in CADD 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 usefully 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.

Why should you use CAD?

Traditional drafting is repetitious and can be inaccurate. It may be faster to create a simple "rough" sketch by hand but larger more complex drawings with repetitive operations are drawn more efficiently using CAD.

Why use AutoCAD?

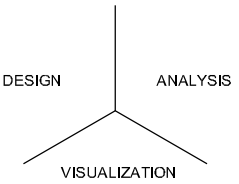
AutoCAD is a computer aided design software developed by Autodesk Inc. AutoCAD was first introduced in 1982. By the year 2000,it is estimated that there were over 4 million AutoCAD users worldwide.

What this means to you is that many employers are in need of AutoCAD operators. In addition, learning AutoCAD will give you the basics for learning other CAD packages because many commands, terms and concepts are used universally.

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 planar 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 follows as Fig 1

Fig 1



COMPONENTS OF COMPUTER AIDED DESIGN

DCN229611

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)

The monitor sis the computer screen and is used to display information. A good monitor is very important for CADD in order to display fine graphics. A colour monitor is essential because many CADD 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

Fig 2

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 CADD applications.

Printers and plotters (Fig 3)

CADD 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.

Fig 3

Printer

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

Key board (Fig 4)

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

Type writer 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.

Fig 4

Key Board

Page up and down key: To move the preceding 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 7 delete keys simultaneously, the machine automatically restart.

Enter key: In alert PC that finish 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 curser, 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 CADD 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

Fig 5

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.

Digitizers are available in many sizes and styles. A number of commands are printed on the digitizer surface. To enter a command, place the puck over the desired command and press the "Enter" button. The selected command is instantly entered. The puck buttons are configured to perform many other tasks. For example, one button is used to make selections, another to enter the data, another to return to the previous menu and another to cancel the last command.

A mouse is another pointing device that can be used with CADD. Like the puck, the mouse allows you to control the position of the cursor on the screen by rolling it across a flat surface, but it does not require a digitizer. Some programs support working with a mouse only, while others support both the mouse and the digitizer. A mouse is much cheaper than a digitizer or puck, but provides only limited data entry options.

CADD software

A CADD program contains hundreds of functions that enable you to accomplish specific drawing tasks. A task may involve drawing an object, editing and 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 CADD 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 CADD. 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 CADD 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 CADD program is designed to change the appearance of all drawing elements created with CADD.

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 CADD 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.

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

CADD programs usually offer a number of special features that make working with CADD 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 CADD program has or how elaborate they are various 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

CADD user interface provides the environment and the tools that allow you and the computer to communicate. Each CADD program establishes an environment that best suits its purpose. The goal is to make working with CADD 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.

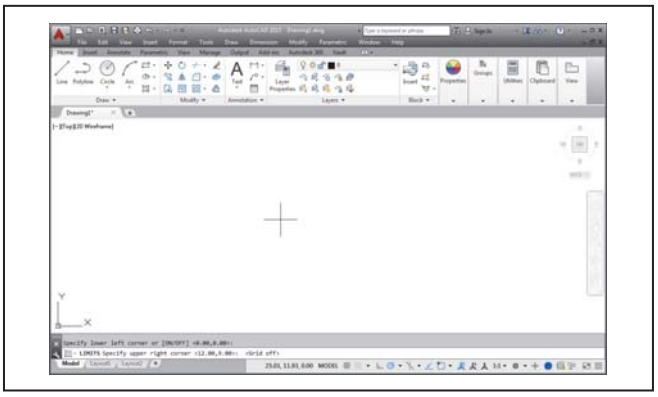
Graphical user interface (GUI)

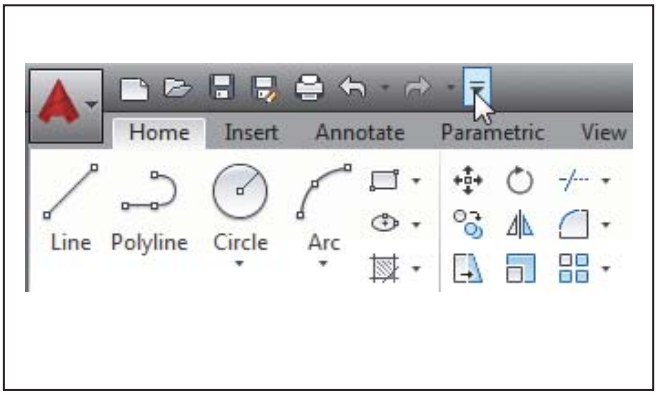
Objectives : At the end of this lesson you shall be able to
- **describe graphical interface of auto cad**
- **explain key board function keys.**

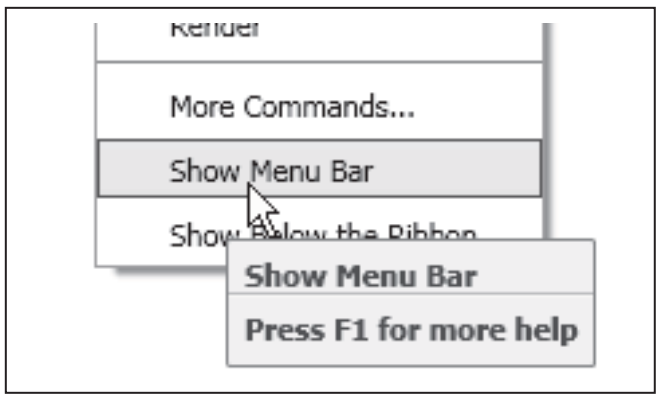
Introduction

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

Graphical user interface (GUI) OF Auto CAD

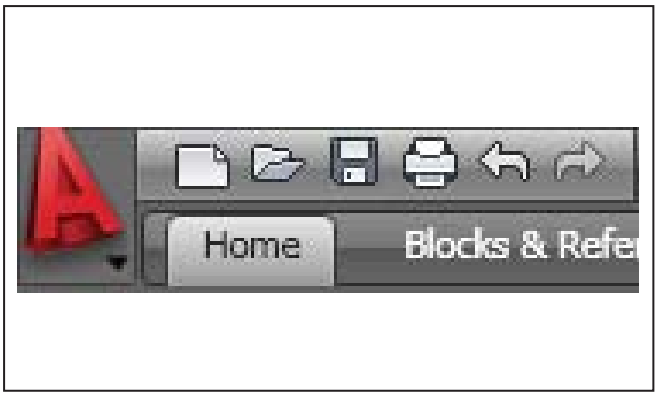






Quick access toolbar

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



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

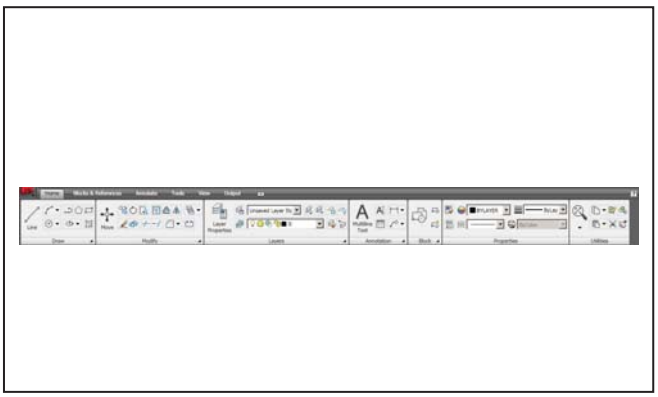
Drag commands you want to add from the command list pane in the customize user interface dialog box to the quick access toolbar.

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.



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.

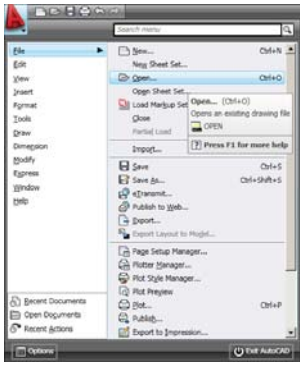
1.5 Menus and colours.

Menu browser

1 Click on the a icon in the upper left corner of the drawing area.

2 Click the desired pull down menu.

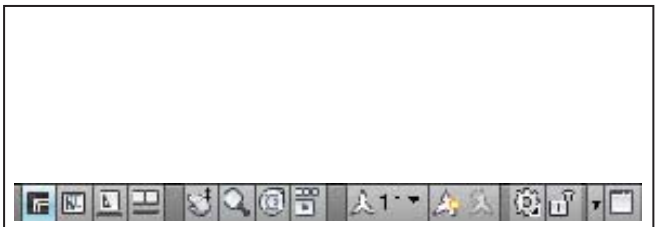
3 Click on the command to be executed from the pulldown.



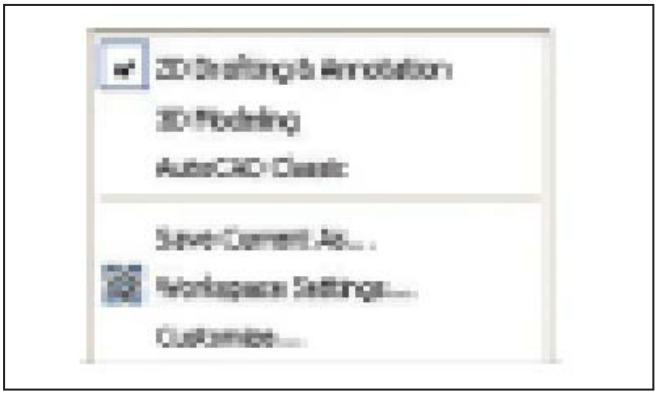
Workspaces

You can switch between the workspaces from the menu browser.

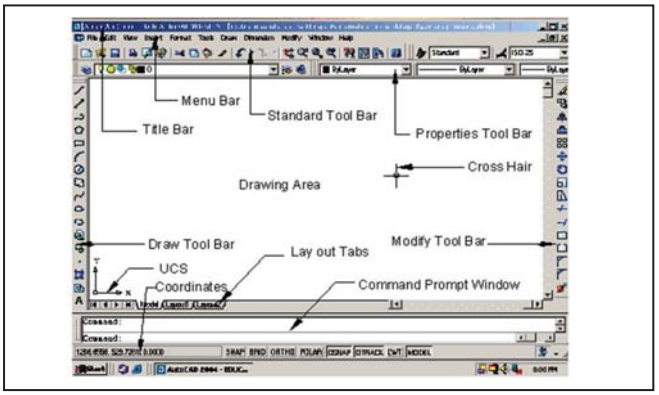
1 Click the workspace switching icon in the lower left corner of the screen.



2 Click on one of the following workspace options.



Auto CAD classic workspace



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

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 have 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 black 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 of 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 tabes 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. These keys are pressed for the following purposes.

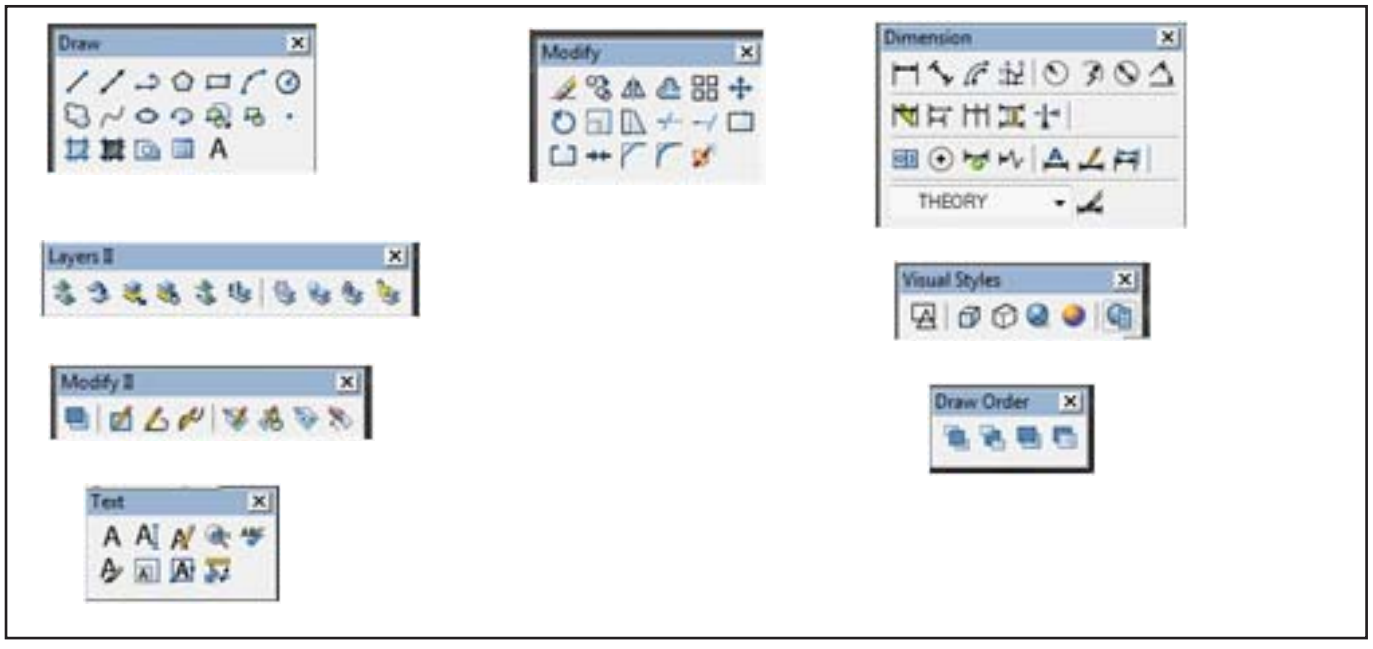
Key	Function defined
F1	Online help.
F2	Toggles between command window on and off.
F3	Toggles between OSNAP on and off.
F4	Toggles between Tablet on and off.
F5	Switches among isoplanes top, right and left.
F6	Toggles between coordinates on and off.
F7	Toggles between grid on and off.
F8	Toggles between ortho mode on and off.
F9	Toggles between snap mode on and off.
F10	Toggles between polar tracking on and off.
F11	Toggles between objects snap tracking on and off.
F12	Save as.

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.



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

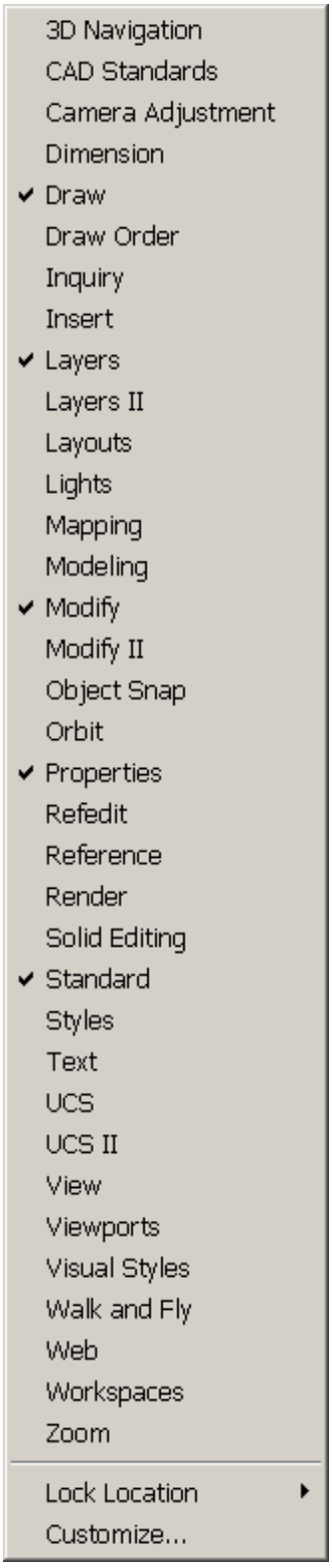
The following accelerator keys, which are effective within the Multilane Text Editor, dialog box.

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+1	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 cur sor location
Ctrl+X	Cuts selected text to the clipboard
Ctrl+SPACE	Removes character formatting in slected text.

Loading toolbars.

Right- clicking on an icon in any toolbar.

This will show a list of all available toolbars.



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, have 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 beginning. Before installing one should aware of the minimum requirements to install and run the product.

System requirements: To should be reviewed about the system requirements administration permission locating serial number and product key closing all numbering applications completing the dead tasks and now it is reedy for installing auto cad. Before installing auto cad that make sure the computer needs the minimum hardware and software.

Serial number and product key.

Whatever auto cad install, which is prompter for the per sons serial number and the product key in 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 out side of the product packing or in the auto desk. The serial is consists of in three digit pre fix followed by the product key consists of fine characters.

The information entered is permanently retained with the porduct. This information canot 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.

Basic Commands - I

Objectives : At the end of this lesson you shall be able to
- **circle arch**
- **ellipse polygon.**

Introduction

AutoCAD allows you to have across to a large number of commands, a general rule is that you use 20% of the commands 80% of the time. I will start by introducing you to the most common drawing commands. When you combine these with the basic modify commands, you will be able to make elaborate drawings quite quickly. In other words, most of the commands you will use while using Auto cad are taught in level1.

The important thing to remember is that AutoCAD will expect you give it 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 (Fig 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.

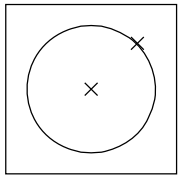
The command line tells you what information AutoCAD requires to continue.

Your first drawing alignment will be to use the drawing commands in conjunction with the co-ordinate system it is very important to understand how to give the program 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.

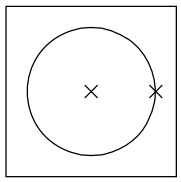
Fig 1



CIRCLE COMMAND

DCN3210011

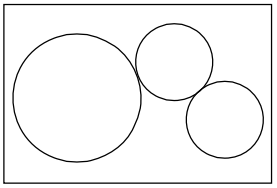
Fig 2



CIRCLE COMMAND

DCN3210012

Fig 3



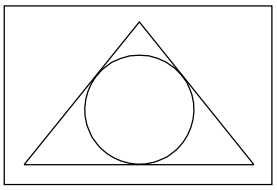
CIRCLE COMMAND

DCN3210013

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

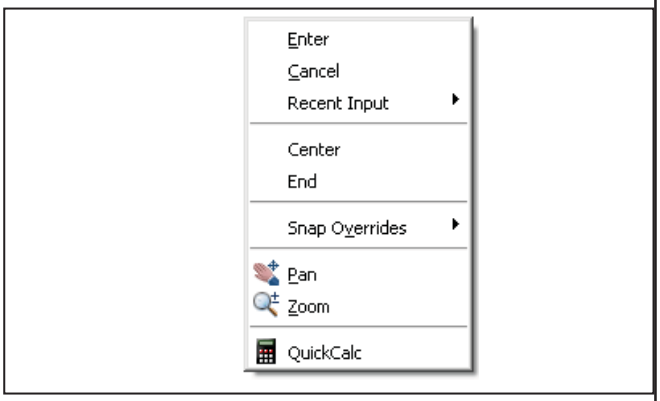


DCN3210014

CIRCLE COMMAND

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)

3 point arc

Start, centre, chord length

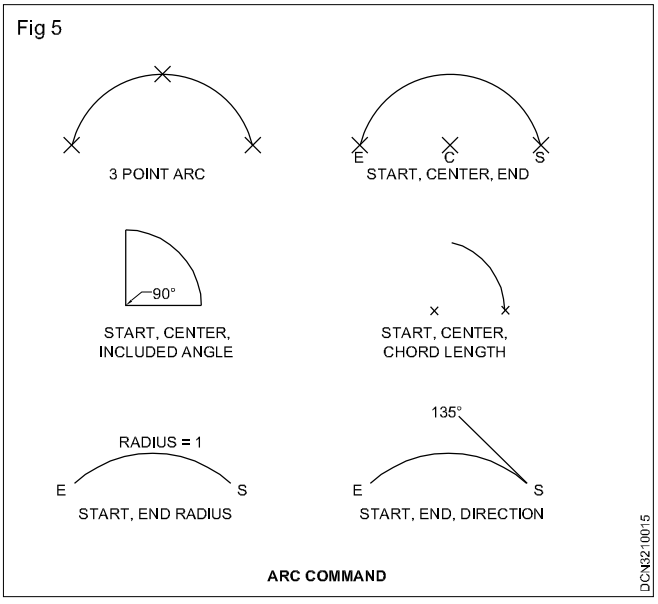
Start, centre, end

Start, end, radius

Start, centre, included angle

Start, end direction

Fig 5



DCN3210015

ARC COMMAND

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 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.

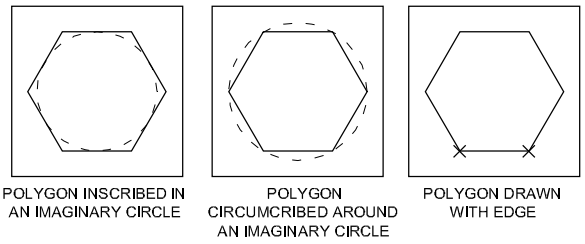
Isocircle : Creates an isometric circle in the current isometric drawing plane.

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

Polygon (Fig 6)

1	Choose	Draw, ploygon.
		(or)
2	Click	The polygonicon.
		(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 in side or outside of an imaginary circle. Inscribed in circle/ circum scribed about circle (I/C)

Fig 6



Basic commands - II

Objective : At the end of this lesson you shall be able to
- **express move, copy, offset, rotate, trim,on,fillet, array, straiten, lemgthen.**

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.

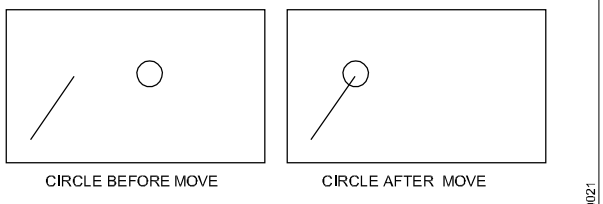
Command	Keystroke	Location	Result
Rectangle	RECTANGLE/REC	Home>Draw>Rectangle	Draws a rectangle after you enter one coner and then the second.
Trim	TRIM/TR	Home>Modify>Trim	Trims objects to a selected cutting edge.
Exlend	EXTEND/EX	Home>Modify>Extend	Extends objects to a selected boundary edge.
Offset	OFFSET/O	Home>Modify>Offset	Offsets an object (parallel) by a set dis tance.
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.

Command	Keystroke	Location	Result
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 se lection set.
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)

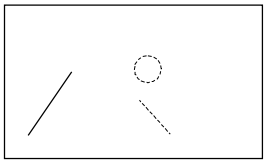
1	Choose	Modify, Move. Or
2	Clik	The Move icon or 
3	Type	Move at the command prompt command: MOVE or M
4	Pick	Objects to move select objects (select)
5	Pick	A point to move from base point of displacement: (Pick point)
6	Pick	A point to move to second point of displanement: (pick point)

Fig 1



MOVE COMMAND

Fig 2



MOVE COMMAND

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

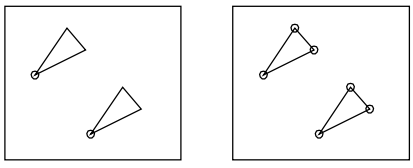
AutoCAD requires that objects be selected in order to be processed. The Select Objects prompt occurs after many commands, including the SELECT command itself.

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.

Fig 3



COPY COMMAND

DCN32100023

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

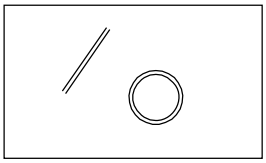
1	Choose	Modify, copy. 
		(or)
2	Click	The copy icon
		(or)
3	Type	Copy at the command prompt.
4	Pick	Objects to copy.
		Select objects: (select)
5	Pick	A point to move from.
		Base point or displacement /multiple: (pick point).
6	Pick	A point to copy to.
		Second point of displacement: (Pick point)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

Fig 4



OFFSET COMMAND

DCN32100024

Offset distance

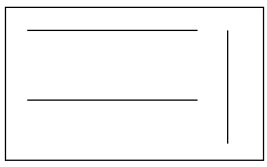
To offset a specified distance:

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 off set: (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)

Fig 5



OFFSET COMMAND

DCN32100025

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 ob ject snaps) Select object to offset: (pick) through point: (select object)

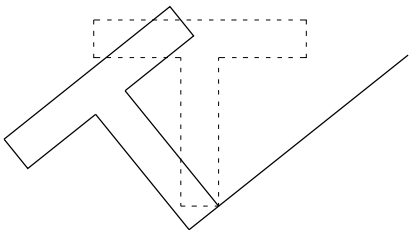
Offset through a point

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>/Refer ence: (number) (or)
7	Pick	A rotation angle<Rotation angle>/Refer ence: (point)

Fig 6



ROTATE COMMAND

DCN32'10026

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

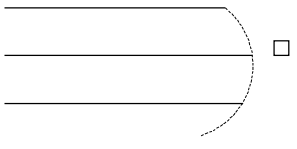
A positive angle causes counterclockwise rotation, and a negative angle produces clockwise rotation. If you respond to the last prompt with r, you can specify the current rotation and the new rotation you want. AutoCAD prompts

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.

Fig 7



TRIM COMMAND

DCN32'10027

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 youare done choosing objects Select object to trim/Undo: (press en ter)

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

Cutting drawing objects along an edge

CADD 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 objectgs that are to be erased along that edge.

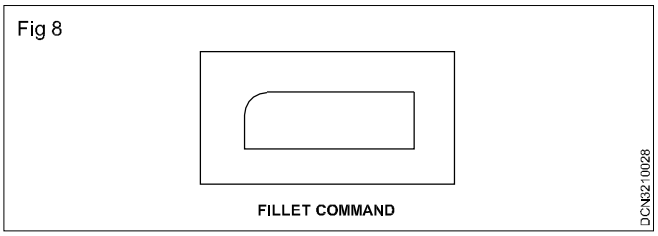
Making sharp and rounded corners

CADD 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 a nentire Polyline
	R	Sets the filletradius.
	T	Sets the trimmode (trim cuts the fil let corner and no trim keeps the fillet corner).



TIP

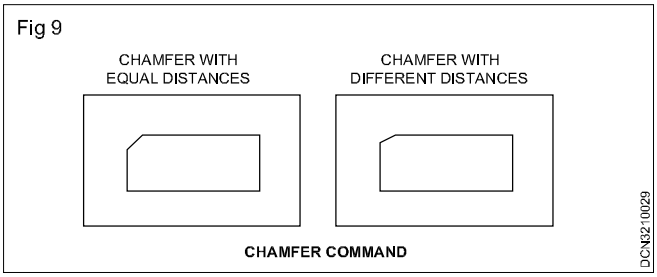
You can also fillet PARALLEL lines as well as PLINES with LINES

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

Chamfer

1	Choose	Modify,chamfer. (or)
2	Click	The chamfer icon.  (or)
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 in stead 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

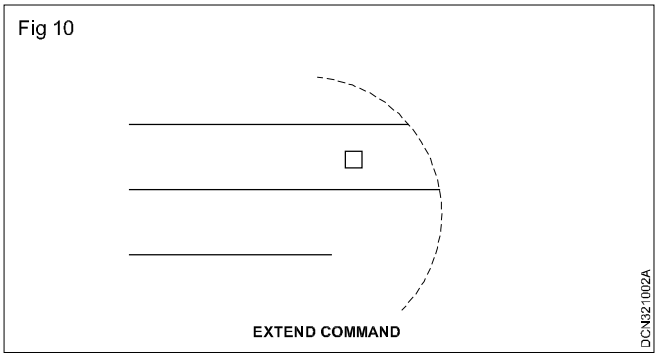
Making chamfered corners

CADD 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)...
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 choos ing objects.

Lines extended to an arc (Arc is boundary edge)



TIP

- Use the object selection option FENCE to choose mul tiple objects.

Extending drawing objects to an edge

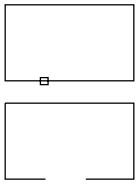
CADD allows you to extend lines to a selected drawing object. Often you need to extend lines to construct a drawing and to fix any graphical errors. To extend lines, you need to select an edge to which the lines should extend and then select the lines to be extended.

Dividing an object into equal parts

CADD 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)

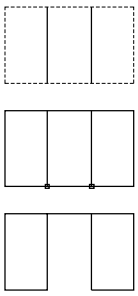
Fig 11



BREAK COMMAND

DCN321002B

Fig 12



BREAK COMMAND

DCN321002C

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

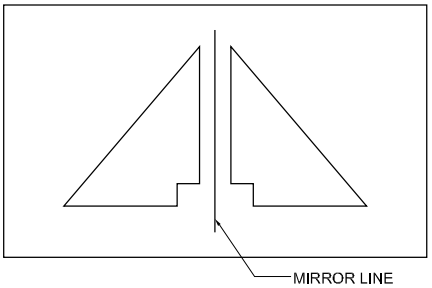
If you break a circle, it changes to an arc by deleting the portion from the first point to the second, going counterclockwise.

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: (Se lect)
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

Fig 13



MIRROR COMMAND

DCN321002D

Mirroring drawings

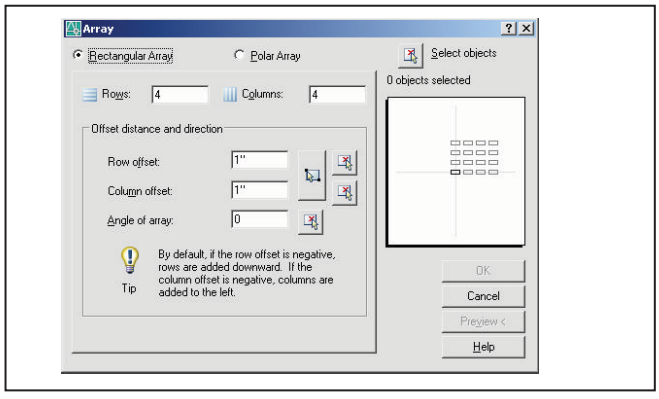
CADD allows you to create mirror images of drawings. This capability is very useful when you want to draw something that is symmetrical on both sides. You need to draw only one half of the drawing; the rest of the drawing can be completed using the mirror function. To make a mirror image, you need to 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

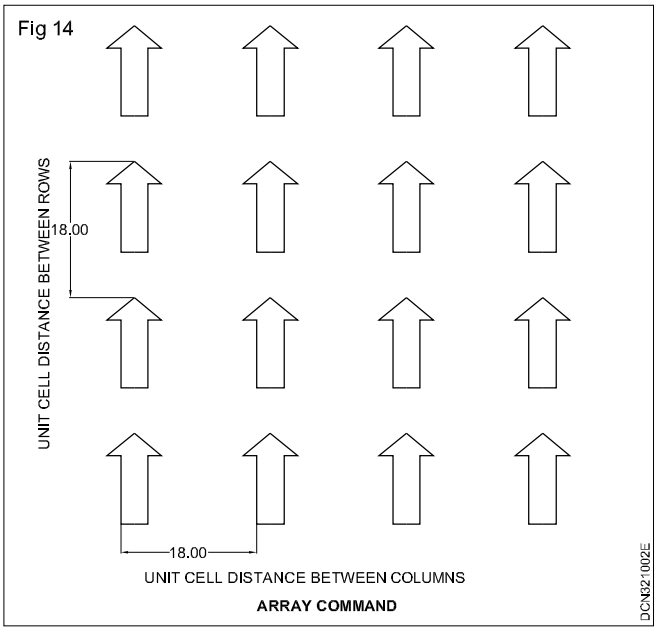
Rectangular array

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>: (num ber)
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: (+ num ber = right, - number = left)

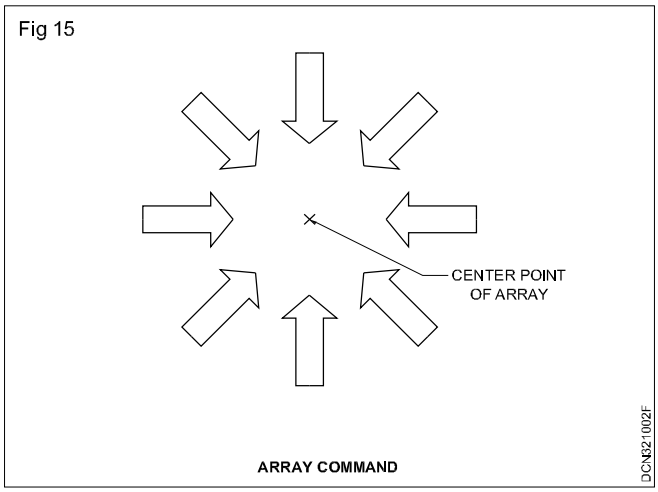


Creating an array of objects (Fig 14)



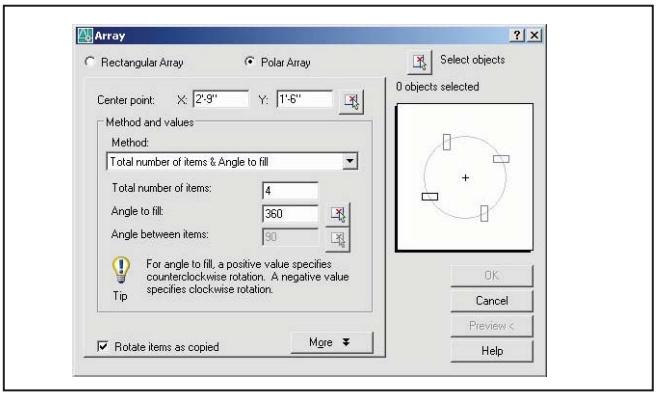
The array command in AutoCAD is used to make multiple copies of objects. Although you can use the copy command to duplicate objects, the array command is more flexible and precise. One advantage of using the array command is that it allows you to copy objects in a defined angle and exact number of copies. 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 15)



To draw a polar array:

1	Choose	Modify, array. (or)
2	Click	The array icon. (or)
3	Type	Array at the command prompt. Com mand: 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 ar ray. 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

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 ob jects to stretch.
Other corner: (point)

7 Press ENTER to accept objects to stretch

8 Pick A base point to stretch from Base point: (point)

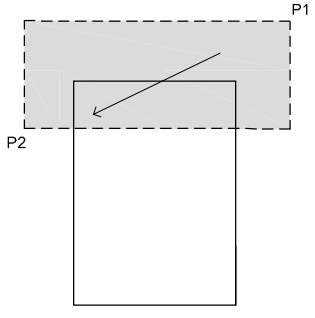
Stretching diagrams (Fig 16)

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

Fig 16



STRETCH COMMAND

DCN321002G

TIP

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

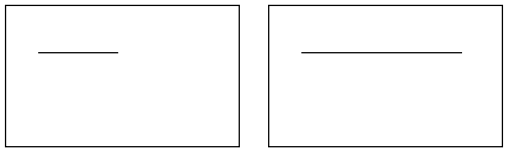
Lengthen (Fig 17)

1 Choose Modify, lengthen.

(or)

2 Type Lemgthen 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

Fig 17



OBJECT BEFORE LENGTHEN OBJECT AFTER LENGTHEN

LENGTHEN COMMAND

DCN321002H

Explode command (Fig 18)

1 Choose Modify, explode.

(or)

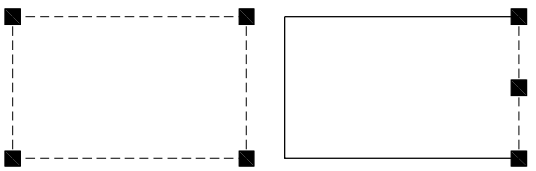
2 Pick The explode icon.

3 Type EXPLODE at the command prompt.
Command: EXPLODE (Fig 18)

(or)

4 Pick The object to explode. Select objects: (pick)

Fig 18



POLYLINE BEFORE EXPLODE POLYLINE (LINE) AFTER EXPLODE

EXPLODE COMMAND

DCN321002I

4.3 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 rein sert erased objects
Command: OOPS

Other CAD commands

Objectives : At the end of this lesson you shall be able to
- **points, rectangle, poliline, spline, multllines, construction line**
- **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.

Most programs allow you to define a style for multiple parallel lines. You can specify how many parallel lines you need, at what distance and if they are to be filled with a pattern or solid fill.

A number of add-on programs use multiple lines to represent specific drawing features. For example, an architectural program has a special function called "wall". When you use this option, it automatically draws parallel lines representing walls or specified style and thickness.

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.

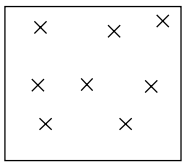
Adding hatch patterns to drawings

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)

Fig 1



POINT COMMAND

DCN32100031

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)

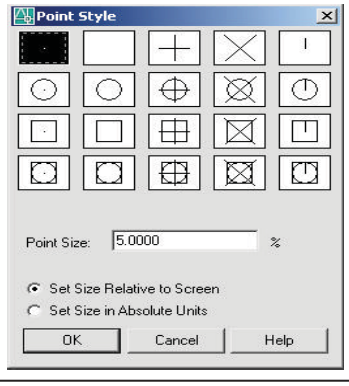
Point styles 21.1

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



Rectangle Fig 2

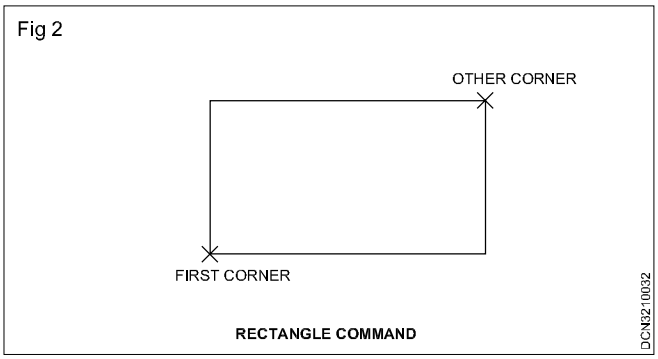
1 Choose Draw, rectangle.

(or)

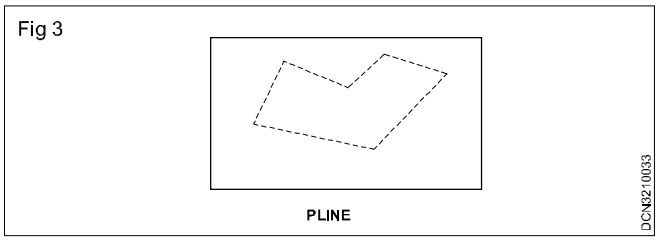
2 Click The rectangle icon

(or)

3	Type	Rectangle at the command prompt Com mand: 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 3)



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 Com mand: 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 4)

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.

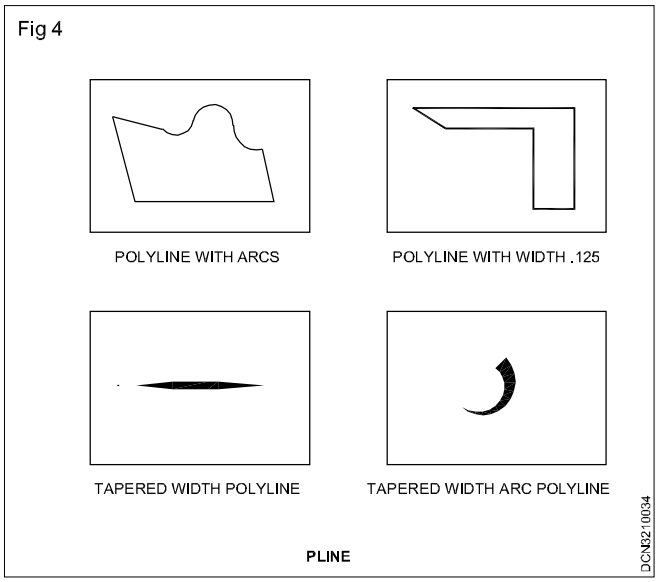
Width : Specifies the width of the next polyline segments. Can be tapered.

Polyline with arcs

Polyline with width 125

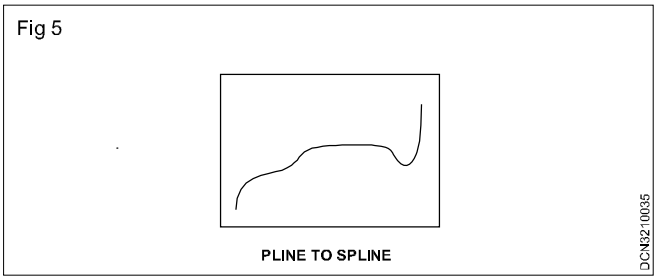
Tapered width polyling

Tapered width arc polyline



Convert pline to spline (Fig 5)

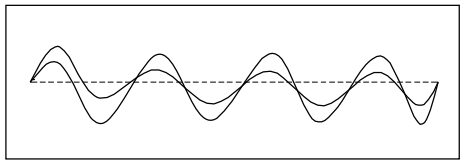
1	Draw	A Pline
2	Type	PEDIT to edit the polyline as a spline.
3	Choose	Draw, Spline
4	Type	Object at the command prompt.
5	Click	Once on the polyline to turn it into a spline.



Spline (Fig 6)

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.

Fig 6



SPLINE

DCN3210036

1	Choose	Draws, spline.
		(or)
2	Click	The spline icon
		(or)
3	Type	Spline at the command prompt Com mand: Spline
4	Pick	A start point for the spline Object /<En ter 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 En ter start tangent (pick point)
8	Pick	Ending tangent point for the spline Enter end tangent (pick point)

Spline options (Fig 7)

Object: Convers 2D or 3D spline-fit polylines to equiva lent splines

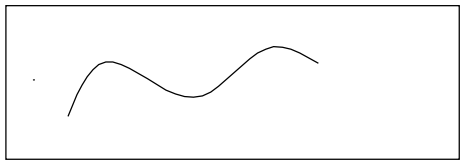
Points: Points that defines the spline

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 informa-tion on spline options.

Fig 7



SPLINE

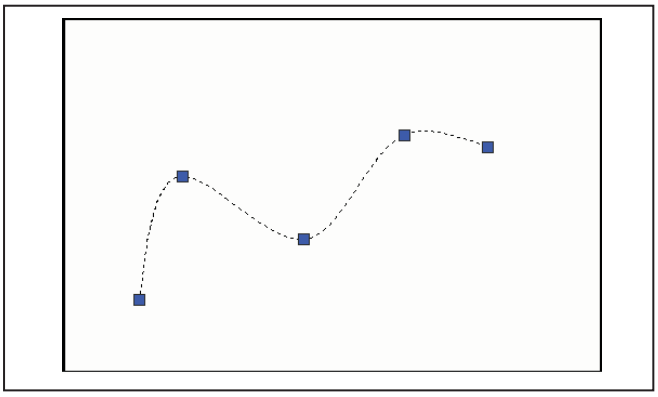
DCN3210037

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.

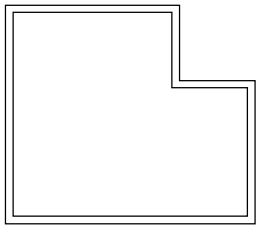


Multilines (Fig 8)

MLINE Command

1	Choode	Draw, multiline.
		(or)
2	Type	MLINE at the command prompt Com mand: 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 Multilines. 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

Fig 8

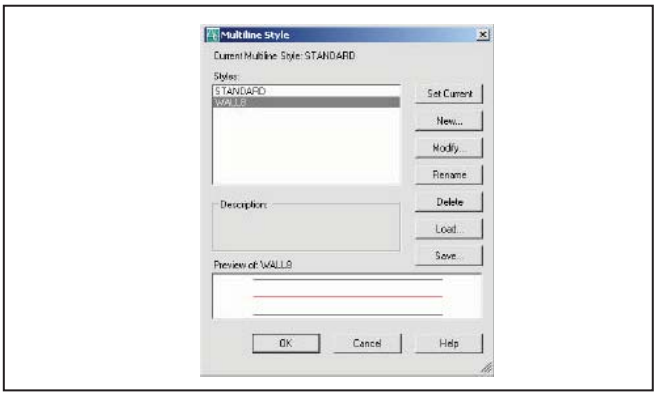


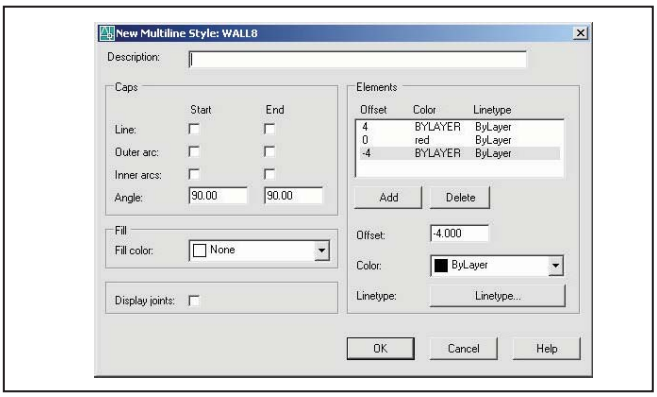
MULTILINES

DCN3210038

Multiline styles

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 ap pearance of the Multilines.
5	Choose	ADD to create the new multiline.





Editing multilines (Fig 9)

1 Choose Modify, Multiline

(or)

2 Type MLEDIT at the command prompt

Command: MLEDIT

3 Choose from one of the mledit options

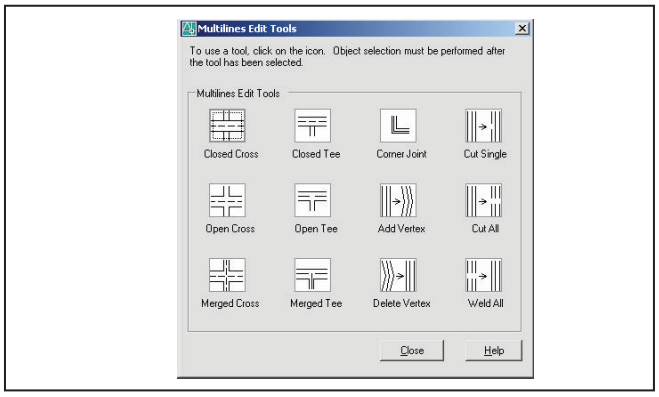
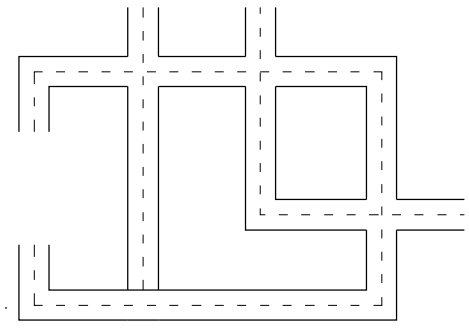


Fig 9



MULTILINES

DCN3210039

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. Com mand: XLINE

Specify a point or [Hor/Ver/Ang/Bisect/ Offset]

XLINE options (Fig 10 & 11)

HOR: Creates a horizontal xline passing through a specified point

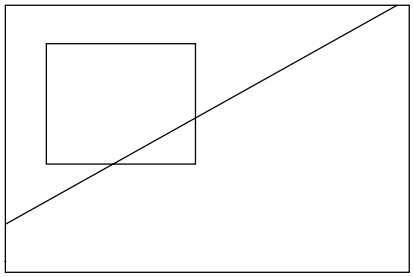
VER: Creates a vertical xline passing through a specified point

ANG: Creates an xline at a specified angle.

BISECT: Creates an xline that passes through the selected angle vertex and bisects the angle between the first and second line

OFFSET: Creates an xline parallel to another object.

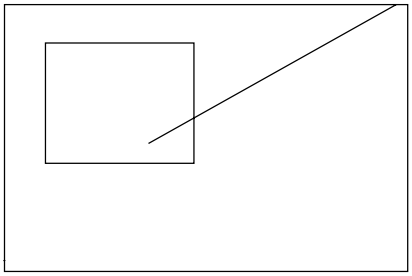
Fig 10



XLINE

DCN3210003A

Fig 11



XLINE

DCN3210003B

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)

Bhatch command

1 Choose — Draw, hatch...

(or)

2 Click — The hatch icon. 

(or)

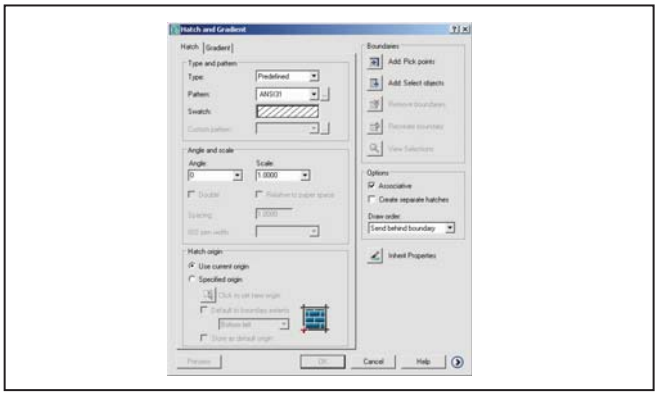
3 Type — BHATCH at the command prompt Command: BHATCH

Bhatch options

Pattern type: Sets the current pattern type by using AutoCAD's Predefined patterns or user defined patterns.

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

Pick points: Constructs a boundary from existing objects that form an enclosed area.



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

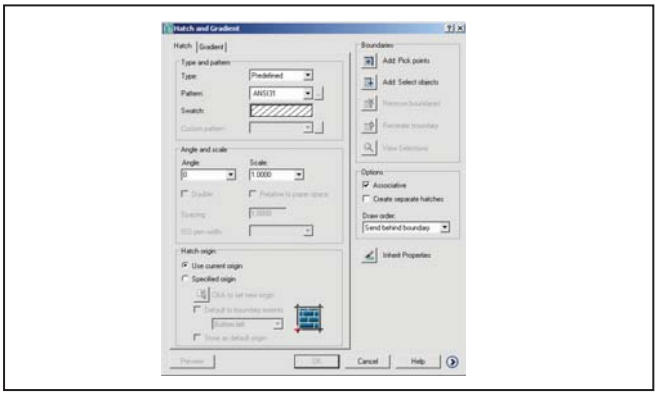
Inherit properties: Applies the properties of an existing associative hatch to the current pattern type and pattern properties options.

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

Associative: Controls associative hatching.

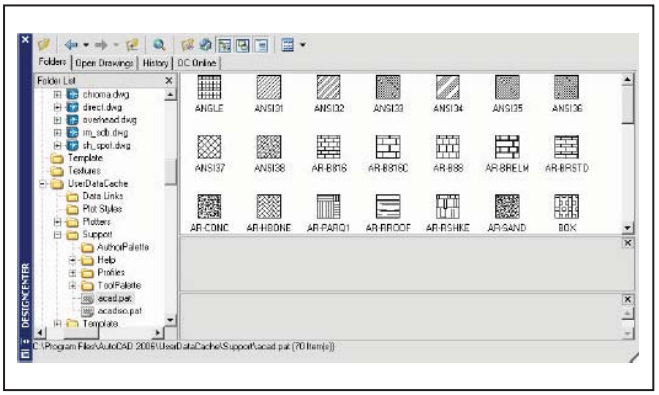
Apply: Crates the crosshatching in the boundary.

Annotative hatch



Hatching from the design center 20.3

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.

CAD basics

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

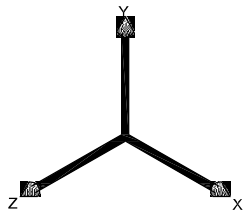
- **explain user co-ordinate system**
- **enumerate Auto CAD commands**
- **express line & erase commands.**

The CAD Database and the user coordinate system

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 forms a point called the origin. Any point in world space can then be defined as the distance from the origin in the X-, Y- and Z- directions. In most CAD systems, the directions of the arrows shown on the axes identify the positive sides of the coordinates.(Fig 1)

A CAD file, which is the electric version of the design, contains data that describes the entities created in the

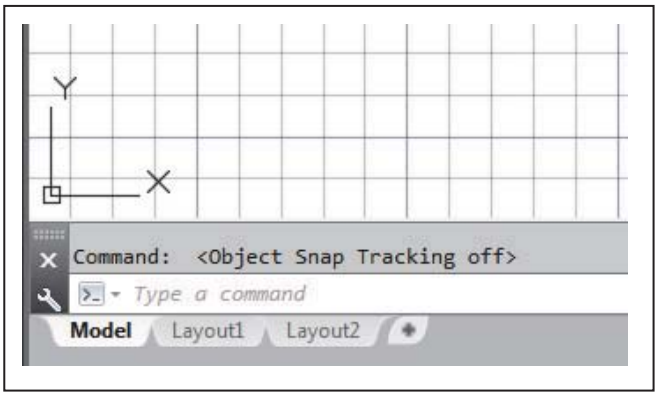
Fig 1



USER COORDINATE SYSTEM

DCN3210041

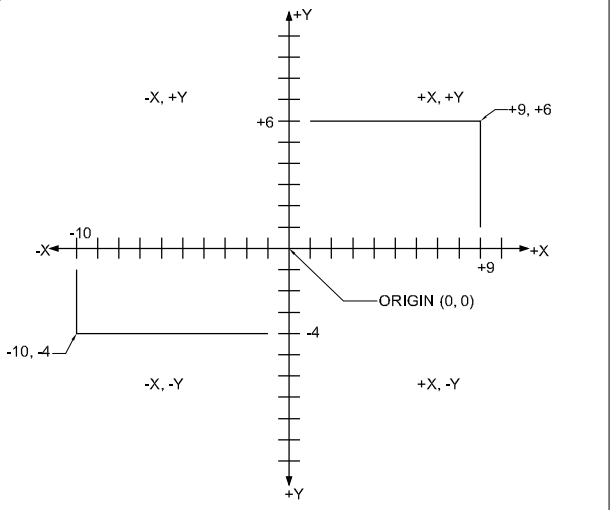
CAD system. Information such as the coordinate values in world space for all endpoints, center points, etc., along with the descriptions of the types of entities are all stored in the file. Knowing that AutoCAD stores designs by keeping coordinate data helps us understand the inputs required to create entities.



The icon near the bottom left corner of the default AutoCAD graphics window shows the positive X-direction and positive Y-direction of the coordinate system that is active. In AutoCAD, the coordinate system that is used to create entities is called the user coordinate system (UCS). By default, the user coordinate system is aligned to the world coordinate system (WCS). The world coordinate system 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.

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 Yaxis(down) (Fig 2)

Fig 2



USER COORDINATE SYSTEM

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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 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.

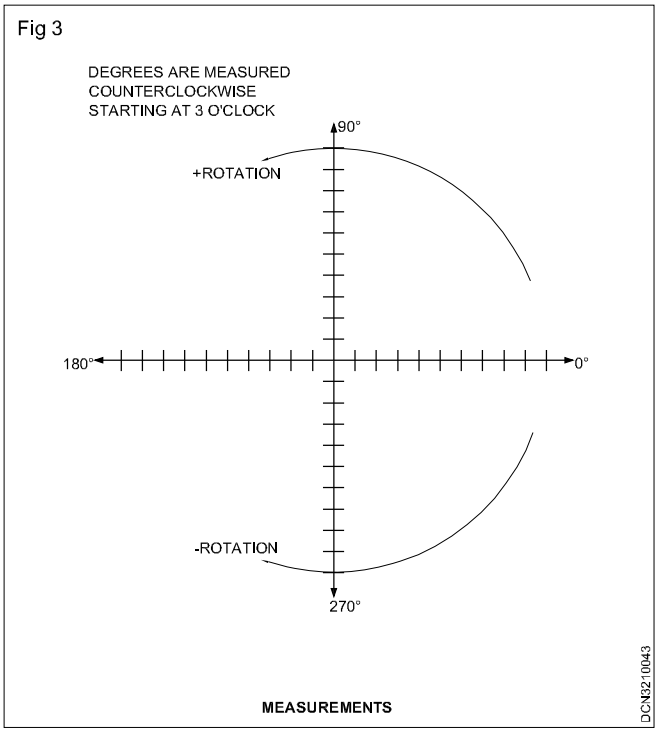
The three ways of entering coordinates shown above are the ONIY way AutoCAD accepts keyboard input. First decide which style you need to use, and then enter as shown. Remember that X is always before Y (alphabetical). Don't forget the '@' symbol when you are entering relative points. Any typing error 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 3)

Fig 3



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

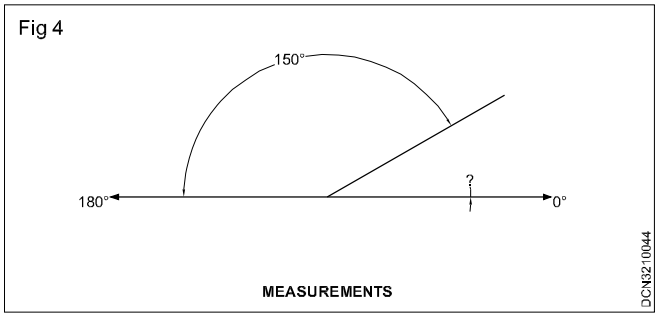
Degrees are measured counterclockwise starting at 3 O'CLOCK

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.

Your 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 that180° 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 4)



1 Start at the 0° position and measure counter-closkwise (+) to 180°

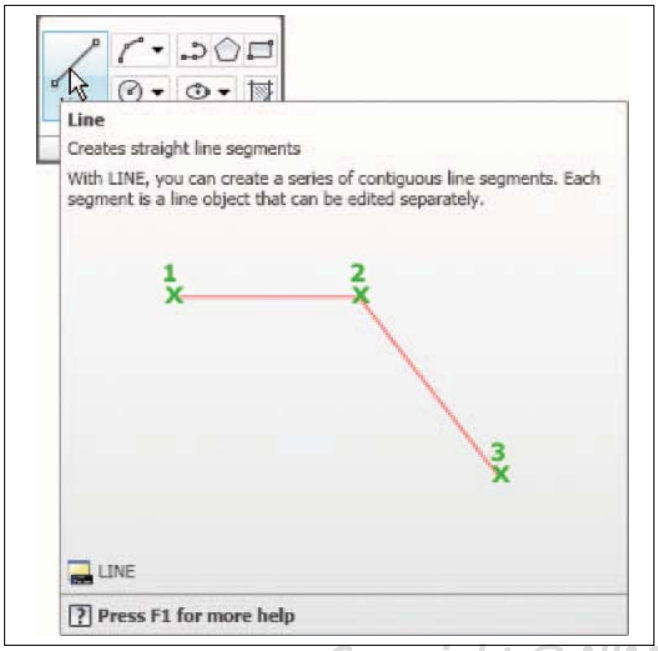
2 From 180°, measure clockwise 150°(-)

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 thepanel you need.

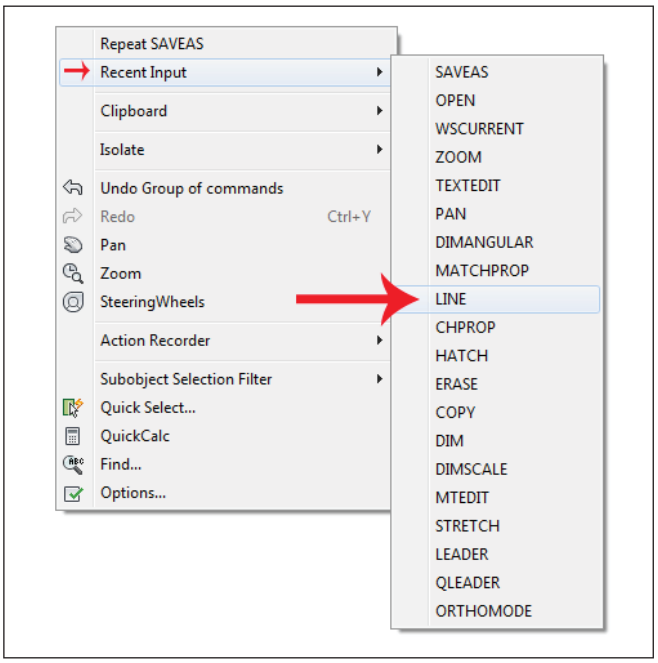
Example: If you want to draw a line, you can do it a few ways:



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

Select the line icon from the DRAW Panel.

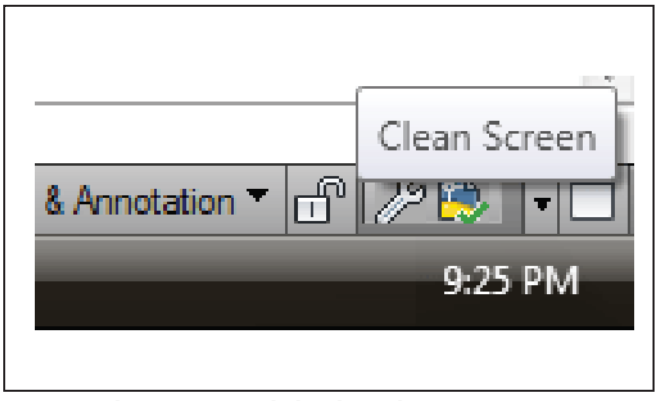
Another way is to Right-Click on the drawing space and choose "Recent Input" from the menu. This will give a list of the most recent command that you have used.



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.

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 the to the standard display, click again on the same icon.



Symbol	Command	Purpose
	Erase	Delete object
	Move	Move object one place to other place
	Copy	Create one or more copies of object
	Stretch	Stertch, shorte, 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.

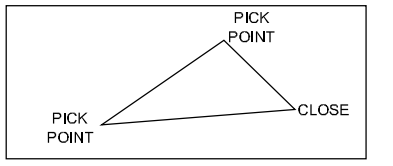
Auto CAD Drawing Commands

Symbol	Command	Major option	Toolbar button	Draw men
	Line	Start, End Point	Line	Line
	Mline	Justification, Scale Style	None	Multiline
	Pline	Vertices	Polyline	Polyline
	Polygon	Number of sides, Inscribed / Circumscribed	Polygon	Polygon

Symbol	Command	Major option	Toolbar button	Draw men
	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 denifition methods
	Revcloud	Arc Length	Revcloud	Revision cloud

Line command (Fig 5)

Fig 5



LINE COMMAND

DCN3210045

Create single straight line segments

1 Choose draw, line

(or)

2 Click the line icon

(or)

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 6)

1 Choose Modify, erase

(or)

2 Click The Erase icon 

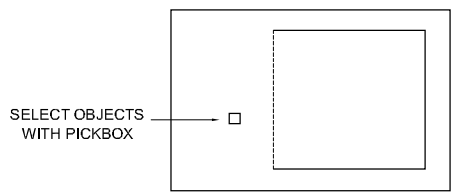
(or)

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

Fig 6



ERASE COMMAND

DC2606E6

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

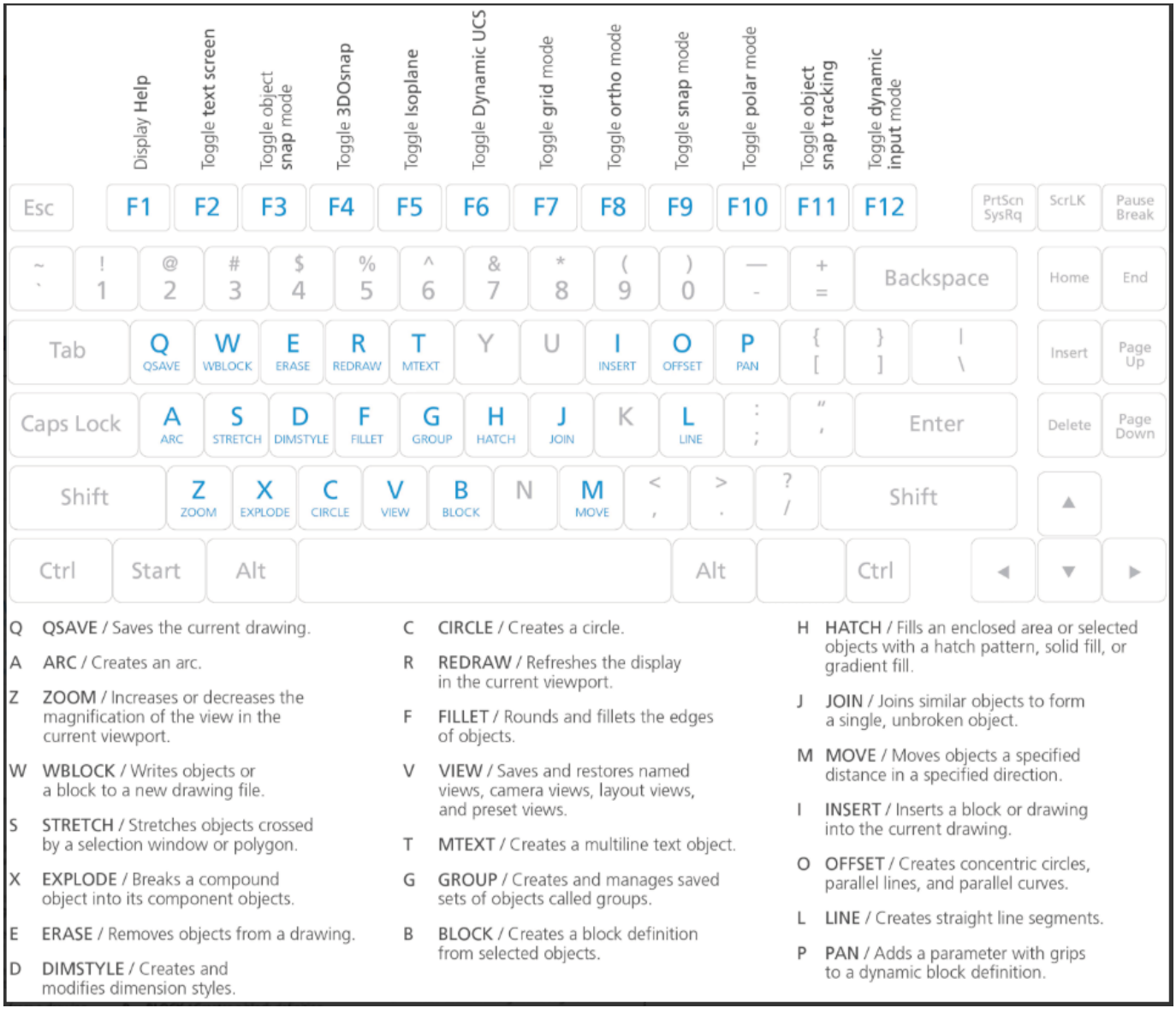
F1	Display Help
F2	Toggle text screen
F3	Toggle object snap mode
F4	Toggle 3DO snap
F5	Toggle Iso plane
F6	Toggle Dynamic UCS
F7	Toggle grid mode
F8	Toggle ortho mode
F9	Toggle snap mode
F10	Toggle polar mode
F11	Toggle object snap tracking
F12	Toggle dynamic input mode

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

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

A

A Arc/Creates an arc.

AA _AREA / Calculates the area and Perimeter of objects or of defined areas.

ADC ADCENTER / Manages and inserts Content such as blocks, xrefs, and hatch patterns.

AL ALIGN/Aligns objects with other objects in 2D and 3D

AP _APPLOAD / Load Application.

AR _ARRAY / Creates multiple copies of objects in a pattern.

ARR _ACTRECORD / Starts the Action Recorder.

ARM _ACTUSERMESSAGE / Insert a user message into an action macro.

ARU _ACTUSERINPUR / Pauses for user input In an action macro.

ARS _ACTSTOP / Stops the Action Recorder and provides the option of saving the recorded actions to an action macro file.

ATI _ATTIPEDIT / Change the textual content of am attribute within a block.

ATT _ATTDEF / Redefines a block and updates associated attributes.

ATE _ATTEDIR / changes attribute information in a block

B

B _BLOCK / Creates a block definition from selected objects.

BC _BCLOSE / Closes the Block Editor.

BE _BEDLT / Opens the block definition In the Block Editor.

BH _HATCH / Fills an enclosed area or selected objects with a hatch pattern, solid fill, or gradient fill.

BO _BOUNDARY / Creates a region or a poly line from an enclosed area.

BR _BREAK / Breaks the selected object between two points.

BS _BSAVE / Saves the current block definition.

BVS _BVSTATE / Creates , sets, or deletes a visibility state in a dynamic block.

C

C _CIRCLE /Creates a circle.

CAM _CAMERA /Sets a camera and target location to create and save a 3D perspective view of objects.

CBAR _CONSTRAINTBAR / A toolbar-like UI element that displays the available geometric constraints on an object.

CH _PROPERTIES / Control Properties of existing objects.

CHA _CHAMFER / Bevels the edges of objects.

CHK _CHECKSTANDARDS / Checks the current drawing for standards violations.

CLI _COLOR / Sets the color for new objects.

CO _ COPY / Copies objects a specified Distance in a specified direction

CT _CTABLESTYLE / Sets the name of the current table style.

CUBE _NAVVCUBE / Controls the visibility and display properties of the View Cube tool.

CYL _CYLINDER / Creates a 3D solid cylinder.

D

D _DIMSTYLE / Creates and modifies dimension styles.

DAN _DIMANGULAR / Creates an angular dimension

DAR _DIMARC / Creates an arc length dimension.

DBA -DIMBASELINE / Creates a linear, angular, or ordinate dimension from the baseline of the previous or selected dimension.

DBC _DBCONNECT / Provides an interface to external database tables.

DCE _DIMCENTER / Creates the center mark or the center lines of circles and arcs.

DCO _DIMCONTINUE / Creates a dimension that starts from an extension line of a previously created dimension

DCON _DIMCONSTRAINT / Applies dimension that starts from an extension line of a previously created dimension.

DCON _DIMCONSTRAIN / Applies dimensional constraints to selected objects or points on objects.

DDA -DIMDISASSOCIATE / Removes associatively from selected dimensions.

DDI _DIMDIAMETER / Creates a diameter dimension for a circle or an arc.

DED _DIMEDIT / Edits dimension text and extension lines.

DI _DIST / Measures the distance and angle between two points.

DIV _DIVIDE / Creates evenly spaced point objects or blocks along the length or perimeter of an object.

DJL _DIMJOGLINE / Adds or removes a jog line on a linear or aligned dimension.

DJO _DIMJOGGED / Creates jogged dimensions for circles and arcs.

DL _DATALINK / The Data link dialog box is displayed.

DLU _DATALINK /Updates data to or from an established external data link.

DO _DONUT /Creates a filled circle or a wide ring.

DOR _DIMORDINATE / Creates ordinate dimensions.

DOV _DIMOVERRIDE /Controls overrides of system variables used in selected dimensions.

DR _DRAWORDER / Changes the draw order of images and other objects.

DRA _DIMRASSOCIATE / Associates or re -associates selected dimensions to objects or points on objects,

DRM -DRAWINGRECOVERY / Displays a list of drawing files that can be recovered after a program or system failure.

DS _DSETTINGS / Sets grid and snap, polar and object snap tracking, object snap modes, Dynamic input, and Quick properties.

DT _TEXT/Creates a single-line text object.

DV _DVIEW / Defines parallel projection or perspective views by using a camera and target.

DX _DATAEXTRACTION / Extracts drawing data and merges data from an external source to a data extraction table or external file.

E-F

E _ERASE / Removes objects from a drawing.

ED _DDEDIT / Edits single-line text, dimension text, attribute definitions, and feature control frames.

EL _ELLIPSE / Creates an ellipse or an elliptical arc.

EPDF _EXPORTPDF / Exports drawing to PDF

ER _EXTERNALREFERENCES / Opens the External References palette

EX _EXTEND / Extends objects to meet the edges of other objects.

EXIT _QUIT / Exits the program.

EXP -EXPORT / Saves the objects in a drawing o a different file format.

EXT _EXTRUDE / extends the dimensions of a 2D object or 3D face into 3D space.

F fillet / Rounds and fillets the edges of objects.

FI _FILTER / Creates a list of requirements that an object must meet to be included in a selection set.

FS _FSMODE / Creates a selection set of all objects that touch the selected object.

FSHOT _FLATSHOT / Creates a 2 D representation of all 3D objects based on the current view.

G-H

G _GROUP / Creates and manages saved sets of objects called groups.

GCON _GEOCONSTRAINT / Applies of persists geometric relationships between objects or points on objects.

GD _GRADIENT / Fills an enclosed area or selected objects with a gradient fill.

GEO _GEOGRAPHICLOCATION / Specifies the geographic location information for a drawing file.

H _HATCH / Fills an enclosed area or selected objects with a hatch pattern, solid fill, or gradient fill.

HE _HATCHEDIT / Modifies an existing hatch or fill.

HI _HIDE/Regenerates a 3D wireframe model with hidden lines suppressed.

I-K

I _INSERT / Inserts a block or drawing into the current drawing.

IAD _IMAGEADJUST / Controls the image display of the brightness, contrast, and fade values of images.

IAT -IMAGEATTACH / Inserts a reference to an image file.

ICL _IMAGECLIP / Crops the display of a selected image to a specified boundary.

ID _ID / Displays the UCS coordinate values of a specified location.

IM _IMAGE / Displays the External References palette.

IMP _IMPORT / Imports files of different formats into the current drawing

IN _INTERSECT / Creates a 3D solid, surface, or 2D region from overlapping solids surfaces, or regions.

INF _INTERFERE / Creates a temporary 3D solid from the interferences between two sets of selected 3D solids.

IO _INSERTOBJ / Inserts a linked or embedded object.

J _JOIN / Joins similar objects to form a single, unbroken object,

JOG _DIMJOGGED / Creates jogged dimensions for circles and arcs.

L-M

L _LINE / Creates straight line segments.

LA _LAYER / Manages layers and layer properties.

LAS _LAYERSTATE / Saves, restores, and manages named layer states.

LE _QLEADER / Creates a leader and leader annotation.

LEN _LENGTHEN / Changes the length of objects and the included angle of arcs.

LESS _MESHSMOOTH;ESS /Decreases the level of smoothness for mesh objects by one level.

LI _LIST / Displays property data for selected objects.

LO -LAYOUT / Creates and modifies drawing layout tabs.

LT _LINETYPE / Loads, sets, and modifies line types.

LTS _LTSCALE / Changes the scale factor of line types for all objects in a drawing.

LW _LWELGHT / Sets the current line weight, display options, and line weight units.

M _MOVE / Moves objects a specified distance in a specified direction.

MA -MATCHPROP / Applies the properties of a selected object to other objects.

MAI _MATERIALS / Shows or hides the Materials window.

ME _MEASURE / Creates point objects or blocks at measured intervals along the length or perimeter of an object.

MEA _MEASUREGEOM / Measures the distance, radius, angle, area, and volume of selected objects or sequence of points.

MI -MIRROR / Creates a mirrored copy of selected objects.

ML -MLINE / Creates multiple parallel lines.

MLA _MLEADERALIGN / Aligns and spaces selected multilayer objects.

MLC _MLEADERCOLLECT / organizes selected multileaders that contain blocks into rows or columns, and displays the result with a single leader.

MLD _MLEADER / Creates a multileader object.

MLE _MLEADEREDIT / Adds leader lines to, or removes leader lines from, a multileader object.

MLS _MLEADERSTYLE / Creates and modifies multileader styles.

MO _PROPERTIES / Controls properties of existing objects.

MORE _MESHSMOOTHMORE / Increases the level of smoothness for mesh objects by one level.

MS _MSPACE/ Switches from paper space to a model space viewport.

MSM _MARKUP / Opens the markup set manager.

MT _MTEXT / Creates a multiline text object.

MV _MVIEW / Creates and controls layout view ports

N-O

NORTH _GEOGRAPHICLOCATION / Specifies the geographic location information for a drawing file.

NSHOT _NEWSHOT / Creates a named view with motion that is played back when viewed with Show motion.

NVIEW _NEW VIEW / Creates a named view with no motion.

O _OFFSET / Creates concentric circles, parallel lines, and parallel curves.

OP _OPTIONS / Customizes the program settings.

ORBIT _3DORBIT / Rotates the view in 3D space, but constrained to horizontal and vertical orbit only.

OS _OSNAP / Sets running object snap modes.

P

P _PAN / Adds a parameter with grips to a dynamic block definition.

PA _PASTESPEC/Pastes objects from the Clipboard into the current drawing and controls the format of the data.

PAR _PARAMETERS / Controls the associative parameters used in the drawing.

PARAM _PARAMETER / Adds a parameter with grips to a dynamic block definition.

PATCH _SURFPATCH / Creates a new surface by fitting a cap over a surface edge that forms a closed loop

PC _POINTCLOUD / Provides options to create and attach point cloud files.

PCATTACH _ POINTCLOUDATTACH / Inserts an indexed point cloud file into the current drawing.

PCINDEX _POINTCLOUDINDEX / Creates an indexed point cloud (PCG or ISD)file from a scan file.

PE _PEDIT/ Edits poly lines and 3D polygon meshes.

PL _PLINE/Creates a 2D poly line.

PO _POINT / Creates a point object.

POFF -HIDEPALETTES /Hides currently displayed palettes (including the command line)

POL _POLYGON / Creates an equilateral closed poly line.

PON _SHOWPALETTES / Restores the display of hidden palettes

PR _PROPERTIES / Displays properties palette.

PRE _PREVIEW / Displays the drawing as it will be plotted.

PRINT_PLOT/Plots a drawing to a plotter, printer, or file.

PS _PSPACE/Switches from a model space viewport to paper space.

PSOLID_POLYSOLID / Creates a 3D wall -like poly solid.

PTW _PUBLISHTOWEB / Creates HTML pages that include images or selected drawings

PU _PURGE / Removes unused items, such as block definitions and layers, from the drawing

PYR _PYRAMID / Creates a 3D solid solid pyramid.

Q

QC _QUICKCALC / Opens the Quick calc calculator.

QCUI _OUICKCUI / Displays the customize User Interface editor in a collapsed state.

QP _QUICKPROPERTIES / Displays open drawing and layouts in drawing in preview images.

QSAVE _QSAVE / Saves the current drawing.

QVD _QVDRAWING / Displays open drawings and layouts in drawing using preview images.

QVDC_QVDRAWINGCLOSE / Closes preview images of open drawings and lay outs in a drawing.

QVL _QVLAYOUT / Displays preview images of model spaces and layouts in a drawing.

QVLC _QVLAYOUTCLOSE / Closes preview images of model space and layouts in the current drawing.

R

R _REDRAW /Refreshes the display in the current viewport.

RA _REDRAWALL / Refreshes the display in all viewports.

RC _RENDERCROP / Renders a specified rectangular area, called a crop window, within a viewport.

RE _REGEN / Regenerates the entire drawing from the current viewport.

REA _REGENALL / Regenerates the drawing and refreshes all viewports.

REC _RECTANG / Creates a rectangular poly line.

REG _REGION / Converts an object that encloses an area into a region object.

REN _RENAME / Changes the names assigned to items such as layers and dimension styles.

REV _REVOLVE / Creates a 3D solid or surface by sweeping a 2D object around an axis

RO _ROTATE / Rotates objects around a base point.

RP _RENDERPRESETS / Specifies render presets, reusable rendering parameters, for rendering an image.

RPR _RPREF / Displays or hides the Advanced render settings palette for access to advance rendering settings.

RP _RENDER/ Creates a photorealistic or realistically shaded image of a 3D solid or surface model.

RW _REDERWIN / Displays the Render window without starting a rendering operation.

S

S _STRETCH / Stretches objects crossed by a selection window or polygon.

SC _SCALE / Enlarges or reduces selected objects, keeping the proportions of the object the same after scaling.

SCR _SCRIPT /Executes a sequence of commands from a script file

SEC _SECTION / Uses the intersection of a plane and solids, surfaces, or mesh to create a region.

SET _SETVAR / Lists or changes the values of system Variables.

SHA _SHADEMODE / Starts the VSCURRENT command.

SL _SLICE / Creates new 3D solids and surfaces by slicing, or dividing, existing objects.

SN _SNAP / Restricts cursor movement to specified intervals.

SO _SOLID / Creates solid-filled triangles and quadrilaterals.

SP _SPELL / Checks spelling in a drawing

SPE _SPLINEDIT / Edits a spine or spline-fit poly line.

SPL _SPLINE / Creates a smooth curve that passes through or near specified points.

SPLANE_SECTIONPLANE / Creates a section object that acts as a cutting plane through 3D objects.

SPLAY _SEQUENCEPLAY / Play s named views in one category

SPLIT _MESHSPLIT / Splits a mesh face into two faces.

SPE _SPLINEDIT / Edits a spline or spline-fit poly line.

SSM _SHEETSET / Opens the sheet set Manager.

ST _STYLE / Creates. Modifies. Or specifies text styles.

STA _STANDARDS / Manages the association of standards files with drawings.

SU _SUBTRACT / Combines selected 3D solids, surfaces, or 2D regions by subtraction.

T

T _MTEXT / Creates a multiline text object.

TA _TABLET / Calibrates, configures, and turns on and off an attached digitizing tablet.

TB _TABLE / Creates an empty table object.

TEDIT _TEXTEDIT / Edits a dimensional constraint, dimension, or text object.

TH _THICKNESS / Sets the default 3D thickness property when creating 2D geometric objects.

TI _TILEMODE / Controls whether paper space can be accessed.

TO _TOOLBAR / Displays, hides , and customizes toolbars.

TOL _TOLERANCE / Creates geometric tolerances contained in a feature control frame.

TOR _TORUS / Creates a donut-shaped 3D solid

TP _TOOLPALETTES / Opens the Tool palettes window.

TR _TRIM / Trims objects to meet the edges of other objects.

TS _TABLESTYLE / Creates modifies, or specifies table styles.

U-W

UC _UCSMAN / Manages defined user coordinate systems.

UN _UNITS / Controls coordinate and angle display formats and precision.

UNHIDE _UNISOLATEOBJECTS / Displays UNIOLATE objects previously hidden with the

ISOLATEOBJECTS or HIDEOBJECTS command.

UNI _UNION / Unions two solid or two region objects.

V _VIEW / Saves and restores named views, camera views , layout views, and preset views.

VGO _VIEWGO / Restores a named view.

VP _DVPOINT / Sets the 3D viewing direction.

VPLAY _VIEWPLAY / Plays the animation associated to a named view.

VS _VSCURRENT / Sets the visual style in the current viewport.

VSM _VISUALSTYLES / Creates and modifies visual styles and applies a visual style to a viewport.

W _WEDGE / Creates a 3D solid wedge.

WHEEL _NAVSWHEEL / Displays a wheel that contains a collection of view navigation tools.

X- Z

X _EXPLODE / Breaks a compound object into its component objects.

XA _XATTAC H / Inserts a DWG file as an external reference (xref).

XB _XBIND / Binds one or more definitions of named objects in an xref to the current drawing.

XC _XCLIP / Crops the display of a selected external reference or block reference to a specified boundary.

XL _XLINE/Creates a line of infinite length

XR _XREF / Starts the EXTERNALREFERENCES command.

Z _ZOOM / Increases or decreases the magnification of the view in the current viewport.

ZEBRA _ANLYSISZEBRA / Projects stripes onto a 3D model to analyze surface continuity.

ZIP _ETRANSMIT / Creates a self -extracting or Zipped Transmittal package.

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**
- **describe mesh modeling**
- **describe construction plane commands**
- **describe computer keyboard short cut.**

Introduction

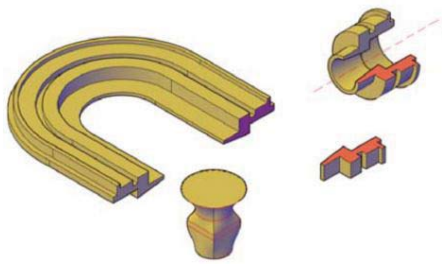
Auto CAD 3D modeling allows you to create drawings using solid, surface, and mesh objects.

Solid, surface, and mesh objects offer different functionality, that, when used together, offer a powerful suite of 3D modeling tools. For example, you can convert a primitive solid to a mesh to take advantage of mesh creasing and smoothing. You can then convert the model to a surface to take advantage of associatively and NURBS modeling.

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.

Fig 1



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.

Fig 2

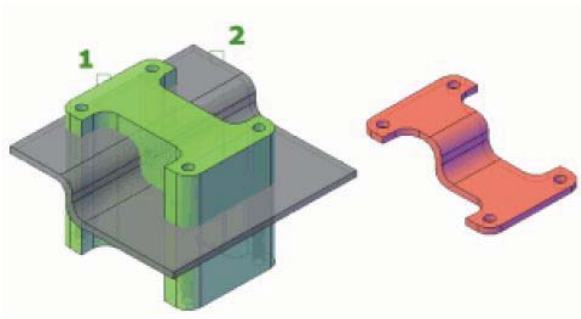
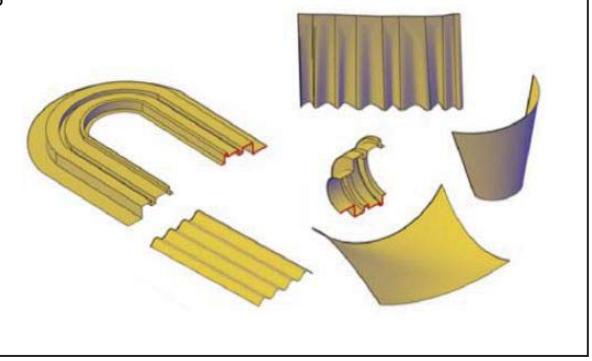


Fig 3



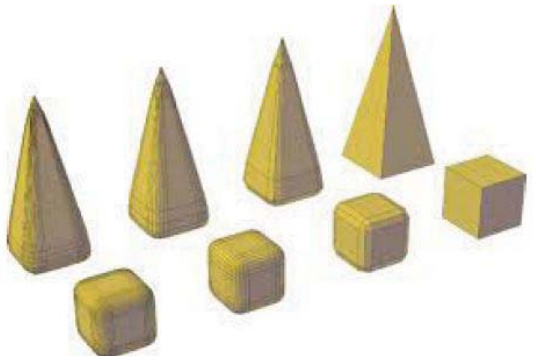
A typical modeling workflow is to create basic models using mesh, solids, and procedural surfaces, and then convert them to nurbs surfaces. This allows you to utilize not only the unique tools and primitive shapes offered by solids and meshes, but also the shaping capabilities provided by surface - associative modeling and nurbs modeling.

You create surface models using some of the same tools that you use for solid models: sweeping, lofting, extruding, and revolving. You can also create surfaces by blending, patching, offsetting, filleting , and extending other surfaces.

Mesh modeling (Fig 4)

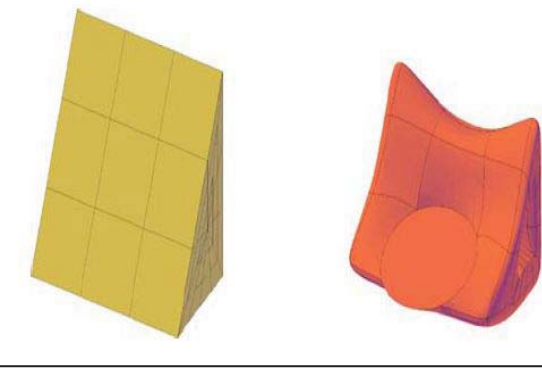
A mesh model consists of vertices, edges, and faces that use polygonal representation (including triangles and quads) to define a 3D shape.

Fig 4



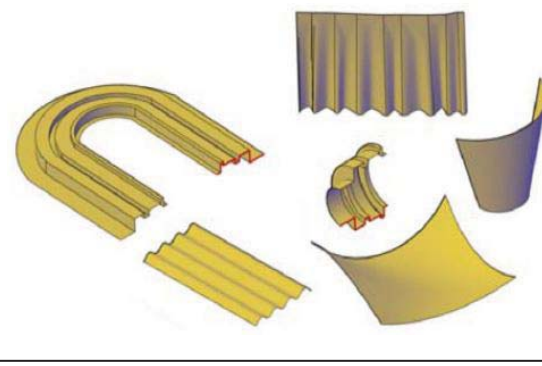
Unlike solid models, mesh has no mass properties. However, as with 3D solids, you can create primitive mesh forms such as boxes, cones and pyramids, starting with Auto Cad-based products 2010 or later. You can modify mesh models in ways that are not available for 3D solids or surfaces. For example you can apply creases, splits, and increasing levels of smoothness . You can drag mesh sub objects (faces, edges, and vertices) to shape the object. To achieve more granular results, you can refine the mesh in specific areas before modifying it. **(Fig 5)**

Fig 5



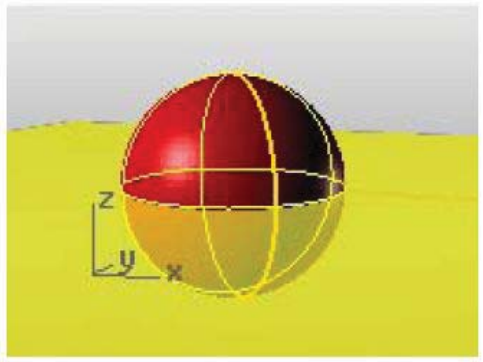
Use mesh models to provide the hiding, shading, and rendering capabilities of a solid model without the physical properties such as mass, moments of inertia, and so on. **(Fig 6)**

Fig 6



A construction plane is like a tabletop that the cursor normally moves on. The construction plane has an origin, X-and y-axes, and a grid. The construction plane can be set to any orientation, and each viewport's construction plane is independent of those in other viewports. **(Fig 7)**

Fig 7



The construction plane represents the local coordinate system for the viewport and can be different from the world coordinate system.

Rhino's standard viewports come with construction planes that correspond to the viewport. The default perspective viewport, however, uses the world Top construction plane. Which is the same construction plane that Is used in the top viewport.

The construction plane grid lies on the construction plane. The dark red line represents the construction plane Y axis. The red and green lines meet at the construction plane origin. The color of these lines can be changed.

To change the direction and origin of a construction plane, from the menu, use the C plane command. Preset construction planes: world Top, right, and Front give you quick access to common.

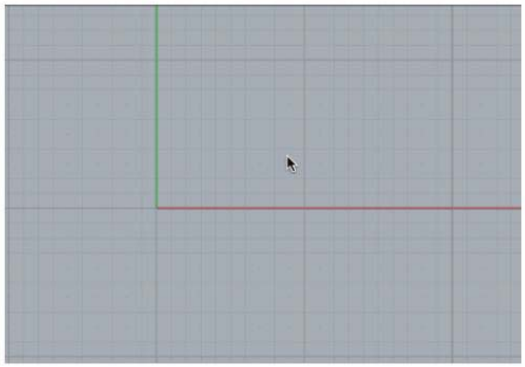
Construction planes: In addition, you can save and restore named construction planes and import named construction planes from another rhino file.

Coordinate input, elevator mode, object snaps, and other cursor constraints allow the cursor to move away from the construction plane.

Notes

- 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. **(Fig 8)**
- 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-axes of the construction plane are shown on the grid in color by default. The visibility and color of the grid axes can be changed.

Fig 8



• Custom construction planes can be named and saved in the 3dm document, They can be restored in any viewport using the Named CPlane 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.

Fig 9

Computer Key board shortcut

< keys

Updated: 09/15/2017 by computer Hope

- Shortcut keys ABCs
- Basic Pc shortcut keys
- PC shortcut keys for special characters
- Microsoft windows shortcut keys
- Apple shortcut keys
- Linux and unix shortcut keys
- F1 - F12 function keys
- Top 10 keyboard shortcuts
- Microsoft excel shortcut keys
- Microsoft word shortcut keys
- Google chrome shortcut keys
- Internet explorer shortcut keys
- Microsoft frontpage shortcut keys
- Microsoft outlook shortcut keys
- Mozilla fire fox keyboard shortcuts
- YouTube keyboard shortcuts
- Keyboard terms
- How do I create a windows shortcut key?

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 hole 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 Ctrl + Shift + E
	Ctrl + Shift + P Ctrl + Shift + P
Insert Link	Ctrl + K Command + K
Toggle Full screen	Ctrl + Shift + F Ctrl + Shift + F
Save	Ctrl + S Command + S
Find	Ctrl + F+ Query Command + F+ Query

Type of recreation land scaping etc

Objectives : At the end of these lesson you shall be able to
- **describe the types of recreation**
- **define park**
- **classification of parks.**

Introduction

Now a days man moved to towns and cities and there came to the urban civilization. As a by-product of this civilization, the town in and around became polluted in all respects even at this state he has got the deep rooted desire to remain in contact with soil and it is for this reason that open spaces in the form of parks and playgrounds should invariably be provided in all town planning.

Types of recreations

On the basis of services rendered by open spaces in the form of recreation, they can be divided into the following two types.

Passive type recreation or parks

Active type recreation or play grounds.

Definition

The park is a place which is provided to meet with the needs of fresh air and peaceaful enjoyment of the unspoiled nature.

Location of urban parks

The urban green space should be located in the town plan very carefully as they serve as a kind of filter or protection against noise, dust, hot sun and harrmful winds.

Classificaation parks

The parks can be classified into the following three ways.

According to character

These are prepared artificially with greats lone by experts in the parks layout. They are planted with grass, shrubs, flower and trees. The water may be introduced in the form of fountains and pools. The seats of suitble design may be provided.

Amusement park or theme park

It is group of entertainment attraction rides, and other events in a location for the enjoyment of loss human of peoples.

Natural parks

In these parks, all efforts are made to maintain the original features of parks and only the necessary minimum adjustment are made to put them for public use.

According to purpose

Botanical parks: These parks are primarily meant for the study of plant specimens. But their atmosphere can be made more pleasant and appealing by the presence of beautiful trees, flowers and lawns.

Zoological parks: These parks contain zoo and it is absolutely necessary for the zoo be given an attractvie parklike setting. A zoological park contains houses and other facilities for animals to be maintained in the zoo.

According to size

Small size parks: The area of these parks varies from one hectare to 4 hectare.

Medium size parks: The size of the parks should not be less than 12 heactares. In thes parks, both types of recreation passive as well as active, may be provided.

Large size parks: The minimum size required for this type of parks is about 40 hectres. This park as a summatin of all types of active recreations like cricket, boating, riding, swimming etc and different types of passive recreations. It also accommodate zoological gardens.

Reservations: The minimum area required for this type of park is 400 hectares. These parks are situated outside the city limits and they include extersive areas of natural sceneries.

National parks: The area of these types of parks may run into thousands to lakhs of hectares. These may includes within their limits Rivers, forests, waterfalls, mountains, wild life places of historical importance, coastal belts. etc,

Play grounds

Objectives : At the end of this exercise, you shall be able to
- **define play grounds**
- **classifications as per age group**
- **describe the size of playgrounds for organized games.**

Introduction

From the days of mankind itself, human beings had more interest to keep themselves physically fit. They also had a deep passion to keep themselves engaged in various active recretions, and there by they managed to maintain sound health, both physically and mentally.

Definition

Play ground is a place with a specific design to allow man to play there. The playgrounds furnish opportunities for the physical growth of body by actively engaging muscels in various games.

Play grounds

The size and locatin of playgrounds will depend upon the age group of people for whom they are required. The provision for various age groups are as follows

Children upto the age of 6 years: It is quite obvious that playground must be near their homes, say within a radius of 400m as they cannot be expected to travel safely more than this distance. The playground must have fencing all round and for further safety, the children play must be supervised, the usual provision is 0.13 hectre per 1000 childern,

Children at school: Each school should have its own playground. The land required for primary shcools is aboult 0.40 hectare for 1000 pupils and for secondary school, it is about 1.20 hectares per 1000 pupils.

Youth and adults: The provision should be within a range of 3 kms or so. The land required is about 1 hectare per 1000 population.

Private clubs: The provision should be made at the rate of 1.20 hectares per 100 members.

If all the above requirements are grouped together, the aggregrate area of land repuired works out to about 2.40 hectares per 1000 population and hence, the open space, for phaygrounds should accordingly be reserved in the town planning scheme.

Size and layout of organized games

Athletic field - 400 meters

Volley ball court

Foot ball

shuttle badminiton

Landscape

Objectives : At the end of this lesson you shall be able to
- **define landscape**
- **state the elements of butt and hand land scape**
- **state the basic landscape principles.**

Introduction

Landscape architecture helps in bringing man closer to nature by allowing him to think about the scenic visual quality of outdoor space. Hence it is rightly considered as a part of environmental design. Cheerful, colourful and refreshing landscape creates a stimulating environment

Mass tree plantation on hills and on the slopes of hills, in green belts, on river banks, around industries and in open spaces is found useful to control pollution, noise and dust. It also controls temperature and humidity. Towns with well planned landscapes, with mass tree plantation act as environmental filter number one.

The relationship of human being with the surrounding physical environment is long and instinctive. It is developed gradually right from childhood through paintings,poetry, literature films television and while abserving flowers and plants. A garden is considered as an extension of the house while parks in towns are considered as lungs with clean air for citizens.

Towns with open spaces for parks and gardens, residential and other types of building with their open space around the building and their terraces, industries with their specific problems of controlling pollution, amusement parks, hotels, aerodromes, roadways, riverbanks, etc. are some areas that require the service of a landscape architect. A landscape architect works with ecologists, horiticulturists. Arechitects and services engineers, besides clients.

Definition

Landscape ecology is the science of studying and improving relationship between ecological processes in the environment and particular ecosystems.

Soft and hard landscape

The total landscape design consists of two parts soft landscape and hard landscape. The details mentioned in the following lines will throw light on various considereation in soft and hard lanscaping which will help achieving unity in design with low cost maintenance.

Soft landscape deals with plantations, their unitary selection, types of trees, shrubs and hedges vines and climbers. It also deals with ground cover, planning of gardens, terrace gardens and their maintenance.

Hard landscape deals with design of space for people and their pedestriain movements. It includes footpaths and cycle ways and also deals with areas around view points, space between buildings, paved surfaces from road to the entrance of a buildings or around buildigs. Human scale, their to and fro movements, visual quality of the surrounding and relation to the building and its finishing material are the major consideratons in this design.

A harmony between soft and hard landscapes results in pleasings patterns and scenic in small or large available plot areas. It also gives a picturesque identity to the town Imaginative utilization of the total available space finally adds to the visual quality of natural and man-made features in the town and around the builings.

Basic landscaping principles

The extent of landscaping varies from small areas around buildings to gradens and parks. Housing complexes, industrial complexes, amusemnt parks, water scapes in the graden, terraces on buildings, hotel compelxes in and around cities and numerous other areas. The demands of the client. budget, nature of land and climate are some variable factors involved.

Some common basic principles to remembered and implemented in tenscaping are as follows:

Unity: Plants, gradients and structures all work harmoniously together.

Balance: To use mass of vegetation, colour or form to create equal visual weight on either side of the centre of interest.

proportion: To take into consideration the scale of the buildings, ultimate size of trees and shrubs.

Variety: Breaking of monotonous effect by selecting suitable of trees and plants with variety in texture and colour. To create elements of surprise in landscaping.

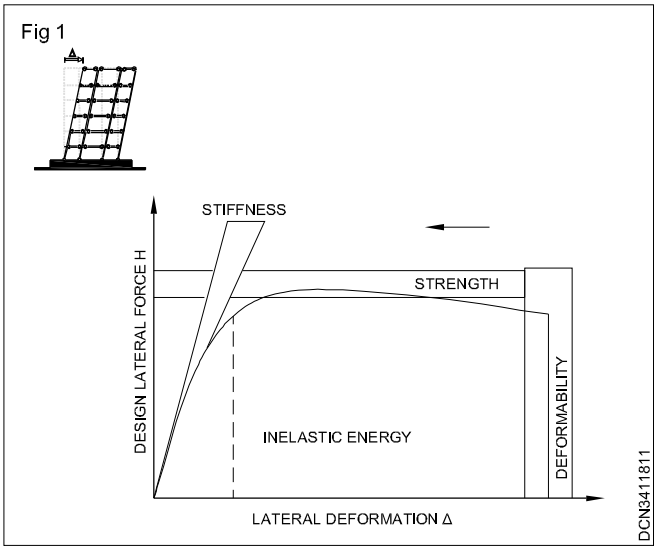
Earthquake resisting building

Objectives : At the end of this lesson you shall be able to
- **define earthquakes**
- **state types earthquakes**
- **explain magnitude and intencity of earth quake**
- **explain terminology and seismogrph.**

Introduction

Investigations of past and recent earthquake damage have illustrated that the building structure are vulnerable to severe damage and/or collapse during moderate to strong ground motion. Among the possible structural damages, seismic induced pounding has been commnly observed in several earthquakes. (Fig 1)

Fig 1



Ground shaking from earthquakes can collapse buildings and bridges, disrupt gas, electric, and phone services and sometimes trigger landslides, avalanches, flash floods, fires, and huge, destructive ocean waves (tsunamis). Every year, earthquakes take the lives of thousands of people, and destroy property worth billions of dollars. Hence, the study of earthquakes and their seismic effects induced on structures are necessary.

The natural disasters like earthquake cannot be prevented, but measures are requied to be taken to reduce the extent of damage. Therefore, designing earthquake resistant structures is indispensable.

This loss of life and property can be prevented by using latest techniques and developments in the field of earth quake engineering. It is imperative that structures are designed to resist earthquake forces, in order to reduce the loss of life.

The paper discusses the impact of earthquakes on building structures, seismic effects on the structure, hazardous effects of warthquakes, necessity of construction of earthquake resistant structures by using latest techniques such as base isolation and energy dissipation devices. What are earthquake resistant structures? How do we design them? are enrolled.

Definition

Earthquakes are natural phenomena, while cause the ground to shake. The earth's interior is hot and in a molten state. As the lava comes to the surface, it cools and new land is formed. The lands so formed have to continuously keep drifting to allow new material to surface. According to the theory of plate tectonics, the entire surface of the earth can be considered to be like several plates, constantly on the move. Thses plates brush against each other or collide at their boundaries giving rise to earthquakes. Therefore regions close to the plate boundaries exhibit less seismicity. Earthquakes may also be caused by other actions such as underfround explosions.

Types of earthquakes

Depending upon the possible cause, the earthquakes may be classified as:

Natural earthquake.

Earthquakes due to induced activities.

Natural earthquakes.

Natural earthquakes may be due to active faults.

Movement of tectionic plates or due to volcanic eruptions.

In earth's crust there are some faults which are not yet settled. The displacement of rocks along faults cause earthquake.

Tectonic means large scale process affectng the structure of the earth curst. This process causes gradual movement of material within the crust of earth. Sometimes it shakes the earth crust.

Volcano is a mountain or hill having a crater through which lava, rock fragments, hot vapour and gas are or have been erupted from the earths crust. Occasionally the volcanoes become active and create earthquake near the mountain crater.

Earthquakes due to induced activities

These are caused by vibrations induced by atomic explosions and collapse of ground due to faulty mining.

Magnitude and intensity of earthquake

The richter magnitude scale

Seismic waves are the vibrations from earthquakes that travel through the earth. They are recorded on istruments called seismographs, Seismographs record a zigzag trace that shows the changing in amplitude of ground oscillations beneath the instrument. Sensitive seismographs, which greatly magnify these ground motions, can detect strong earthquakes from sources anywhere in the world. The time , location, and magnitude of an earthquake can be determined from the data recorded by seismograph stations. The richter scale was developed as a mathematical device to compare the size of earthquakes.

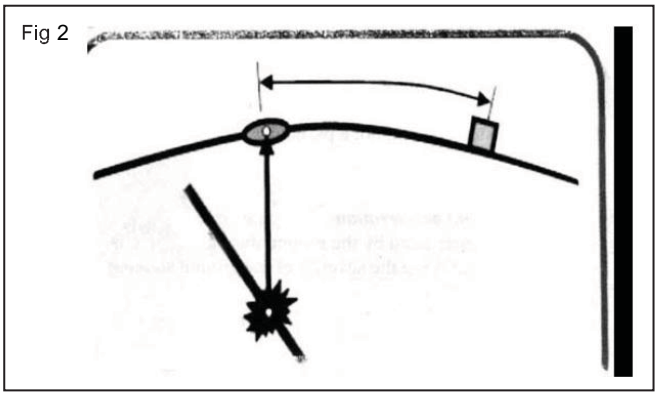
The magnitude of an earthquake is determined from the logarithm of the amplitude of waves recorded by seismographs. On the Richter scale, magnitude is expressed in whole numbers and decimal fractions. For example, a magnitude of 5.0 might be computed for a moderate earth quake, and a strong earthquake might be rated as magnitude 6.0. Each whole number increase in magnitude represents a tenfold increase in measured amplitude; as an estimate of energy, each whole number step in the magnitude scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

The richter scale is not used to express damage. An earthquake in a densely populated area which results in many deaths and considerable damage may have the same magnitude as a shock in a remote area that does nothing more than frightens the wildlife. Large - magnitude earthquakes that occur beneath the oceans may not even be felt by humans. Earthquakes with magnitude of about 2.0 or less are usually called micro earth quakes; they are not commonly felt by people and are generally recorded only on local seismographs. Events with Magnitudes of about 4.5 or greater. There are several thousand such shocks annually are strong enough to be recorded by sensitive seismographs all over the world. Great earthquakes, such as the 1964 good Friday earthquake in Alaska, have magnitudes of 8.0 or higher. On the average, one earthquake of such size occurs somewhere in the world each year.

The modified mercalli intensity scale (Fig 2)

The effect of an earthquake on the Earth's surface is called the intensity. The intensity scale consists of a series of certain key response such as people awakening, movement of furniture, damage to chimneys, and finally total destruction. The current intensity scale being used in the U.S. is the modified Mercalli (MM) intensity scale. The scale is composed of 12 increasing levels if intensity that range from imperceptible shaking to catastrophic destruction. This scale does not have a mathematical basis, instead it is an arbitrary ranking system based on observed effects.

Fig 2



To following is an abbreviated description of the 12 levels of modified mercalli intensity (MMI)

Not fell except by a very few under especially favorable conditions

Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing

Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck. Durable estimated.

Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed: wall shake cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.

Felt by nearly everyone, many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.

Felt by all, many frightened . Some heavy furniture moved, a few instances of fallen plaster.

Damage negligible in buildings of good design and construction, slight to moderate in well-built ordinary structures, considerable damage in poorly built of badly designed structures' some chimneys broken.

Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.

Damage considerable in specially designed structures well-designed frame structures throw out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.

Some well-built wooden structure destroyed, most masonry and frame structures destroyed with foundations. Rails bent.

Few, if any (masonry) structures remain standing. Bridges destroyed. Rail bent greatly.

Damage total lines of sight and

Terminology

Focus: The point on the fault where slip starts is the focus. It is also known as hypocenter.

Epicenter: The point vertically above the focus on he surface of the earth is the epicenter.

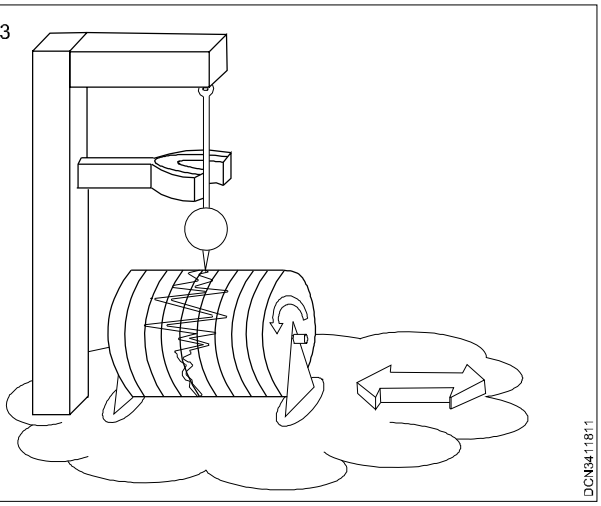
Focal depth: The depth of focus from the epicenter is called the focal depth.

Dpicentral distance: Distance from epicenter to any point of interest on the surface of arth is called epicentral distance.

Seismograph (Fig 3)

Seismograph is an instrument for measuring oscillation of earth during earthquakes. It has three major components the sensor, the recorder and the timer. Figure shows a typical seismograph. The pendulum mass, string, magnet and support together constitute the sensor. The drum, pen and chart paper constitute the recording.

Fig 3



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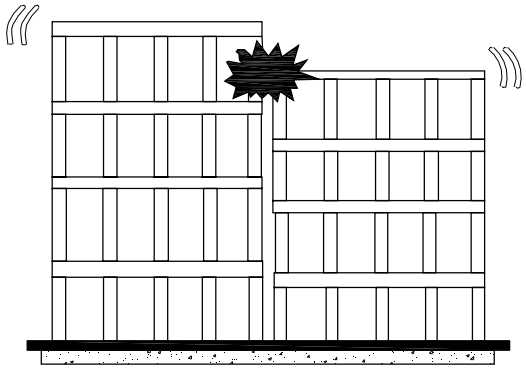
Earthquake hazards & seismic effect

Objectives : At the end of this lesson you shall be able to
- **describe types of earthquake hazards**
- **explain how to building respond to earthquakes**
- **explain seismic effects on structure.**

Earthquake hazards (Fig 1)

Pounding of adjoining structures. Pounding occurs between the two adjoining structures and is dangerous.

Fig 1



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Ground sliding (Fig 2)

Strong ground motion is also the primary cause of damages to the ground and soil upon which, or in which people must build. These damages to the soil and ground can take a variety of forms, cracking and fissuring and weakening, sinking. Settlement and surface fault displacement.

Sometimes, due to earthquake, there is tilting action in the ground. This causes plain land to tilt, causing excessive stresses on building, resulting in damage to buildings. (Fig 3)

Fig 2

Fig 3

Differential settlement

A structure built upon soil which is not homogeneous, the there is differential settlement, with some part of the structure sinking more than other inducing excessive stresses and causes cracking. (Fig 4)

Fig 4

How to buildings respond to earthquakes

The dynamic response of building to earthquake ground motion is the most important cause of earthquake-induced damage to buildings. The damage that a building suffers primarily depends not upon its displacement, but upon acceleration. Whereas displacement is the actual distance the and building may move during an earthquake, acceleration is a measure of how quickly they change speed as they move. During an earthquake, the speed at which both the ground and building are moving will reach some maximum. The more quickly they reach this maximum, the greater their acceleration.

Liquefaction (Fig 5)

During an earthquake significant damage can result due to instability of the soil may result in the development of excess hydrostatic pour water pressure of sufficient magnitude to cause liquefaction of the soil, resulting in settlement, tilting and rupture of structures

Fig 5

Seismic effects on structures

Earthquake ground motion

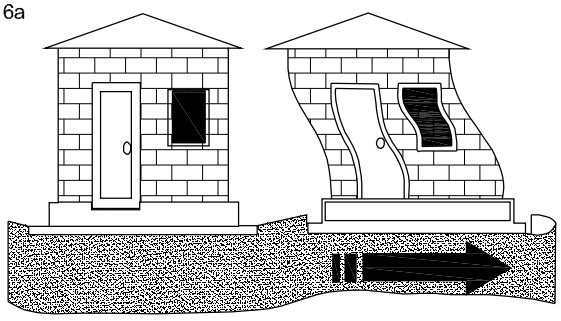
The seismic waves travel for great distances before finally losing most of their energy. At some time after their generation, these seismic waves will reach the earth' surface, and set it in motion. Which we surprisingly refer to as earthquake ground motion. When this earthquake ground motion occurs beneath a building and when it is strong enough, it sets the buildings in motion, starting with the buildings foundation, and transfers the motion throughout the rest of building in very complex way. These motions in turn induce forces which can produce damage.

Real earthquake ground motion at a particular building site is vastly more complicated than the simple wave from. Here it's useful to compare the surface of ground under an earthquake to the surface of a small body of water like a pond. You can set the surface of a pond in motion by throwing stones into it. The first few stones create a series of circular waves. Which soon being to collide with one another. After while, the collisions, which term interference patterns, are being to predominate over the pattern of circular waves. Soon the entire surface of water is covered by ripples and you can no longer make out the original wave forms. During an earthquake, the ground vibrates in a similar manner, as waves of different frequencies and amplitude interact with one another.

Ground motion an building frequencies: (Fig 6a & 6b)

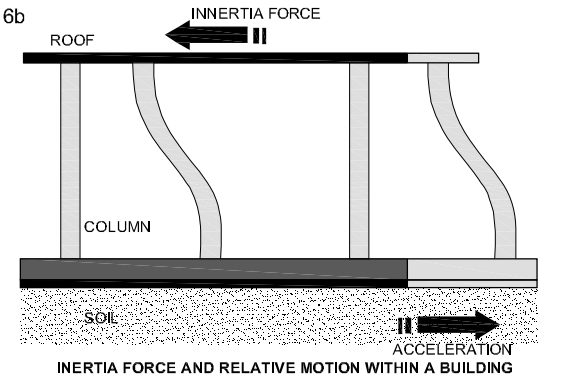
Response of the building to ground motion is a complicated as the ground motion itself. Yet typically quite different. It also begins to vibrate in a complex manner, and because it is now a vibratory system , it also possesses a frequency content. However, the building's cob rations tend to center around one particular frequency. Which is known as its natural or fundamental frequency. So the shorter a building is the higher its natural frequency. The taller the building is, the lower its natural frequency.

Fig 6a



EARTH OF INERTIA IN A BUILDING WHEN SHAKEN AT ITS BASE

Fig 6b



INERTIA FORCE AND RELATIVE MOTION WITHIN A BUILDING

Seismic zones

In most countries, the macro level seismic zones are defined on the basis of seismic intensity scales. In this guide, we shall refer to seismic zones as defined with reference to MSK intensity scale as described in appendix I for buildings.

Zone A: Risk of widespread collapse and destruction (MSK IX or greater),

Zone B: Risk of collapse and heavy and heavy damage (MSK vIII likely),

Zone C: Risk of damage (MSK VII likely),

Zone D: Risk of minor damage (MSK VI maximum),

The extent of special earthquake strengthening should be greatest in Zone A and, for reasons of economy , can be decreased in zone C, with relatively little special strengthening in zone D. However, since the principles state in 3.1 are good principle for building in general (Not just for earthquake), they should always be followed.

Building frequency and period

Another way to understand this to think of the building's response in terms of its natural period. The building period is simply the inverse of the frequency: Whereas, the frequency is the number of times per second that the building will vibrate back and forth, the period is time it takes for the building to make one complete vibration. The relationship between frequency f and the period T is: T= 1/f. This means that a short building with a high natural frequency also has short natural period. A very tall building with a low frequency has a long period. For example, It takes the empire state building a comparatively long time to away back and forth during a strong gust of wind.

Building stiffness

The taller a building, the longer its natural period tends to be. But the height of a building is also related to another important structural characteristic: The building's flexibility. Taller buildings tend to be more flexible than short buildings. (consider a thin metal rod. If the rod is somewhat longer, and of the same diameter it becomes much easier to bend. Buildings behave similarly.) So, a short building is a stiff. While a taller building is flexible.

Stiffness greatly affects the building's uptake of earthquake generated force. Reconsider the example above, of the rigid stone block deeply founded in the soil. The rigid block of stone is very stiff; as result responds in a simple., dramatic manner. Real buildings, of course are more inherently flexible. Being composed of many different parts.

Furthermore, not only is the block stiff, it is brittle: and because of this, it cracks during the earthquake. This leads us to the next important structural character sting affecting a building's earthquake response and performance: ductility.

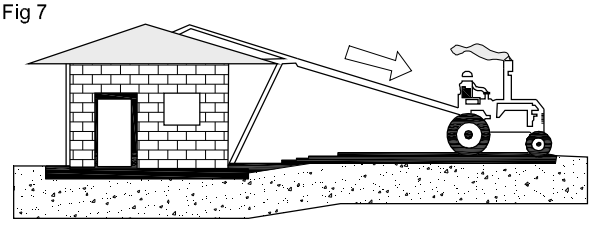
Ductility

Ductility is the ability to undergo distortion or deformation bending, for example without resulting in complete breakage of failure. The ductility or flexibility of structure is one of the most important factors affecting its earth quake performance. One of the primary tasks of an engineer designing a building to be earthquake resistant is to ensure that the building will possess enough ductility to withstand the size and types of earthquakes it is likely to experience during its lifetime.

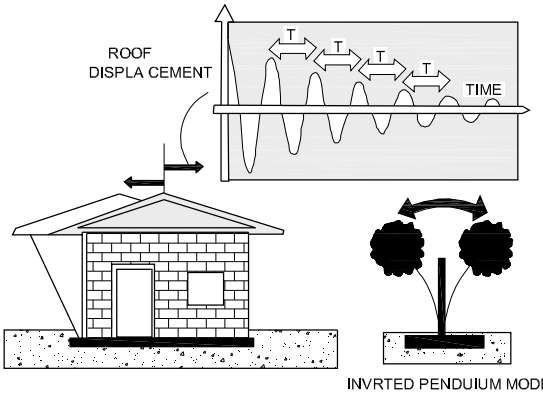
Damping (Fig 7)

All vibrating objects, including, will eventually stop vibrating as time goes on. More precisely, the amplitude of vibration decays with time. Without damping, a vibrating object would never stop vibrating. Once it had been set in motion. In a building during an earthquake, damping the decay of the amplitude of building's vibrations is due to internal friction and the absorption of energy by the building's structural and nonstructural elements.

Fig 7



(a) BUILDING PULLED WITH A ROPE TIED AT ITS ROOF



(b) OSCILATION OF BUILDING ON CUTTING THE ROPE

FREE VIBRATION OF RESPONSE OF A BUILDING :
THE BLACK AND FORTH MOTION IS PERIODIC.

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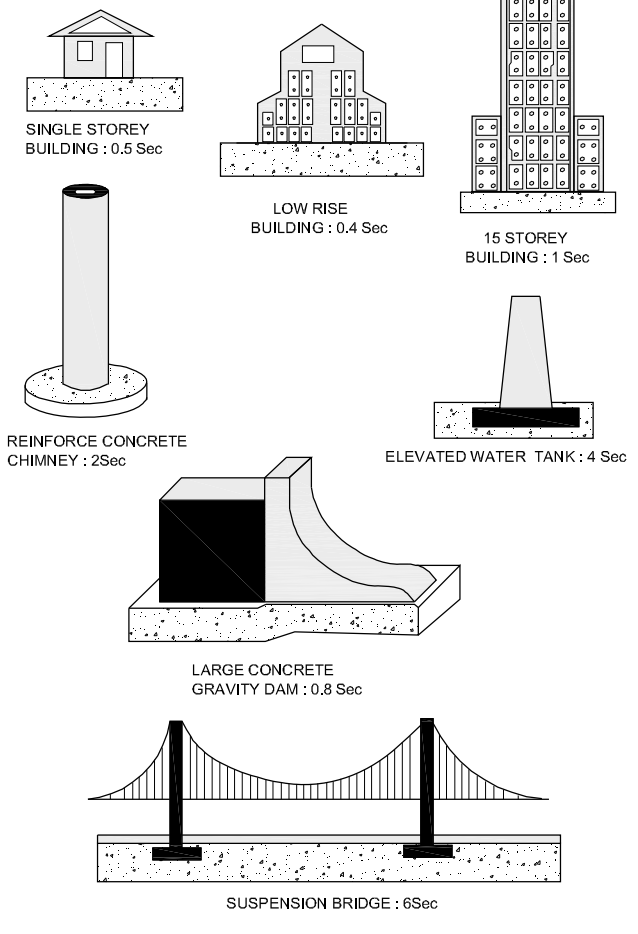
All buildings have some intrinsic damping. The more damping a building possesses, the sooner it will stop vibrating which of course is better. Today, some of the more advanced techniques of earthquake resistant design and construction employ added damping devices like shock absorbers to increase artificially the intrinsic damping of a building and so improve its earthquake performance. (Fig 8 & 9)

Fig 8



FANTAMENTAL NATURAL PERIODS OF STRUCTURES DIFFER OVER A LARGE RANGE.THE NATURAL PERIOD VALUES ARE ONLY INDICATIVE ; DEPENDING ACTUAL PROPERTIES OF THRE STRUCTURE , NATURAL PERIOD MAY VARY CONSIDERABLY

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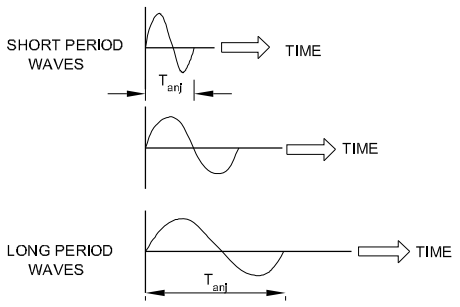
Fig 9



STRONG EARTH QUAKE GROUND MOTION IS TRANSMITTED BY WAVES OF DIFFERENT PERIODS

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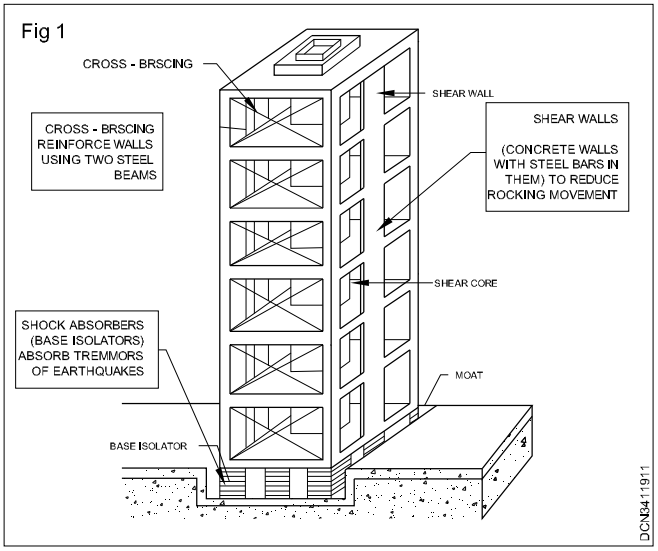
Earthquake resistant structure

Objectives : At the end of this lesson, you shall be able to
- **state the concept of earthquake**
- **explain the requirement of structural safety.**

Concept of earthquake resisting buildings (Fig 1)

Experience in past earthquakes has demonstrated that many common buildings and typical methods of construction lack basic resistance to earthquake forces.

Fig 1



In most cases this resistance can be achieved by following simple, inexpensive principles of good building construction practice. Adherence to these simple rules will not prevent all damage in moderate or large earthquakes, but life threatening collapses should be prevented, and damage limited to repairable proportions. These principles fall into several broad categories.

Planning and layout of the building involving consideration of the location of rooms and walls, openings such as doors and windows, the number of storey's, etc. At this stage, site and foundation aspects should also be considered.

Layout and general design of the structural framing system with special attention to furnishing lateral resistance, and Consideration of highly loaded and critical sections with provision of reinforcement as required.

Earthquake - proof: An earthquake proof building is a building that has been built to survive an earthquake. The building is built with special technology that has materials made in earthquake areas. No building, however, can be made 100% safe and building earthquake proof structures to be more effective is just trial and error.

Why earthquake resistant structural design?

Buildings or structures are usually designed to bear only vertical loads. However, in the event of an earthquake. The ground shakes to & fro. This motion of the ground, imposes an additional horizontal load on the building which it is unable to withstand unless specifically so designed: hence the damage.

Surprisingly, the additional cost to make a building/ structure earthquake resistant is very low, usually about 5% of the structural cost of the building which comes out to be not more than.

How to build?

A number of methods have been developed to build earthquake - resistant structures. These techniques range from extremely simple to fairly complex. For small to medium - sized buildings, the simpler reinforcement techniques include making the structure ductile when subjected to earthquake. This ductility is achieved using properly placed reinforcement and providing support walls called shear walls. Shear walls, made of reinforced concrete (concrete with steel rods or bars embedded init). help

Strengthen the structure and help resist rocking forces

Sometimes, the buildings are protected using medium sized devices that act like shock absorbers between the building and its foundation. These devices called base isolators, are usually bearings made of alternate layers of steel and an elastic material such as synthetic rubber. Also base isolators absorbs some of the sideways motion that would otherwise damage a building.

Reducing earthquake damage

An earthquake - resistant building has a number of special structural features. Interior support walls called shear walls, made of reinforced concrete. Strengthen the structure and help resist rocking forces. Shear walls in the center of a building form a shear core. Cross - bracing reinforces walls with diagonal steel beams. Base isolators act as shock absorbers, and a most allows a building to sway.

Seismic retrofitting

Seismic retrofitting means providing earthquake resistance to an old building. Retrofitting also allows a building to withstand much greater earthquake forces then those for which it was originally designed with much less structural damage. Retrofitting also means making a building re - serviceable and reusable after it has suffered moderate to major structural damages during an

earthquake. A seismic retrofitting generally costs between 1% and 3% of a home's value.

Structural safety

As a result of the discussion of structural action and mechanism of failure of chapter 2, the following main requirements of structural safety of buildings can be arrived

A free standing wall must be designed to be safe as a vertical cantilever.

This requirements will be difficult to achieve in un-reinforced masonry in zone A. Therefore all partitions inside the buildings must be held on the sides as well as top. Parapets of category I and II buildings must be reinforced and held to the main structural slabs or frames.

Horizontal reinforcement in walls is required for transferring their own out-of-plane inertia load horizontally to the shear walls.

The walls must be effectively tied together to avoid separation at vertical joints due to ground shaking.

Shear walls must be present along both axes of the building.

A shear wall must be capable of resisting all horizontal forces due to its own mass and those transmitted to it.

Roof or floor elements must be tied together and be capable of exhibiting diaphragm action.

Trusses must be anchored to the supporting walls and have an arrangement for transferring their inertia force to the end walls.

To meet these safety requirements are presented in the following chapters for various building types. In view of the low seismicity of Zone D, no strengthening measures from seismic consideration are considered necessary except and emphasis on good quality of construction. The following recommendations are therefore intended for Zones A, B and C. For this purpose certain categories of construction in a number of situations were defined in table.

Table : Categories of buildings for stregthening puposes

Category	Combination of contionuous for the catergory
I	Important building on soft soil in zone A
II	Important building on firm soil in zone A Important building on soft soil in zone B Important building on soft soil in zone A
III	Important building on firm soil in zone B Important building on soft soil in zone C Important building on firm soil in zone A Important building on soft soil in zone B
IV	Important building on firm soil in zone C Important building on firm soil in zone B Important building on firm soil in zone C

I.S: Codes on earthquake resistant buildings

After observing Indian earthquakes for several years bureau of Indian standard has divided the country into five zones depending upon the severity of earthquake. IS 1893 -1984 shows the various zones.

The following IS codes will be of great importance for the design engineers:

IS 1893 - 2002: Criteria for earthquake resistant design of structures (5th revision)

IS 4928 - 1993: Code of practice for earthquake resistant design and construction of buildings. (2nd revision)

IS 13827- 1992: Guidelines for improving earthquake resistance of low strength masonry building.

IS 13920 -1997: Code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces.

IS 13935 - 1993: Guidelines for repair and seismic strengthening of buildings.

Improving earthquake resistant for structure

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

- **explain special requirement for earth quake in small and tall building.**

Special requirements for earth quake resisting buildings

For small building (Fig 1)

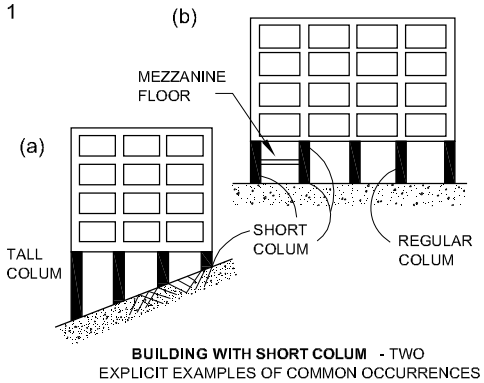
The earthquake resistance of small buildings may be increased by taking some precautions and measures in site selections, building planning and constructions as explained below:

Site selection: The building constructions should be avoided on

Near unstable embankments

On sloping ground with columns of different heights

Fig 1



BUILDING WITH SHORT COLUM - TWO EXPLICIT EXAMPLES OF COMMON OCCURRENCES

Flood affected areas

On subsoil with marked discontinuity like rock in some portion and soil in some portion.

Building planning: Symmetric plans are safer compared to unsymmetric. Hence go for square or rectangular plans rather than L, E, H, T shaped. Rectangular plans should not have length more than twice the width.

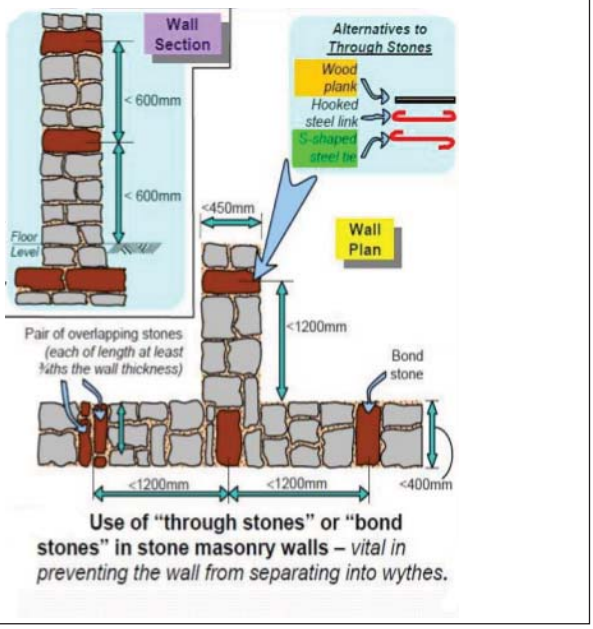
Foundations: Width of foundation should not be less than 750 mm for single storey building and not less than 900 mm for storeyed buildings. Depth of foundation should not be less than 1.0 m for soft soil and 0.45 m for rocky ground. Before foundation is laid remove all loose materials including water from the trench and compact the bottom. After foundation is laid back-fill the foundation properly and compact. (Fig 2)

Masonry. In case of stone masonry

Place each stone flat on its broadest face.

Place length of stones into the thickness of wall to ensure interlocking inside and outside faces of the wall.

Fig 2



Use of "through stones" or "bond stones" in stone masonry walls – *vital in preventing the wall from separating into wythes.*

Fill the voids using small chips of the stones with minimum possible mortar.

Break the stone to make it angular so that it has no rounded face.

At every 600 to 750 mm distance use through stones.

In case of brick masonry.

Use properly burnt bricks only.

good bond.

Blocks should be strong.

Brush the top and bottom faces before laying.

In general walls of more than 450 mm should be avoided. Length of wall should be restricted to 6 m. Cross walls make the masonry stronger. It is better to build partition.

Doors and window openings (Fig 3)

Walls with too many doors and windows close to each other collapse early.

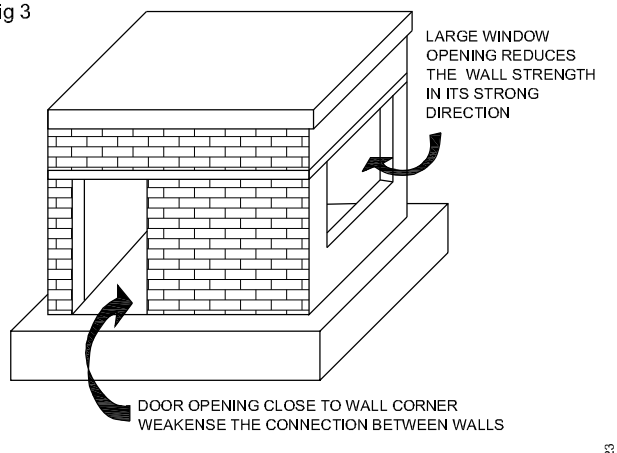
Windows should be kept as same level.

The total width of all openings in wall should not exceedrd the length of wall.

Doors should not be placed at the end of the wall. They should be at least at 500 mm from the cross wall.

Clear width between two openings should not be less than 600 mm.

Fig 3



Roof

In sloping roofs with span greater than 6 m use trusses instead of rafters.

Buildings with 4 sided sloping roof is stronger than the one with two sided sloping, since gable walls collapse early.

Chajjas

Restrict chejja or balcony projections to 0.9 m. For larger projections use beams and columns.

Parapet

Masonry parapet wall can collapse easily. It is better to build parapet with bricks up to 300 mm followed by iron railings.

Concrete and mortar: Use river sand for making mortar and concrete. It should be sieved to remove pebbles. Silt should be removed by holding it against wind. Coarse aggregates of size more than 30 mm should not be used. Aggregates should be well graded and angular. Before adding water cement and aggregates should be dry mixed thoroughly.

Bands

The following R.C. bands should be provided (Fig 4)

Plinth band

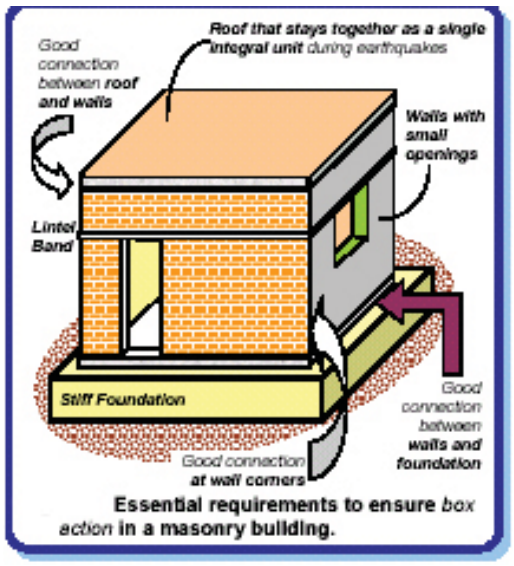
Lintel band

Roof band

Gable band

For making R.C. bands minimum thickness is 75mm and at least two bars of 8 mm diameters are required. They should be tied with steel limbs of 6 mm diameter at 150 mm spacing.

Fig 4



Essential requirements to ensure box action in a masonry building.

If wall size is large, diagonal and vertical bands also may be provided.

Retrofitting: Retrofitting means preparing a structure in a scientific manner so that all elements of a building act as an integral unit.

It is generally the most economical and fastest way to achieve safety of the building. The following are some of the methods in retrofitting:

Anchor roof truss to walls with brackets.

Provide bracings at the level of purlins and bottom chord members of trusses.

Strengthen gable wall by inserting sloping belt on gable wall.

Strengthen corners with seismic belts.

Anchor floor joists to walls with brackets.

Improve storey connections by providing vertical reinforcement.

Induce tensile strength against vertical bending of walls by providing vertical reinforcement at all inside and outside corners.

Encase wall openings with reinforcements.

Earthquake resistance of tall buildings

Tall buildings are subjected to heavy horizontal forces due to inertia during earthquake. Hence they need shear walls. A shear wall is a R.C.C. enclosure within the building built to take shear forces. It is usually built around lift room. These shear walls must be provided evenly throughout the buildings in both directions as well as from bottom to top. Apart from providing shear walls, the following techniques are also used for making tall buildings earthquake resistant.

The conventional approach to earthquake resistant design of buildings depends on providing the building with strength, stiffness and inelastic deformation capacity which are strong enough to withstand a given level of earthquake - generated force. This is generally accomplished through the selection of an appropriate structural configuration and the careful detailing of structural members, such as beams and columns, and the connections approach to earthquake resistance is not to strengthen the building, but to reduce the earthquake - generated forces that is put on the building. By de - coupling the structure from seismic ground motion it is possible to reduce the earthquake - induced forces in it.

The most important advanced techniques of earthquake resistant design and construction are:

Increase natural period of structure by "Base isolation".

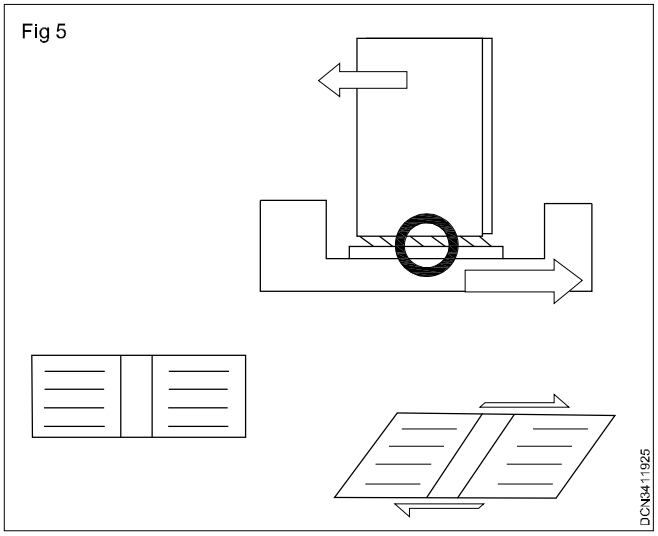
Increase damping of the system by "Energy dissipating devices".

By using active control devices.

Base isolation

This is the most widely used method against earthquake damage. A base isolated structure is supported by a series of bearing pads which are placed between the building and the building's foundation. A variety of different types of base isolation bearing pads have now been developed, including ones called lead rubber bearings. (Fig 5)

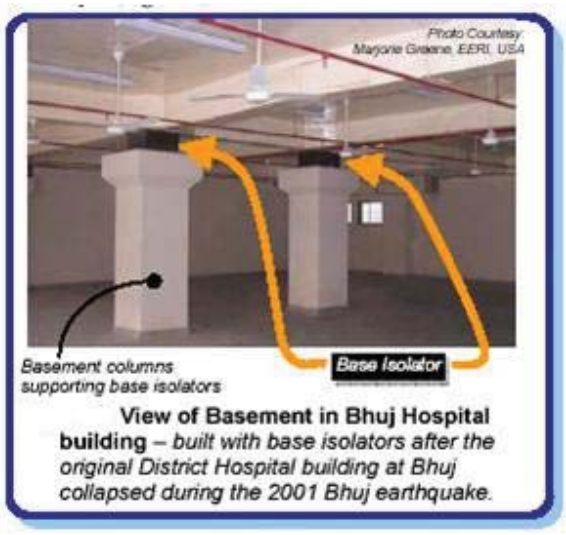
Fig 5



The concept of base isolation is explained through an example building resting on frictionless rollers. When the ground shakes, the rollers freely roll, but the building above does not move. Thus, no force is transferred to the building due to the shaking of the ground; simply, the building does not experience the earthquake. Now, if the same building is rested on the flexible pads that offer resistance against lateral movements, then some effect of the ground shaking will be transferred to the building above. If the flexible pads are properly chosen, the forces induced by ground shaking can be a few times smaller than that

experienced by the building built directly on ground, namely a fixed base building. The flexible pads are called base-isolators, whereas the structures protected by means of these devices are called base-isolated buildings. The main feature of the base isolation technology is that it introduces flexibility in the structure. (Fig 6)

Fig 6



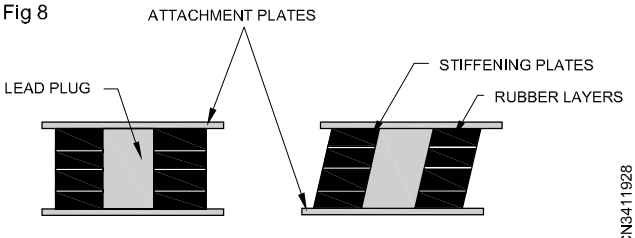
View of Basement in Bhuj Hospital building – *built with base isolators after the original District Hospital building at Bhuj collapsed during the 2001 Bhuj earthquake.*

Due to the flexibility in the structure, a robust mediumrise masonry or reinforced concrete building becomes extremely flexible. The isolators are often designed, to absorb energy and thus add damping to the system. This helps in further reducing the seismic response of the building. (Fig 7)

Many of the base isolators look like large rubber pads, although there are other types that are based on sliding of one part of the building relative to other. Also, base isolation is not suitable for all buildings. Mostly low medium rise buildings rested on hard soil underneath: high - rise buildings or buildings rested on soft soil are not suitable for base isolation. A leader-rubber bearing is made from layers of rubbers sandwiched together with layers of steel. In the middle of the bearing is a solid lead "plug." On top and bottom, the bearing is fitted with steel plates which are used to attach the bearing to the building and foundation. The bearing is very stiff and strong in the vertical direction, but flexible in the horizontal direction.

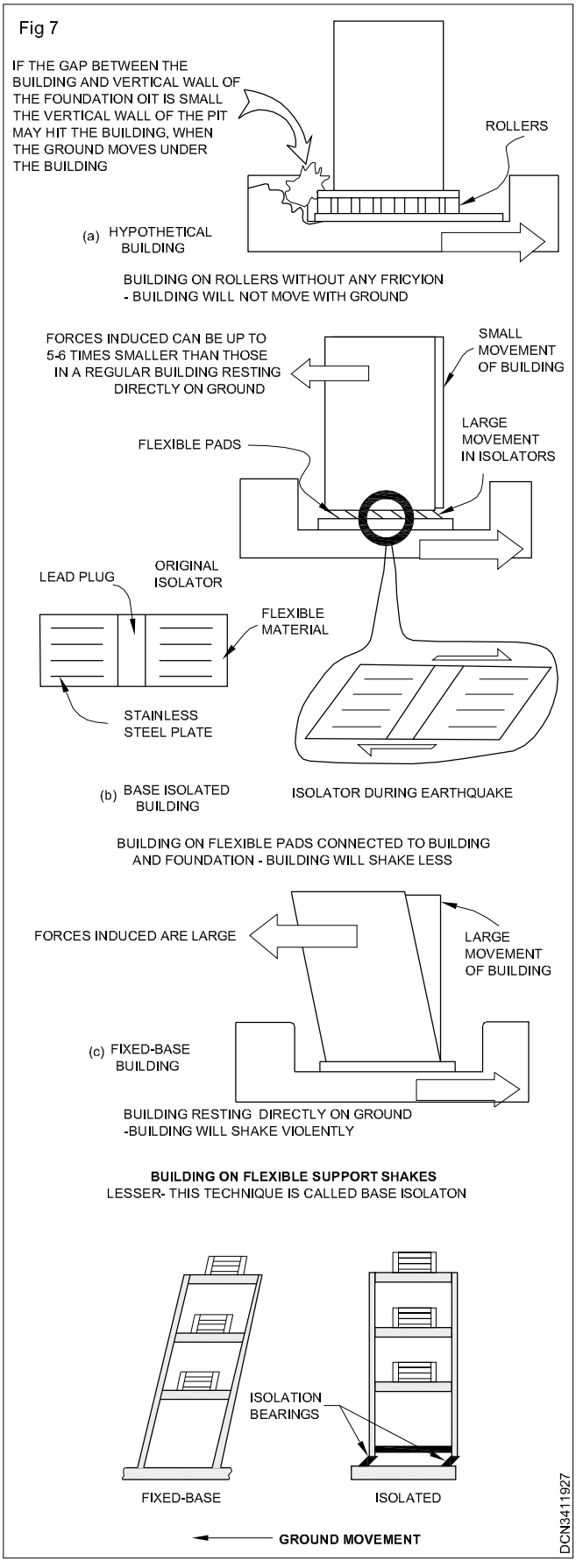
Working principle: Fig 8. shows how this isolation system works. As a result of an earthquake, the ground beneath each building begins to move. In figure 8, it is shown moving to the left. Each building is undergoing displacement towards the right, which is due to inertia. In addition to

Fig 8



LEAD -RUBBER BEARINGS

Fig 7

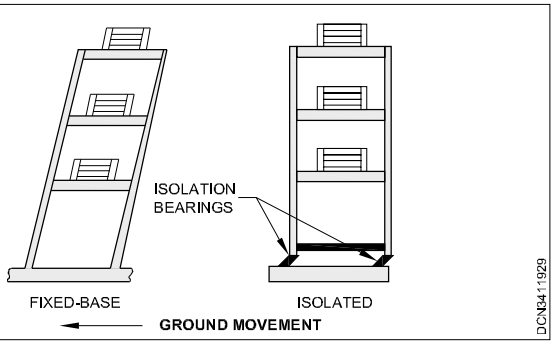


displacing to the right, the un-isolated building is also changing shape into more of a parallelogram from a rectangular. This is the process if deforming. And of course, the primary cause of earthquake damage is deformation which the building goes through as a result of inertial force acting on it.

Response of base isolated buildings

The base-isolated building, though is still displacing, retained it's original rectangular shape. Only the leadrubber bearing supporting the building are deformed. The baseisolated building escaped the deformation and damage-which shows that the inertial forces acting on the base-isolated building have been reduced. Experiments and observations of base-isolated buildings in earthquakes have been shown to reduce building accelerations to as little as ¼ of the acceleration of fixed base buildings. (Fig 9)

Fig 9



Since the rubber isolation bearings are highly elastic, they don't suffer any damage. The lead plug in the middle of the example bearing experience the same deformation as the rubber. However, it also generates heat as it does so. In other words, the lead plug reduces, or dissipates, the energy of motion i.e. kinetic energy-by converting that energy into heat. And by reducing the energy entering the building, it helps to slow and eventually stop the building's vibrations sooner- in other words; it damps the building's vibrations.

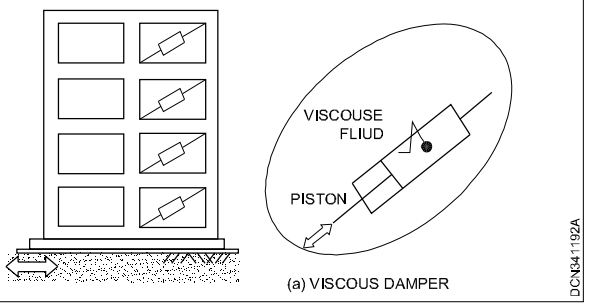
Energy dissipation devices

Another approach for controlling seismic damage in buildings and improving their seismic performance is by installing seismic dampers in place of structural elements, such as diagonal braces. These dampers act like the hydraulic shock absorbers in cars-much of the sudden jerks are absorbed in the hydraulic fluids and only little is transmitted above to the chassis of the car. When seismic energy is transmitted through them, dampers absorb part of it, and thus damp the motion of the building. Commonly used types of seismic dampers includes:

Viscous dampers (energy is absorbed by silicon-based fluid passing between piston cylinder arrangement) (Fig 10)

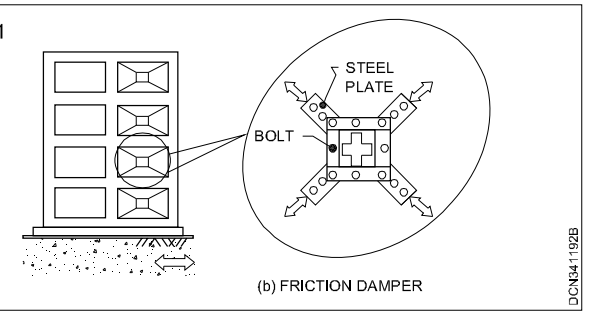
Friction dampers (energy is absorbed by surfaces with friction between them rubbing against each other)

Fig 10



Each of these are suitable for a certain building and are isolated accordingly. (Fig 11)

Fig 11

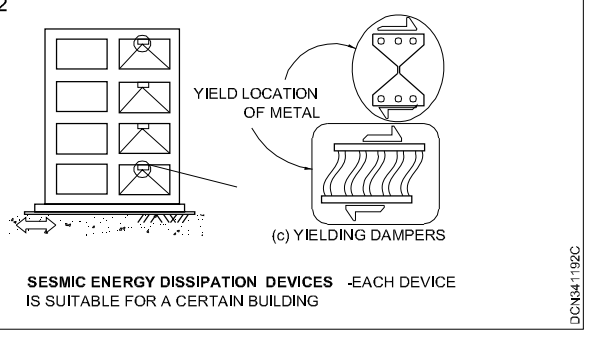


Yielding dampers (energy is absorbed by metallic components that yield) (Fig 12)

Thus by equipping a building with additional devices which have high damping capacity, we can greatly decrease the seismic energy entering the building.

Visco elastic dampers(energy is absorbed by utilizing the controlled shearing of solids)

Fig 12



Working principle

The fluid damper consists of a stainless steel piston with bronze orifice head. It is filled with silicon oil. The piston head utilizes specially shaped passages which alter the flow of the damper fluid and thus alter the resistance characteristics of the damper. Fluid dampers may be designed to behave as a pure energy dissipater or a spring or as a combination of the two.

A fluid viscous damper resembles the common shock absorber such as those found in automobiles. The piston transmits energy entering the system to the fluid in the damper, causing it to move within the damper. The movement of the fluid within the damper fluid absorbs this kinetic energy by converting it into heat.

In automobiles, this means that a shock received at the wheel is damped before it reaches the passengers compartment. In buildings this can mean that the building columns protected by dampers will undergo considerably less horizontal movement and damage during an earthquake.

Active control devices

After development of passive devices such as base isolation and TMD. The next logical steps is to control the action of these devices in an optimal manner by an external energy source the resulting system is known as active control device system. Active control has been very widely used in aerospace structures. In recent years significant progress has been made on the analytical side of active control for civil engineering structures. Also a few models explains as shown that there is great promise in the technology and that one may expect to see in the foreseeable future several dynamic "Dynamic intelligent buildings" the term itself seems to have been joined by the Kajima corporation in Japan. In one of their pamphlet the concept of active control had been explained in every simple manner and it is worth quoting here.

People standing in swaying train or bus try to maintain balance by unintentionally bracing their legs or by relaying on the mussels of their spine and stomach. By providing a similar function to a building it can dampen immensely the vibrations when confronted with an earthquake. This is the concept of Dynamic Intelligent Building (DIB).

The philosophy of the past conventional a seismic structure is to respond passively to an earthquake. In contrast in the DIB which we propose the building itself functions actively against earthquakes and attempts to control the vibrations. The sensor distributed inside and outside of the building transmits information to the computer installed in the building which can make analyses and judgment, and as if the buildings possess intelligence pertaining to the earthquake amends its own structural characteristics minutes by minute.

Active control system: The basic configuration of an active control system consists of three basic elements:

Sensors to measure external excitation and/or structural response.

Computer hardware and software to compute control forces on the basis of observed excitation and/or structural response.

Actuators to provide the necessary control forces.

Thus in active system has to necessarily have an external energy input to drive the actuators. On the other hand passive systems do not required external energy and their efficiency depends on turnings of system to expected excitation and structural behaviors.

The advantage of an active system lies in its much wider range of applicability since the control forces are worked out on the basis of actual excitation and structural behavior.

Conclusion

Earthquakes occur without any prior warning and are, therefore, unpredictable. But, they lead to severe damage to civil engineering structures, bridges, and living things.

Hence, the natural disasters like earthquake cannot be prevented, but measures are required to be taken to reduce the extent of damage.

As a civil engineer, the precautions to be taken such that there is no destruction to structures which are responsible for severe deaths of living things.

The design and construction of structures that are resistant to earthquakes have to be planned very effectively since they affect the building structures and cause severe damage/destruction to living things.

The two recent technologies are base isolation and energy dissipation devices which absorbs the seismic waves during an earthquake are using in the construction of earthquake resistant structures.

The recent technologies have been introduced for safeguarding the life. These improvements of structures however, reduce the damage to the structure but, to some extent only.

Innovative construction and safety against erthquake

Objectives : At the end of this lesson you shall be able to
- **define innovative construction**
- **explain modern method of construction and perceived benefit**
- **explain earthquake safety tips.**

Introduction

To protect and improve the built and natural environment, the government promotes the construction of green and innovative buildings. The objective is to encourage the design and construction of buildings that encompass the following features. Fig 1

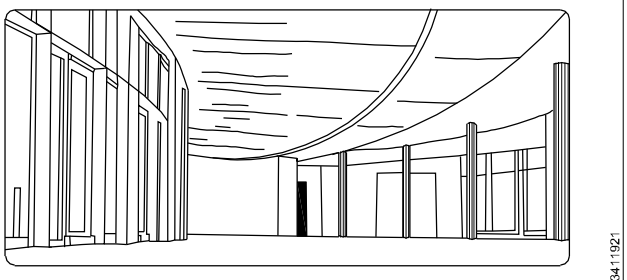
a Adopting a holistic life cycle approach to planning, design, construction and maintenance.

b Maximizing the use of natural renewable resource and recycled/green building material.

c Minimizing the consumption of energy, in particular those non - renewable types, and

d Reducing construction and demolition waste.

Fig 1



BUILDING

DCN3411921

Definition

Innovation is a complex and multidimensional process that has received the attention of researches in all fields due to its contribution to economic growth, competitiveness and quality of life. Innovation in general terms is the creation and adoption of new knowledge to improve the value of products, processes, and services. Innovation in construction services has been recognized as a source of competitive advantage by the policy makers as well as industry practitioners.

The construction industry has always been among the driving forces of the economy, however it has also long been criticised for its lack of efficiency in comparison to other industries and its unwillingness to innovate. The performance of the UK construction industry was analysed in the "Rethinking construction" report (Egan, 1998). In addition to creating a 'movement for innovation' the report described how the construction industry, at its best, displayed excellence and delivered the most difficult and innovative projects.

Innovative construction is defined as

"A construction process that can encompass the use of composite new and traditional materials and components often with extensive factory produced sub-assembly sections and components. This may be in combination with accelerated on - site assembly methods and often to the exclusion of many of the construction industry traditional trades. The process includes new buildings and retrofitting, repair and extension of existing buildings."

Modern methods of construction (MMC)

In the real estate business with companies activity competing for tenants to occupy their buildings to sustain their income flow and maximise profits the development of new attractive modern buildings using innovative construction materials and techniques can provide a real market advantage. Consequently designers of buildings are under tremendous pressure to reduce erection and manufacturing costs and to consider sustainable materials that offer sufficient thermal insulation properties, whilst still producing aesthetically pleasing buildings.

To achieve this many new and innovative methods of construction are being adopted and the use of modern methods of construction (MMC) is becoming increasingly prevalent. However, from a risk engineering and insurance perspective the introduction of new materials and innovative construction techniques can create uncertainly about the risk posed and the performance of these buildings in the longer - term.

Perceived benefits of MMC

Some of the perceived benefits of MMC are:

- Improved quality control of components produced under factory controlled conditions.
- Services (eg. electrics, plumbing) can be pre - planned and either fully or partly pre - installed for final connection on site.
- Faster construction times on site.
- Fewer workers required on site and for shorter periods.
- Less wastage of materials.

Current and emerging methods of construction

This section highlights some of the new and innovative building products and methods of construction being encountered now and which are becoming increasingly common. These new methods tend to involve extensive factory production of sub- assembly sections and components in combination with accelerated on - site assembly methods. The methods can broadly be separated into two distinct areas.

1 Superstructure components

- Volumetric or modular construction
- Pods
- Panellized
- Hybrid
- Timber framed
- On - site manufacture

2 Lightweight cladding systems

- Brick slip
- Rain screen
- Render systems
- Timber
- Concrete
- Tile hanging
- Steel

The preceding is by no means an exhaustive list with new materials and construction techniques continually being developed and evolving. However, the following sections will provide a little more insight into each of the preceding.

Superstructure components

Volumetric

Factory produced three - dimensional units that are then transported to site and bolted together. The frames will normally be steel, timber or concrete and can be supplied with all external and internal finishes (including services such as electrics and plumbing), or solely the basic structure. Unlike pod construction, volumetric does not require a superstructure. Examples include: hotels, students accommodation, fast food restaurants.

Pods

Factory produced three - dimensional elements that are incorporated into the superstructure of a building. These are ready made rooms which can be pieced together to make complete premises when set within a light steel framework. All the building services will typically be pre installed with just the final connection made on site. Examples include: hotel bathrooms, kitchen units for accommodation blocks.

Panellized

Factory produced flat panel units transported to site for assembly. Typically these would form the exterior walls of the building - they can be load - bearing (ie. providing structural support) or non - load- bearing. They can be made of timber, light gauge steel, structurally insulated panels (SIPs), concrete or non - structural in-fill walling used to create the whole building. They can be used for virtually any type of building.

Hybrid

These structures combine both volumetric and panellised approaches within the same building and are also known as semi - volumetric.

Timber framed

Timber framed buildings have been around for hundreds of years, however, the concept is now being used to create some much larger and more innovative structures that have been previously. Examples include: apartment blocks and retail shed type buildings where it is sometimes used to support the roof in combination with steelwork. There have been some very large fires involving timber framed buildings while under construction leading to their total destruction.

On - site manufacture

Site based assembly methods include the use of traditional components but in innovative designs including the establishment of manufacturing facilities at construction sites. An example of this is aircrete planks that have the strength of concrete but whose micro cellular structure is low in unit weight.

Lightweight cladding systems

These are external finishes that link well with off-site manufacturing systems due to their low structural loadings and speed of installation.

Brick slips

Individual brick slices that are fixed vertically by adhesive. Normally brick slips will be glued to plastic wall facing sheet though they are also available in larger panels that are hung onto the superstructure.

Rain screen

These are weatherproof external coverings that are easily fixed to factory produced framework attached to the building and can be made from metals, ceramics, granite, terracotta, vitreous enamel, laminates and timber. Insulation material may be present behind the cladding.

Render systems

Render is an external covering applied to the outside of a building, usually directly on to bricks, blockwork, boards, or insulation. It is normally made from limestone, cement and polymers and can be produced in a wide variety of colours and finishes. The actual render is non combustible, but the covered material to which it is applied can often be combustible (eg. foam plastic insulation).

Timber cladding

Although a traditional building material the use of timber cladding has become increasingly common in recent years alongside the desire for increased use of sustainable building materials. For new commercial buildings it is commonly used in combination with other cladding systems, although it can form the majority of the external area of the building.

External insulated finish systems (EIFS)

These systems involve attaching insulation material directly to an external wall that is then covered with a render or other type of finish such as tiles, metal or brick. There are ventilated and non - ventilated systems, the former having an air gap between the insulation and the exterior covering. The insulation used is very often a foam plastic material (eg. expanded polystyrene) which is highly combustible when exposed to fire.

Risk and insurance considerations

As many of these method and forms of construction are new there is a level of uncertainly how they will perform over time and the impact that might arise on the frequency and size of loss. Issues which need to be considered in relation to MMC buildings include.

- The use of lightweight and combustible materials may allow a greater degree of fire spread leading to increased claims costs. Similarly the use of combustible materials externally may increase potential for damage from external fires whether deliberate (arson) or accidental.
- Where component parts are fixed together (notably modules and pods), there may well be hidden voids through which smoke and water can permeate throughout the building, leading to even a small incident causing a disproportionately high loss.

- Because many MMC systems are new and innovative, the contractors may have no previous experience of the materials and assembly techniques required. This may actually lead to a poorer quality finish than if more traditional methods had been used.
- Repairs may be more or less straightforward. For example if a building is constructed of pods and one of these is damaged the pod may not be able to be repaired in situ but may need to be removed and replaced causing disruption to and removal of the surrounding pods and external finishes thus increasing the replacement costs and times.
- There may be increased risks of water damage and storm losses due to the materials used and the effects of wear and tear over time. Also, the ability of many MMC materials to withstand the effects of flooding is unknown in many cases.
- There may be problems in obtaining replacement components in future, especially in the event that manufactures go out of business.

Safety against earthquake

Earthquake safety tips to follow

Emergency kit and disaster plan are important

Earthquakes are not a frequent occurrence. However, they can be very disruptive because they occur suddenly and tend to affect large areas. Earthquakes can be a one time event of a few seconds shaking or a series of events of varying duration.

Because earthquakes happen without warning, being prepared in advance is critical to minimize damages and loss. Consider these earthquake safety tips

Before an earthquake

- Know your risk. Research the area and find out if you live near an active fault line and whether or not the ground around you is more susceptible to the effects of an earthquake.
- Retrofit and reinforce your house. If you're in a high risk area, take steps to reinforce your house. Bolt your house to the foundation and reinforce support beams as needed. Secure any furniture such as bookshelves and cabinets to the walls to minimize risk of falling over during a quake. Secure cabinet doors to help keep dishes and other contents from falling out.
- Create a disaster plan to protect yourself and your family. Earthquake preparedness can help reduce anxiety and minimize injury. Know where to take cover in your house and how to communicate with other family members after the earthquake if you're not together. Designate a safe place to meet outside of the house after the shaking stops.
- Put together an emergency kit. Your kit should include non- perishable food, water, first aid supplies, flashlights, camping supplies (stove, battery - powered lantern, etc). extra batteries, blankets and any personal items you may need (medications, toiletries, clothing). If you have pets, make sure they also have adequate supplies. Plan for a week's worth of supplies for each person. You'll need at least four gallons of drinking water per person for a week.
- Be prepared to act. Know how to act so your response is automatic. Identity safe places in your work area to 'Drop, cover and hold on'. Know at least two ways to exit the building safely after an earthquake.
- Stock up on emergency supplies. Keep the basics: Flashlight, first - aid kit, whistle, gloves, goggles, blankets and sturdy shoes. Coordinate supplies with your work group or department. Plan as if food and water may not be available for about 24 hours and other supplies for up to 3 days.
- Arrange your work area for safety. Make sure that bookcases, large file cabinets and artwork are anchored. Store heavy objects on low shelves. Store breakable objects in cabinets with latches. Use normal work order process to get furniture anchored.

During an earthquake

- Stay away from windows and furniture that could potentially fall over. One of the biggest hazards during an earthquake is falling debris and furniture. Avoid areas in your house where you might be exposed to these hazards.
- Take cover in a safe place in your house. Get under a sturdy table or desk to avoid being hit by anything. If you can't take safe cover, protect your head and neck with your arms.
- Do not try and go outside until after the shaking stops. If you are already indoors, you are safer taking cover inside than attempting to leave your house during an earthquake you could be hit by falling debris as you're trying to get out.
- Remain calm as the quake occurs - others will respond to your actions. A cool head can prevent panic. If you are indoors when the shaking occurs, stay there. Move away from windows and unsecured tall tall furniture. Drop, cover and hold on under a desk, a table or along an interior wall. Protect your head, neck and face. Stay under cover until the shaking stops and debris settles.
- If you are outdoors, move to an open area away from falling hazards such as trees, power lines, and buildings. Drop to the ground and cover your head and neck.

After an earthquake

- Be prepared for aftershocks. Earthquakes are often followed by aftershocks additional quakes that follow the main event. These can last for days or even weeks after a major earthquake.

- Check your gas lines and make sure there are no leaks. If you smell gas leaking, turn off the gas if possible and call the gas company. Do not use an open flame in your house until you are sure it is safe. Wait for the gas company to turn the gas back on.
- Check for damaged electrical wiring. Shut off the power if you see damaged wiring in your house.
- Keep your shoes on. You may have broken glass or spilled chemicals on the floor of your house as a result of the earthquake. Don't walk around barefoot until you're sure the floor is clean and safe.
- Document the damage. If your insurance policy covers earthquake damage, make sure you take photos or video of the damage to use in the claim process.
- Remain calm and reassuring. Check yourself and other for injuries. Do not move injured people unless they are in danger. Use your training to provide first aid, use fire extinguishers, and clean up spills. In laboratories, safely shut down processes when possible.
- Expect aftershocks. After large earthquakes, tremors and aftershocks can continue for days.
- Be ready to act without electricity or lights. Know how to move around your work area and how to exit in the dark. Know how to access and use your emergency supplies. Be aware of objects that have shifted during the quake.
- If you must leave a building, use extreme caution. Continually assess your surroundings and be on the lookout for falling debris and other hazards.Take your keys, personal items and emergency supplies with you if safe to do so. Do not re - enter damaged buildings until an all - clear is given.
- Use telephones only to report a life-threatening emergency. Cell and hard - line phone systems will be jammed. Text messages take less band width and may go through when voice calls can't be made.

Introduction to R.C.C uses materials and proportion

Objectives : At the end of this lesson you shall be able to
- **define R.C.C**
- **state advantages of R.C.C**
- **list out materils used in R.C.C**
- **explain grade of cement**
- **explain reinforcement materials**
- **explain bending of bars**
- **state the testing of steel reinforcement**
- **calculate bending moment and shear force.**

Introduction

Concrete may be defined as a building material obtained by mixing cement, aggregates and water in a suitable proportion which when allowed to cure, becomes hard like a stone. The proportion of ingredients varies with the nature of work for which the concrete is to be used. It can be readily moulded into durable structural items of various size and shapes. This mixed concrete is strong in compression but weak in tension.

Reinforced cement concrete (R.C.C) is the above said mixture of cement concrete with addition of reinforcement in it. The plain concrete is weak in tension, so steel reinforcement is added to make it strong both in compression and tension. The resulting product of cement, aggregates, water and steel reinforcement is called reinforced cement concrete.

Definition

Concrete is a brittle material and is strong in compression. It is weak in tension, so steel is used inside concrete for strengthening and reinforcing the tensile strength of concrete. The steel must have appropriate deformations to provide strong bonds and interlocking of both materials. When completely surrounded by the hardened concrete mass in forms an integral part of the two materials, known as “reinforced concrete”.

Reinforced concrete is a structural material widely used in many types of structures. It is competitive with steel if economically designed and executed.

Advantages of reinforced concrete

- Reinforced concrete also has greater compressive strength as compared to most other materials used for construction besides good in tension.
- It has better resistance to fire than steel and capable of resisting fire for a longer time.
- It has long service life with low maintenance cost.
- In some types of structures, such as dams, piers and footings, it is the most economical structural material.
- It can be cast to take the shape required, making it widely used in pre - cast structural components.
- It yields rigid members with minimum apparent deflection.
- Yield strength of steel is about 15 times the compressive strength of structural concrete and well over 100 times its tensile strength.
- By using steel, cross sectional dimensions of structural members can be reduced e.g in lower floor columns.
- Less skilled labor is required for erection of structures as compared to other materials such as structural steel.

Disadvantages of reinforced concrete

- It needs mixing, casting and curing, all of which affect the final strength of concrete.
- The cost of the forms used to cast concrete is relatively high.
- It has low compressive strength as compared to steel (the ratio is about 1:10 depending on material) which leads to large sections in columns/beams of multistory buildings cracks develop in concrete due to shrinkage and the application of live loads.

Materials used in R.C.C

1 Cement

Generally any of the following cements is used for R.C.C

a Ordinary or low heat portland cement conforming to IS: 269.

b Rapid hardening portland cements conforming to IS: 8041.

c Portland slag cement conforming to IS: 455.

d Portland pozzolona cement conforming to IS: 1489.

e High strength ordinary portland cement conforming to IS: 8112.

f Hydrophobic cements conforming to IS: 8043.

g High alumina cements conforming to IS: 6452.

h Super sulphated cement conforming to IS: 6909.

2 Fine aggregate

The aggregate which passes through IS sieve no.480 is called fine aggregate. The particle size of this aggregate does not exceed 4.75 mm. Fine particles passing though the sieve no. IS: 15 should not exceed 8%. Sand and sieved quarry dust are usually using as fine aggregate. It should be free from silt clay, salts and other organic matter and it should be conforming to IS: 383.

3 Coarse aggregate

The aggregate, which is retained over, sieve no. IS: 480 are called coarse aggregate. The size of this aggregate depends upon the type and nature of work. It should be free from clay, clods and other organic matter. It should not have glossy surface. It should not be soft, porous or flaky. It should not absorb more than 5% of water by weight when immersed in 24 hours and in all aspects it should be conforming to IS: 383.

4 Water

Water used for making concrete should be free from dirt, organic impurities, sulphur contamination and chlorides which cause efflorescence. The clear water used for drinking purpose (IS: 14543) should be used. The pH value of water should be between 6 and 8. Mixing or using of concrete with seawater is not recommended because of presence of harmful salts in seawater.

5 Reinforcement

Reinforcement shall be any of the following

- Mild steel and medium tensile steel bars conforming to IS: 432.
- Hot rolled deformed bars conforming to IS: 1139.
- Cold twisted bars conforming to IS: 1786.
- Hard - drawn steel wire fabric conforming to IS: 1566.
- Rolled steel made from structural steel conforming to IS: 226.
- All reinforcement shall be free from mill scales, loose rust and coats of paints, oil, mud or other coatings, which destroy or reduce bond.

Grades of concrete

The concrete shall be in grades M5, M7.5, M10, M15, M20,M25,M30,M35 and M40. In the designation of concrete grade, letter M refers to the mix and the number to the specified characteristic compressive strength of 15 cm cube after 28 days, expressed in N/mm2. Grades of concrete lower than M15 shall not be used in R.C.C.

Nominal Proportion for different Grades

Grade	Proportion			Quantity of water in litres per 50 kg of cement
	Cement	Fine aggregate	Coarse aggregate	
M5	1	5	10	60
M7.5	1	4	8	45
M10	1	3	6	34
M15	1	2	4	32
M20	1	1.5	3	30
M25	1	1	2	28

Grade of cement

For engineering purposes, there are many types of cement but in general, 'ordinary portland cement' (OPC) which is available in three grades should be used for house construction.

33 grade ordinary portland cement

This ordinary 'portland' cement is used widely in the country. It is more suitable cement for masonry and general concrete works where the members are not taken to very high stresses. It is not suitable where 'sulphate' is in the soil or in the ground water.

43 Grade ordinary portland cement

43 grades of cement are used where high early strength in 1 to 28 days range is required. These days the 'structural engineers' propose this cements mainly for RCC works where each structural member takes high tensile stress.

53 grade ordinary portland cement

53 grades of cement are used where high early strength in 1 to 28 days range is required. These days 'structural engineers' propose these cements mainly for RCC works where a member takes high tensile stress.

Caution in the use of 53 grade cement in construction

The strength of 53 grade cement does not increase much after 28th day because of early gain while 33 grade cement continues to gain strength after 28th day.

In addition, due to faster hydration process, the concrete releases heat of hydration at much faster rate initially and release of heat is the highest in case of 53 grades. The heat of hydration being higher, the chances of micro cracking of concrete is much greater. Thus during initial setting period of concrete, the higher heat of hydration can lead to the damage of micro-cracking within the concrete which may not be visible at surface.

This cracking is different from shrinkage or cracks which occur due to faster dryness of concrete in windy conditions. The situation can be worse when we tend to increase the quantity of the cement in concrete with a belief that such increments are better for both strength and durability of concrete.

Thus it is very essential to be very careful in advance that higher grade cement specially grade 53 should be used only where such use is warranted for making the concrete of higher strength and also where precautions are taken to relieve the higher heat of hydration through chilling of aggregates. (Grade refers to the strength of cement at 28 days, when tested as per IS: 4031 - 1988). If the 28 days strength is less than 33N/mm2, it is called 33 grade cement. If the 28 days strength lies between 33 to 43 N/mm2, it is called 43 grade cement. If the 28 days strength is lies between 43 to 53 N/mm2, it is called 53 grade cement.

Reinforcement: The material which can be used as reinforcement in R.C.C. work should have the following characteristics:

1 It should be able to develop perfect bond with concrete.

2 Its co-efficient of thermal expansion should be nearly same as that of concrete.

3 It should have high tensile strength.

4 Concrete should not produce any harmful effect on the embedded material.

5 It should be easy to cut, bend, bind or weld.

6 It should be easily available.

It is seen that steel meets all the above requirements and as such it is the only material which is used on large scale in R.C.C works.

The various types of steel that are commonly used for making different forms of reinforcement are mild steel, medium tensile steel, high tensile steel and hard drawn steel. These differ from each other in their chemical composition and other properties like, ultimate tensile strength, yield points etc.

The various forms in which steel is used as reinforcement in R.C.C work are: round bars, deformed bars, twisted bars, square bars and flats. Sometimes expanded metal fabric or fabric made by welding or weaving steel wire in the form of oblong or square mesh are also used as reinforcement in slabs, shells and concrete roads. For works of large dimensions like massive foundations, etc., sections like rolled steel beams, channels or angle iron are also used as reinforcement.

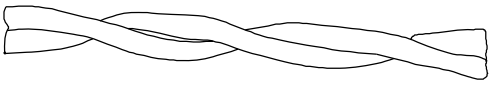
Mild and medium tensile steel bars of round section are most commonly used in R.C.C work. The diameter of round bars (in mm.) used in normal building work are:

6,8,10,12,16,18,20,22,25,28,32,36 and 40

Bars of greater diameter, i.e., 45 mm. and 50 mm., are only used in exceptionally heavy foundations, large girders, or counterforts etc.

With the introduction of deformed bars and twisted bars, the use of plain round bars is gradually declining. Deformed bars or high yield strength deformed bars (HYSD) are furnished with lugs, ribs or other form of surface deformations for the purpose of increasing their bond strength with concrete. (Fig 1)

Fig 1



TWIN TWISTED BARS

DCN3512411

It is seen that the process of twisting a plain or a deformed bar results in the following improvements in its properties:

- Considerable increase in yield stress.
- Increase in tensile strength.
- Increase in bond strength.

Twisted plain or deformed bars not only have high yield stress but also have bond strength which is 40% more than that of plain round bars. On account of increased bond strength such bars do not need end hooks, and require reduced length for overlaps etc. thereby effecting reduction in the cost of reinforcement and labour.

Permissible stresses in reinforcement: The permissible stresses in steel reinforcement as per IS: 456 - 1978 are given in table 1.

HYSD bars having yield stress (0.2% proof stress) equal to 415 N/mm^2 and permissible tensile stress equal to 230 N/mm^2 are exceedingly being used in R.C.C. work. These bars are also commonly known as Fe 415 HYSD bars.

In case of structures requiring use of still higher tensile strength of reinforcing bars, another form of HYSD bars known as Fe 500 HYSD are used. These bars have a yield stress equal to 500 N/mm^2 and have permissible tensile stress equal to 275 N/mm^2.

It is observed that HYSD bars when used in combination with high strength concrete i.e. M20 and above prove to be more economical.

Characteristic strength of steel reinforcement

The term characteristic strength of steel reinforcement means that value of the strength of steel below which not more than 5% of the test results are expected to fall. The characteristic strength of different type of steel reinforcement or (fy) is taken as the value of the minimum yield stress (or 0.2% proof stress) for the type or grade of steel used in the manufacture of the reinforcement. The value of (fy) or the characteristic strength for three commonly used type of reinforcing bars are given in table 2.

Table 1 - Permissible stresses in steel reinforcement

Types of stress in steel reinforcement	Permissible stresses		
	Mild steel bars conformating to grade I of IS:432 (Part I) - 1966 or deformed mild steel bars conforming to IS:1139 - 1966	Medium tensile steel conforming to IS: 432 (part I) 1966 or deformed medium tensile steel bars conforming to IS: 1139 - 1966	High yield strength deformed bars conforming to IS: 1139 - 1966 or IS: 1786 - 1979 (Grade Fe 415)
1	2	3	4
1 Tension (σ_{st} or σ_{sc})			
a Upto and including 20 mm	140N/mm^2	Half the guaranteed yield stress subject to a maximum of 190 N/mm^2	230 N/mm^2
b Over 20 mm	130N/mm^2		230 N/mm^2
2 Compression in column bars (σ_{sc})	130 N/mm^2	130 N/mm^2	190 N/mm^2
3 Compression in bars in a beam or slab when compressive resistance of concrete is taken into account.	The calculated compressive stress on the surrounding concrete multiplied by 1.5 times the modular ratio or σ_{sc} which ever is lower.		
4 Compression in bars in a beam or slab where the compressive resistance of concrete is not taken into account.			
a Upto and including 20 mm.	140N/mm^2	Half the guaranteed yield stress subject to a maximum of 190 N/mm^2	190 N/mm^2
b Over 20 mm.	130N/mm^2		190 N/mm^2

Note 1: For high yield strength deformed bars of grade Fe 500, the permissible stress in direct tension and flexural tension shall be 0.55 fy. The permissible stresses for shear and compression reinforcement shall be as for grade Fe 415.

Note 2: For welded wire fabric conforming to IS: 1566 - 1967 the permissible value in tension sst is 230 N/mm2.

Note 3. The yield stress of steels for which there is no clearly defined yield point should be taken to be 0.2 percent proof stress.

Note 4: When mild steel conforming to grade II of IS: 432 (part I) - 1966 is used, the permissible stresses shall be 90 percent of the permissible stresses in column 2 above or if the design details have already been worked out on the basis of mild steel conforming to grade I of IS 432 (part I) - 1966, the area of reinforcement shall be increased by 10 percent of that required for grade I steel.

Handling of reinforcement at site

Whatever be the magnitude of R.C.C. work, it is necessary to prepare a bar bending schedule based on the structural drawing prior to start of handling reinforcement at site.

Bar bending schedule is a descriptive list containing details regarding the exact bending shape, dimension and diameter of each and every bar together with the number of bars of each shape.

Bars are cut to the desired lengths and then bent cold in accordance with the details given in bar bending schedule. Before placing the bars in position in the formwork it is necessary to ensure that the reinforcement is clean and free from, loose mill scale, loose rust, oil or other coating. This precaution is necessary to meet the requirement of good bond between concrete and steel for monolithic behaviour.

The reinforcement should be placed accurately in position and maintained in position by tying bars at junction with binding wire or by welding. To ensure proper cover to reinforcement, small precast cover blocks made out of cement mortar are used. The cover blocks are inserted below the reinforcement mesh and tied to it with the help of binding wire, prior to concreting. In addition, precaution should be taken to prevent the displacement or distortion of reinforcement during concreting.

Table 2 - Characteristic strength of steel reinforcement

S.N.	Types of reinforcement	Yield stress or 0.2% proof stress	Characteristic strength (F_y)	Permissible tensile strength σ_{st}
1	Mild steel bars conforming to grade 1 of IS:432 (Part 1) or deformed m.s. bars conforming to IS: 1139.	250 N/mm^2 (average)	250 N/mm^2	140 N/mm^2 (for bars upto 20 mm ϕ) 130 N/mm^2 (for bars over 20 mm ϕ)
2	High yield strength deformed bars (HYSD bars) conforming to IS: 1109 or grade Fe 415 of IS: 1786.	415 N/mm^2	415 N/mm^2	230 N/mm^2
3	High yield strength deformed bars conforming to grade Fe 500 of IS:1786.	500 N/mm^2	500 N/mm^2	275 N/mm^2

Reinforcement shall be any of the following:

a Mild steel and medium tensile steel bars conforming to IS: 432.

b Hot rolled deformed bars conforming to IS: 1139.

c Cold twisted bars conforming to IS:1786.

d Hard - drawn steel wire fabric conforming to IS: 1566.

e Rolled steel made from structural steel conforming to IS: 226.

f All reinforcement shall be free from mill scales, loose rust and coats of paints, oil, mud or other coatings, which destroy or reduce bond.

Types of reinforcement steel (Figs 2-16)

In R.C.C works steel reinforcement may be used in the form of plain round bars deformed bars, twisted bars, and square bars or flats. According to chemical composition and other properties like yield point, ultimate strength etc. steel is divided into.

1 Mild steel (Fe 250)

Grade -I (IS:432)

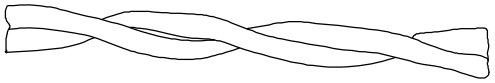
Grade -II (IS:432)

2 Medium tensile steel (IS:432)

3 High yield strength deformed bars (Fe 415) (IS: 1139).

Twisted bars are nothing but mild steel bars whose quality has been improved by various processes of cold working and have improved its yield stress is about 50% more than that for ordinary mild steel bars. The ribs, legs and deformations on their surface increase the bond strength.

Fig 2



TWIN TWISTED BARS

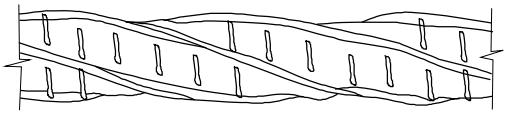
DCN35124412

Fig 3

RIBBED TORSTEEL

DCN35124413

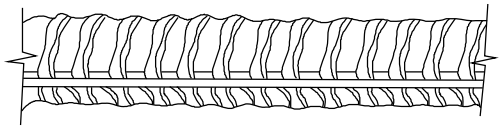
Fig 4



GRIP BAR

DCN35124414

Fig 5



TRSTRONG BAR 1 & 2

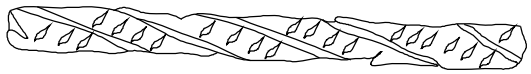
DCN35124415

Fig 6

TISCON 42 , 12 MM , 2 RIBS

DCN35124416

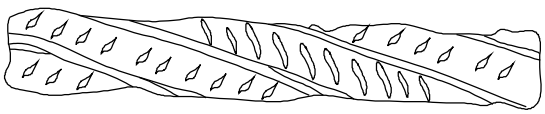
Fig 7



TISCON 42 , 12 MM , 4 RIBS

DCN35124417

Fig 8



TISCON 42 , 20 MM , 4 RIBS

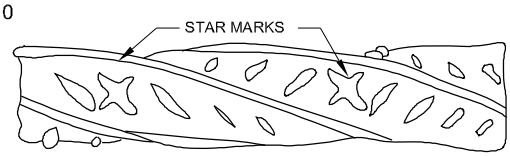
DCN35124418

Fig 9

TISCON 50 , 12 MM , 2 RIBS

DCN351241I9

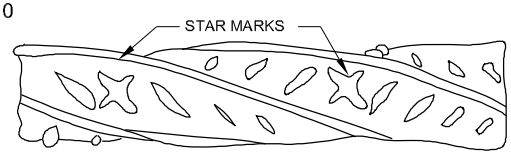
Fig 10



TISCON 50 , 20 MM , 4 RIBS

DCN351241A

Fig 10



TISCON 50 , 20 MM , 4 RIBS

DCN351241A

Fig 11

CIRCULAR BAR

DCN351241B

Reinforced materials

1 **Deformed bars:** There are bars whose surface is roughened to increase the resistance to slipping between the bar and the concrete. These have same types of corrugation or projections on their surface which check the slipping.

2 **Twisted bars:** The quality of steel bars can be improved by the use of various processes or working. One of these methods is if twisting of bars. Twisting of bars may be singly or doubly is shown in figure. During the double as twin twisting the length of combined bar will be shortened. The effects of twisting are as follows"

i A considerable increase in the yield strength of bar.

ii A slight increase in ultimate tensile stress.

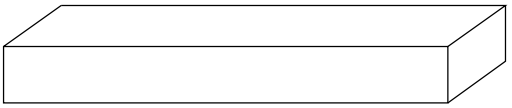
iii Considerable decrease in the ultimate elongation.

Do the yield stress is increased by 50% or more and thus the working stresses are also increased proportionality and it results by 33% or so. The steel used as reinforcement shall conform with IS:456.

I.S. Codes

Indian standard codes have been prepared to be used for the construction of various structures. On such code IS: 456 which deals with construction of reinforced cement concrete structures. Various specification to be adopted for steel and concrete are laid down in the code for guidance. While designing the R.C.C structures these codes are followed.

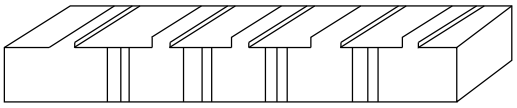
Fig 12



SQUARE BAR

DCN351241C

Fig 13



SQUARE BAR WITH INDENTATIONS

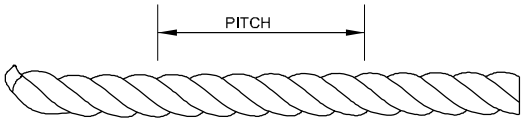
DCN351241D

Fig 14

TWISTED BAR

DCN351241E

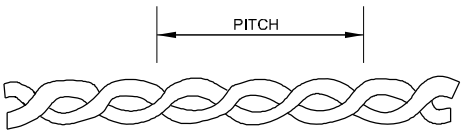
Fig 15



SINGLE - SQUARE TWISTED BAR

DCN351241F

Fig 16



TWIN TWISTED BAR

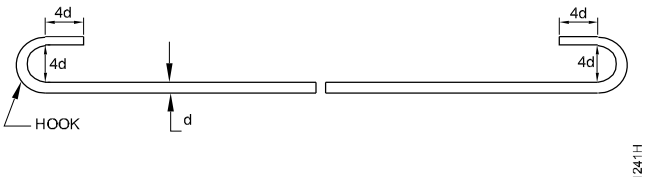
TWISTED BARS

DCN351241G

Bending of bars

In case round bars are used as reinforcement in concrete, hooks at the ends are provided. Provision of hooks, bends and laps etc. are shown in fig 17 & 20.

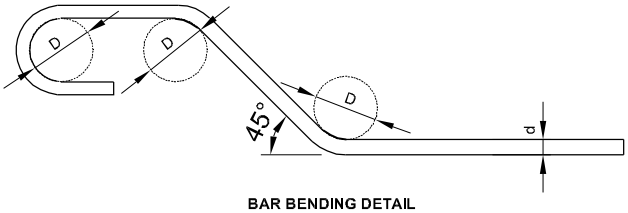
Fig 17



STRAIGHT BAR

DCN351241H

Fig 18



BAR BENDING DETAIL

DCN351241I

Fig 19

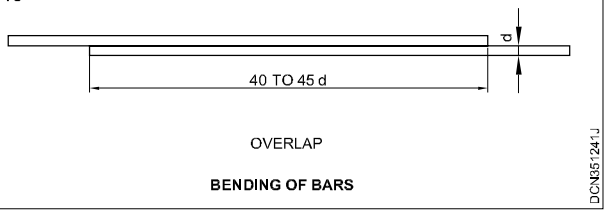
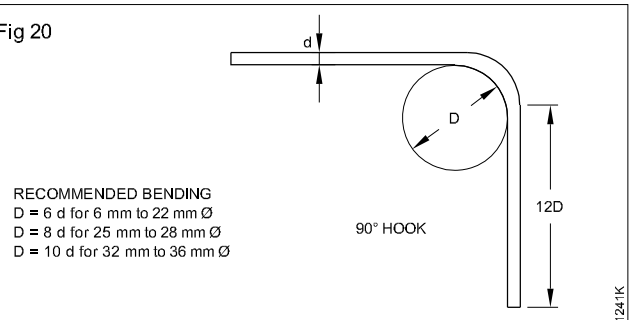


Fig 20



Cover in reinforcement

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

Clear cover at the ends of bars = Not less than twice the dia of bars but minimum 25 mm.

Clear cover of slabs = 15 mm or dia of bar whichever is more

Clear cover of beams = 25 mm or dia of bar whichever is more

Clear cover for columns = 40 mm or dia of longitudinal bar whichever is more

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 thickness may be increased.

Symbols and conventions

a Abbreviations relating to shape of bars: These are to indicate the general shape of reinforcing bars.

Alt Alternate bar

Bt Bent bar

B Bottom bar

T Top bar

St Straight bar

Stp Stirrup

Sp Spiral

Ct Column tie

Min Minimum

Max Maximum

b Abbreviations relating to structural members: These are used in the key plan for easy identification of members.

Bm or B Beam (S)

Col Column (S)

FG Footing (S)

GR Girder (S)

JT Joint (S)

LL Lintel (S)

LB Lintel beam (S)

Sb or S Slab (S)

WL Longitudinal wall

Wx Cross wall

£ Centre line

c Symbols for type and size of reinforcement: These are used distinguishing between plain, square or deformed bars used in a structure.

□ Plain round bar or diameter of plain round bar

ø Plain square bar or side of plain square bar

Deformed bar, or square twisted bar or its nominal size

d Symbols relating to position and direction of reinforcement: These indicate the limits and direction of particular bars used in structural elements.

EW Each way.

@ Spacing centre to centre.

Limit of area covered by bars.

Direction in witch bars extend.

e Examples denoting reinforcement: These form the most important symbols used against each type of reinforcement indicated in a drawing.

16 @ 150

(16 mm DIA PLAIN BARS SPACED AT

150mm CENTRE TO CENTRE)

20@ 250

(20mm DIA DEFORMED BARS SPACED AT

250mm C.C)

f Some drawing conventions in R.C.C detailing (Fig 21)

Each symbol is to be pointed by an arrow and the details of bars denoted as given in (e).

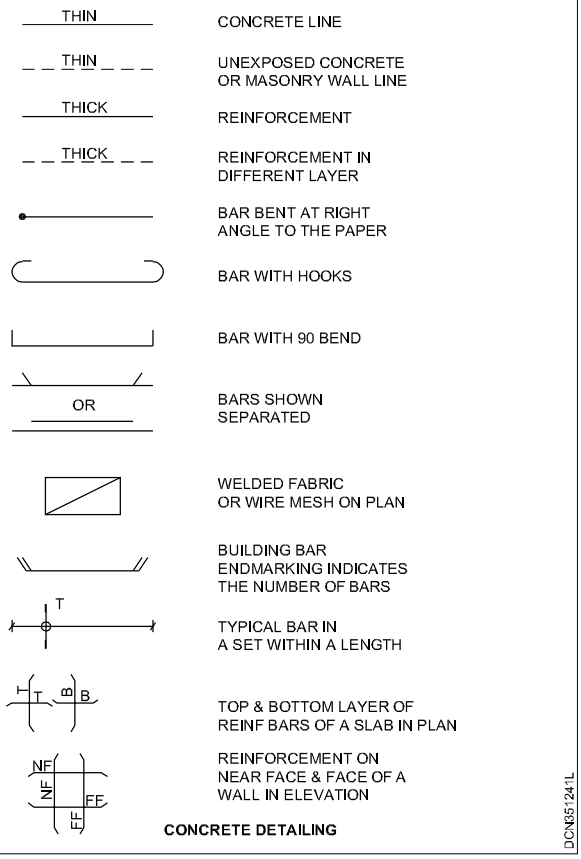
Testing of steel reinforcement

Steel reinforcement shall be produced under a permanent system of routine inspection and testing.

The testing is done to determine the yield point, ultimate strength, percent elongation, bend and weight per meter.

The universal tensile test is to determine the strength of materials. During the test, the specimen, elongation reduction and applied load are measured, tensile stresses and strain are calculated from the result. After the material break, the final length and cross sectional area of specimen is used to calculate the percentage of elongation and percentage of reduction.

Fig 21



The rate of testing shall be as follows:

- For chemical composition, one analysis per test unit. The chemical composition (cast analysis) of the steel reinforcing bar shall have been determined by the QA manufacturer. (Quality assessment manufactures)
- For rebend tests and nominal mass per metre, one test specimen per test unit and nominal diameter.
- For surface geometry, one test specimen per test unit and nominal diameter. Alternatively, beam test with the same rate of testing may be used.
- For tensile tests, one test specimen per 30 tonnes with at least three test specimens per test unit and nominal diameter.

Bending moments and shearing forces

Introduction

When any structure is loaded, stresses are induced in the various parts of the structure, and in order to calculate the stresses, where the structure is supported at a number of points, the bending moments and shearing forces acting must also be calculated. In general, a structure may be considered to consist of a series of beams, linked together in some way, and further, the complete structure may be treated as a beam with an elaborate cross-section. Calculations can be made progressively first on the structure as a whole and then on the individual parts.

Some basic definitions

Beam: Beam is a structural member which is acted upon by a system of external loads at right angles to the axis.

Bending: Bending implies deformation of a bar produced by loads perpendicular to its axis as well as force - couples acting in a plane passing through the axis of the bar.

Plane bending: If the plane of loading passes through one of the principal centroidal axes of the cross-section of the beam, the bending is said to be oblique.

Point load: A point load or concentrated load is one which is considered to act at a point. In actual practice, the load has to be distrubuted over a small area because such small knife-edge contacts are generally neither possible notr desirable.

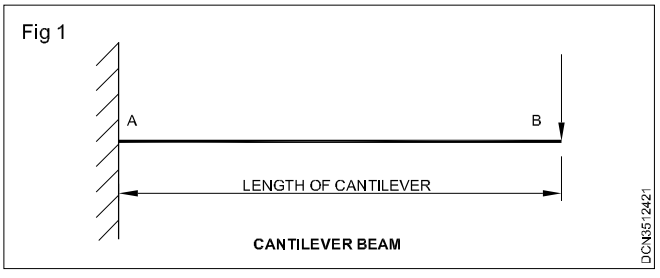
Distributed load: A distributed load is one which is distributed or spread in some manner over the length of the beam. If the spread is uniform (i.e. at the uniform rate, say w kN/metre run) it is said to be uniformly distributed load and is abbreviated as U.D.L. If the spread is not at uniform rate, it is said to be non-uniformly distributed load, triangular and trapezium distributed loads takes under this category.

Classification of beams

Depending upon the type of supports beams are classified as follows:

1 **Cantilever:** A cantilever is a beam whose one end is fixed and the other end free. Fig 1 shows a cantilever with end A rigidly fixed into its support and the other end B free. The length between A and B is known as the length of cantilever.

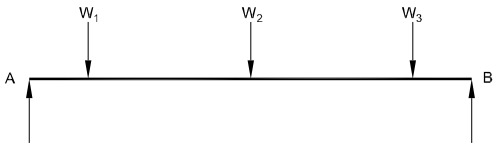
Fig 1



2 **Simply (or freely) supported beam:** A simply supported beam is one whose ends freely rest on walls or columns or knife edges (Fig 2). In all such cases the reactions are always upwards.

3 **Overhanging beam:** An over-hanging beam is one in which the supports are not situated at the ends i.e. one or both the ends project beyond the supports. In Fig 3 and D are two supports and both the ends A and B of the eam are overhanging beyond the supports C and D the respectively.

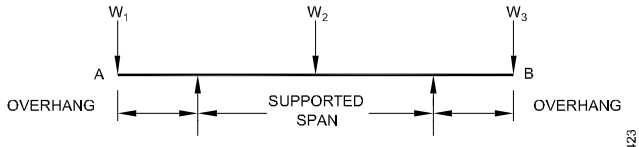
Fig 2



SIMPLY SUPPORTED BEAM

DCN3512422

Fig 3

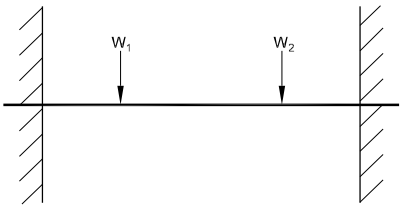


OVERHANGING BEAM

DCN3512423

4 Fixed beam: A fixed beam is one whose both ends are rigidly fixed or built in into its supporting walls or columns. (Fig 4)

Fig 4

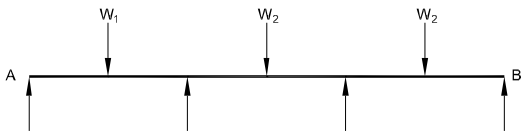


FIXED BEAM

DCN3512424

5 Continuous beam: A continuous beam is one which has more than two supports (Fig 5) The supports at the extreme left and right are called the end supports and all the other supports, except the extreme, are called intermediate supports.

Fig 5



CONTINUOUS BEAM

DCN3512425

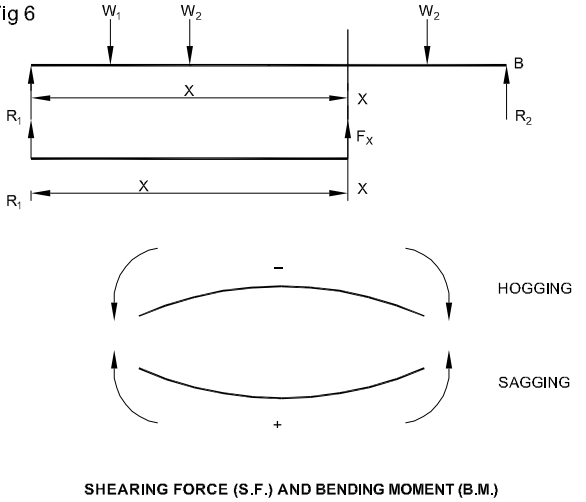
It may be noted that the first three types of beams (i.e. cantilevers, simply supported beams and overhanging beams) are known as statically determinate beams as the reactions of these beams at their supports can be determined by the use of equations of static equilibrium and the reaction are independent of the deformation of beam. The last two types of beams (i.e. fixed beams and contrinuous beams) are known as statically indeterminate beams as their reactions of support cannot be determined by the use of equations of static equilibrium.

Shearing force (S.F) and bending moment (B.M)

When a beam, which is in equilibrium under a series of forces, is cut in some section X , and And the beam to the left to the section remains in equilibrium (Fig 6) then some force must act at the section. Prior to cutting, this force would be provided by the adjacent material, and would act tangentially to the section. Hence there will be shearing force at the section. Numerically this shearing force will be given by the algebraic sum of the forces to the left or to the right of the section. Numerically this shearing force will be given by the algebraic sum of the forces to the left or to the right of the section. As a convention, an upward force to the left of a section is counted as producing negative shearing force. Similarly an upward force to the right of the section will produce positive shearing force.

Considering further the equilibrium of the material to the left of the section X (Fig 6), it follows that there can be no resultant moment to the left of the section. Hence, any moment produced by the forces acting on the beam must be balanced by an equal and opposite moment produced by the internal forces acting in the beam at the section. This is the bending moment at the section.

Fig 6



SHEARING FORCE (S.F.) AND BENDING MOMENT (B.M.)

DCN3512426

The bending moment is the algebraic sum of moments to the left or right of the section. In each case, by considering equilibrium, either for forces or moments, the resultant caused by the applied forces to one side of the section is balanced by the bending moment and shearing force acting at the section. The sign convention for bending moments is that a beam in "hogging" condition is subject to negative bending moment, and one in a "sagging" condition to positive bending moment. (Fig 6)

Sign conventions

For writing the general expressions for bending moment, and shearing force we shall be adopting the following sign conventions.

Shearing force: A shearing force having an upward direction to the right hand side of a section or downwards to the left of the section will be taken "positive". Similarly, a 'negative' shearing force will be one that has a downward direction to the right of the section or upward direction to the left of the section.

Bending moment: A bending moment causing concavity upwards will be taken as 'positive' and called as sagging bending moment, a bending moment causing convexity upwards will be taken as 'negative' and called hogging bending moment.

1 Cantilever with an end load

Refer fig. 7, A cantilever is supported at one end only, being built-in at its support, giving it a fixed slope at that point.

Consider a section XX at a distance x from the free end A.

S.F at $X=S_x=-W$

B.M. at $X=M_x=-Wx$

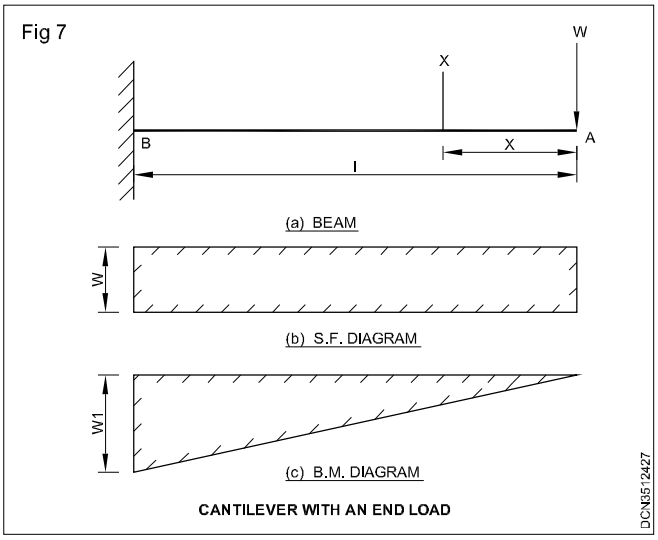
Thus we find that S.F. is constant at all sections of the member between A and B. But B.M. at any section is proportional to the distance of the section from the free end.

At X=0, i.e. at A, B.M=0

At X=l, i.e at B, B.M.=Wl

S.F. and B.M. diagrams are shown in (Fig 7)

Fig 7



CANTILEVER WITH AN END LOAD

1 Cantilever with uniformly distributed load

Let the load be distributed over the whole length of the beam, the loading being w per unit run (Fig 8)

Consider the section XX at a distance x from the free end A.

S.F. at X=Sx=-wx

B.M. at X=Mx=-w.x.x/2

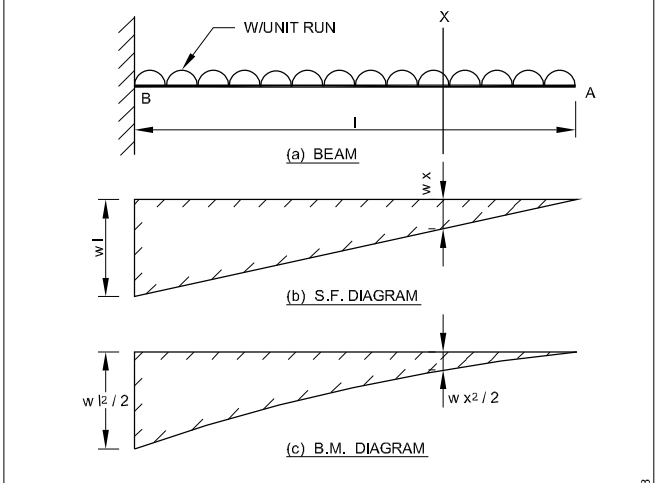
$$-\frac{wx^2}{2}$$

Thus we find that the variation of the shear force is according to a linear law, while the variation of bending moment is according to parabolic law.

At x=0, Sx=0 and Mx=0

At x=l, Sx=-wl and $M_X = \frac{wl^2}{2}$

Fig 8



CANTILEVER WITH UNIFORMLY DISTRIBUTED LOAD

2 Cantilever with uniformly distributed load and a concentrated load at the free end

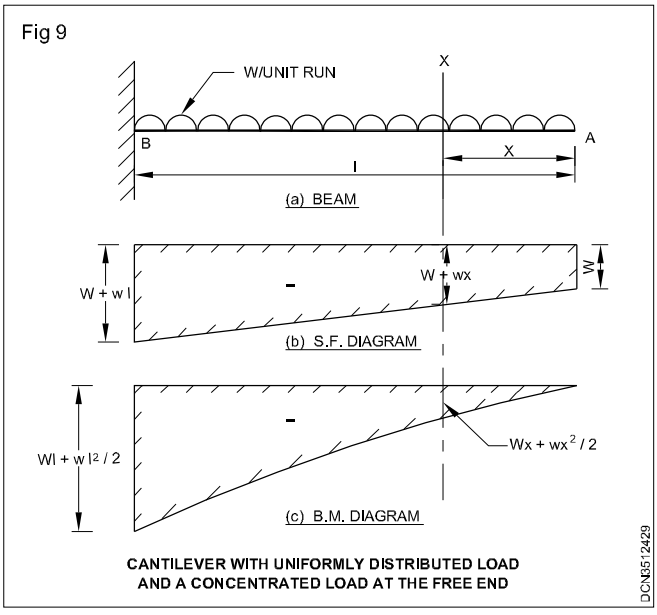
(Fig 9) shows a cantilever AB of length l (fixed at B and free at A) carrying a uniformly distributed load of w per unit run over the whole length and a concentrated load W at the free end.

Consider any section XX at a distance x from the free and A. The S.F. and B.M. at section X, are respectively given by

$S_X = -(W + wx)$ and M_X = -

We find that the S.F. varies following a linear law while B.M. varies following a parabolic law.

Fig 9

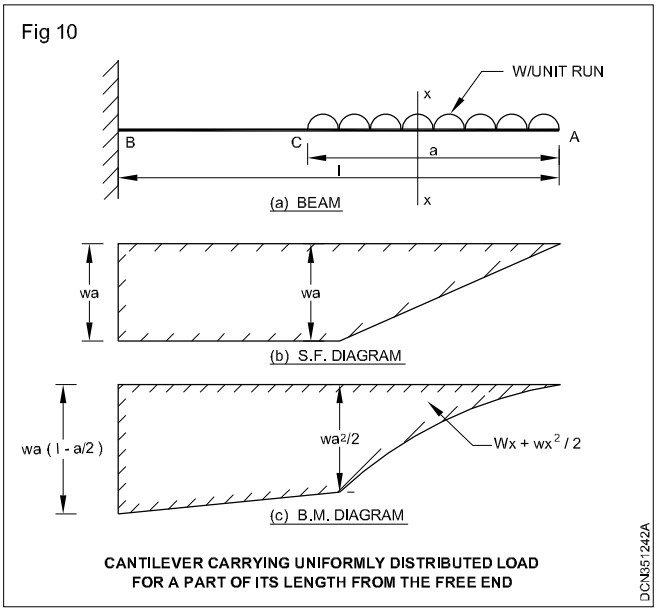


CANTILEVER WITH UNIFORMLY DISTRIBUTED LOAD AND A CONCENTRATED LOAD AT THE FREE END

3 Cantilever carrying uniformly distributed load for a part of its length from the free end

Fig.10 shows a cantilever AB of length l carrying a uniformly distributed load of w per unit run for a distance a from the free end.

Consider any section between C and A distant x from the free end A.



S.F. and B.M at this section are given by

S_X = -wx and M_X = -

The above relations hold good for all values of x between x=0 and x=a (i.e. between C and A). Thus for this range S.F. varies following a linear law while the B.M. varies following a parabolic law.

At x=0 Sx=0 and Mx=0

At x=a S_x=-wa and M_X= -

Now consider any section hold good for all values of x between x=0 and x=a (i.e between C and A). Thus for this range S.F. varies following a linear law while the B.M. at the section are given by

Sx = -wa and Mx = $-wa\left[X-\frac{a}{2}\right]$

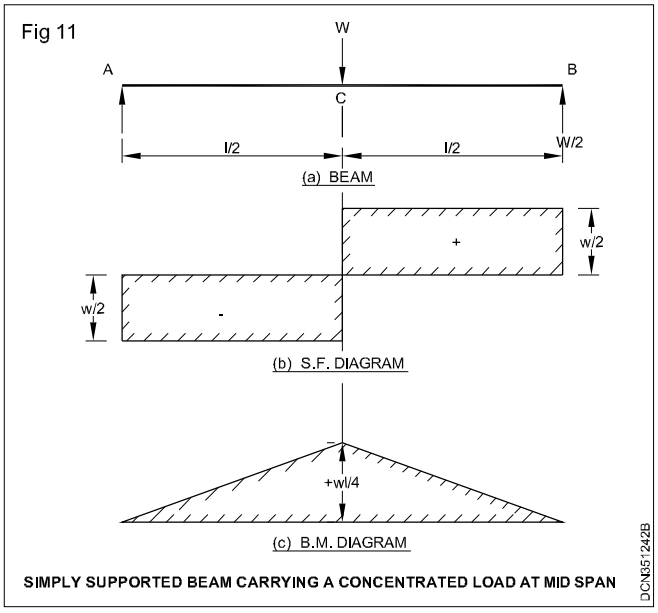
Thus between B and C, S.F. is constant at -wa but B.M. varies according to linear law.

At x = a_1 M_X = -wa (a-a/2) = -

At x = l, M_X = - wa (l - a/2)

4 Simply supported beam carrying a concentrated load at mid span

Fig.11 shows a beam AB simply supported at the ends A and B. Let its span be l and carry a point or concentrated load W at the mid span. As the load is symmetrically place on the span, reaction at each support is W/2.



For any section between B and C S.F. =+W/2

For any section between C and A

At the section C the S.F. changes from +

B.M at a distance x from B in BC,

M_X = +

B.M. at B (where x=0), M_B = 0

B.M. at C (where x = l/2), M_C =

B.M. at a distance x from B in CA,

- W(x - 1/2)

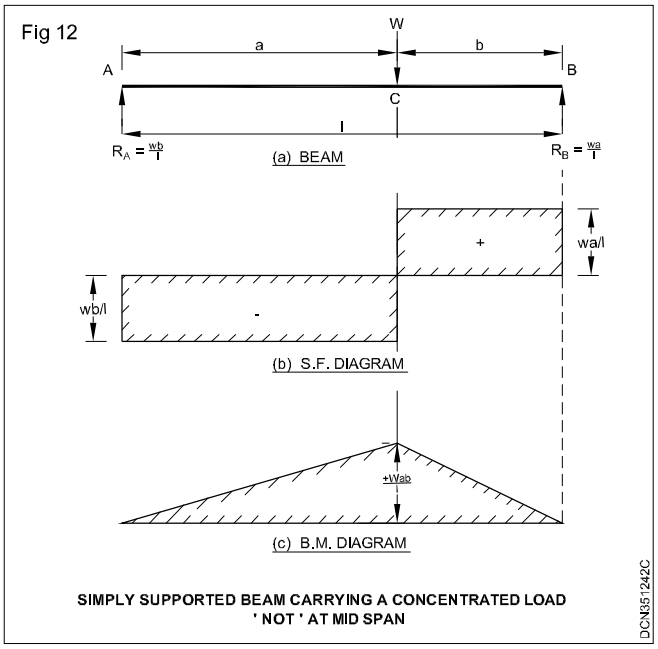
B.M at C where x = 1/2, M_C = +

B.M. at A where x = l, M_A = +

B.M. at supports in case of simply supported beams is always zero.

5 Simply supported beam carrying a concentrated load 'NOT' at mid span (Fig 12)

Let the beam AB of span l carry a concentrated load W at a distance a from A and a distance b from B.



Taking moments about A to determine the support reactions, we have:

RB x l=Wxa

But $R_A+R_B=W$

$$\therefore R_A = W - \frac{Wa}{l} = \frac{W(l-a)}{l} = \frac{Wb}{l}$$

S.F. just to the left of B is + $\frac{Wa}{l}$. It remains constant upto C.

S.F just to the left of C is

$$\left(+\frac{Wa}{l} - W\right) = \left[\frac{-W(l-a)}{l}\right] = -\frac{Wb}{l}$$

It remains constant upto A.

B.M. at the supports A and B=0

$$\text{B.M at C, } M_C = \frac{Wa}{l} \times b = \frac{Wab}{l}$$

Thus B.M. is maximum at C where S.F. changes sign.

6 Simply supported beam carrying a uniformly distributed load of w per unit run over the whole span.

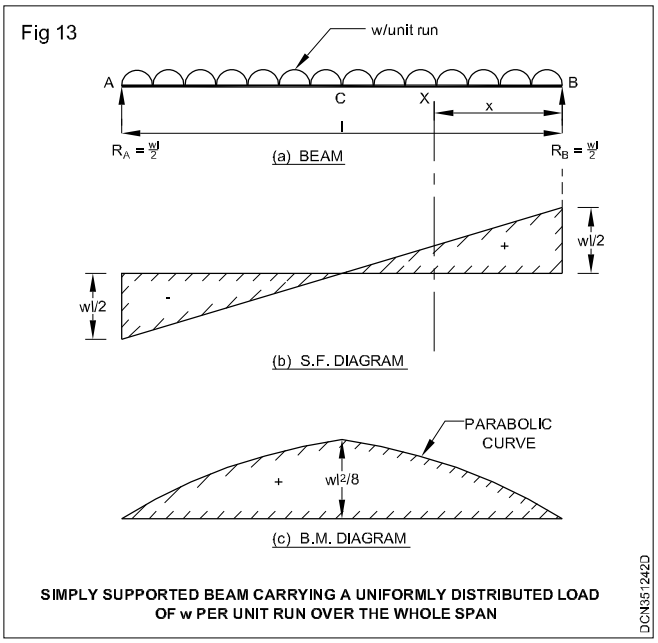


Fig 13 shows a simply supported beam AB carrying a uniformly distributed load (U.D.L) of w per unit over the whole span

By symmetry each support reaction is equal i.e.,

$$R_A = R_B = \frac{wl}{2}$$

S.F. at the section X at the distance x from B,

$$S_X = +\frac{Wl}{2} - WX$$

S.F. at B (where x=0) $S_B = +\frac{Wl}{2}$

S.F. at mid span C

$$\left(\text{where} \times = \frac{1}{2}\right), S_C = +\frac{wl}{2} = -\frac{wl}{2} + 0$$

S.F. at A (where x=l), $S_A = +\frac{wl}{2} Wl = -\frac{Wl}{2}$

B.M. at the section X,

B.M. at B (where x=0), MB=0

B.M. at A (where x=l)

For the B.M. to be maximum put $\frac{dMX}{dx}$ for eqn. (i) above equal to zero.

$$\therefore \frac{dmx}{dx} = +\frac{wl}{2} - wx = 0$$

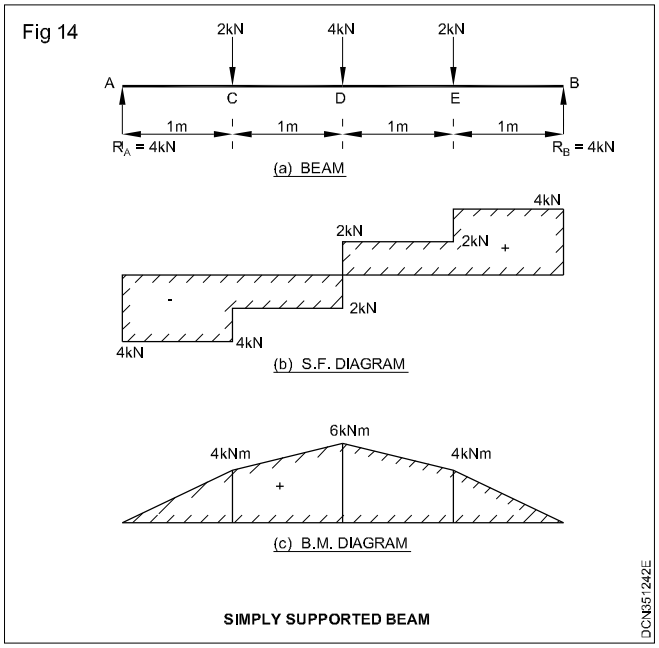
i.e., $\times = \frac{1}{2}$ (For the B.M. to be maximum, it may be noted that, S.F. at this point is zero).

$$M_{max} \times + \frac{wl}{2} \times \frac{1}{2} - \frac{w}{2} \times \left[\frac{1}{2}\right]^2 = \pm \frac{wl^2}{8}$$

The B.M. at M shall be maximum or minimum when $\frac{dM}{dX}$=0 i.e., S=0. Thus at the sections where S.F. is zero or changes sign (because then it passes through zero) the B.M. is either maximum or minimum.

7 Example - draw the S.F. and B.M. diagrams for simply supported beam loaded as shown in Fig 14

Sol. To determine the support reactions taking moments about A, we get



RBx4=2x1+4(1+1)+2(1+1+1)=2+8+6=16

$$RB = \frac{16}{4} = 4KN$$

But RA+RB=2+4+2=8kN

$\therefore R_A$ =A 8-R_B =8-4 =4KN

S.F. calculations

S_{B-E}=+4kN

S_{E-D}=4-2=2kN

S_{D-C}=2-4=-2kN

S_{C-A}=-2-2=-4kN

S.F. diagram is shown in Fig 14(b)

B.M. Calculations

M_B=0

M_E=4x1=4kNm

M_D=4(1+1)-2x1=8-2=6kNm

M_C=4(1+1+1)-2(1+1)-4x1

=12-4-4=4kNm

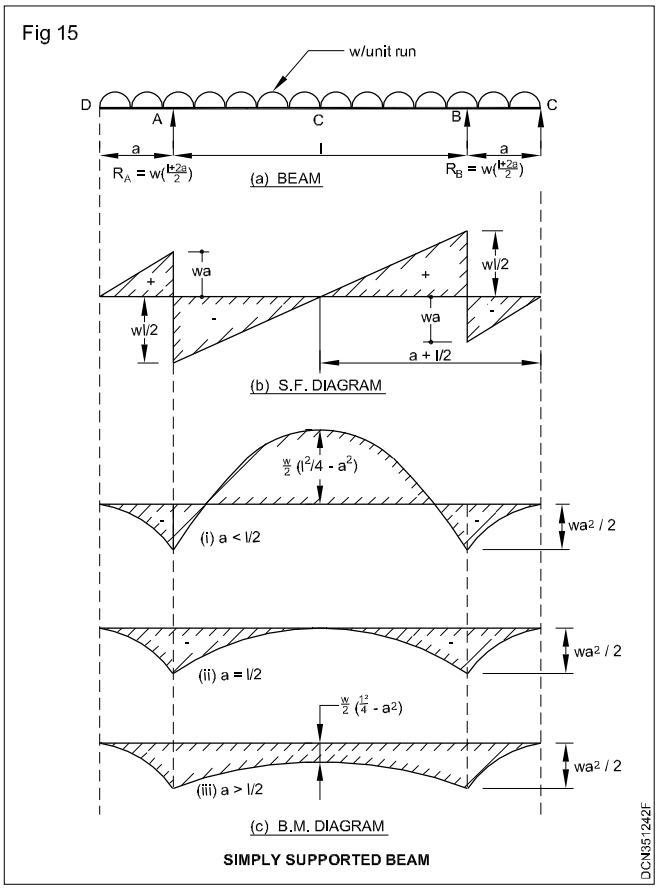
M_A=4(1+1+1+1)-2(1+1+1)-4(1+1)-2x1

=16-6-8-2=0

B.M. diagram is shown in Fig 14(c)

8 Simply supported beam with equal overhangs and carrying a uniformly distributed load of w per unit run over the whole length

Fig.15 shows a beam DABC of length (l+2a) with supports at A and B so that AB=l and DA=BC=a. Let the beam carry a uniformly distributed load of w per unit run over the entire length.



Since the loading is symmetrical on the beam, each vertical reaction equals half the total load on the beam,

$$\therefore R_A = R_B = \frac{w(l + 2a)}{2}$$

S.F. just to the right of B = -wa

S.F. just to the left of B.

$$= - wa + \frac{w(l+2a)}{2} = +\frac{wl}{2}$$

S.F. just to the right of A

$$= -w(l+a)+2x\frac{w(l+2a)}{2} = +\frac{wl}{2}$$

SF just to the left of A

$$= -s(l+a)+2X\frac{w(l+2a)}{2} = +wa$$

The S.F. is $+\frac{wl}{2}$ at B and $-\frac{wl}{2}$ at A as such that it will be zero at the midpoint between A and B.

$$\text{B.M. at B} = -wa \times \frac{a}{2} = -\frac{wa^2}{2}$$

B.M. at the point of zero shear i.e. at a distance (a+l/2) from C is the maximum.

$$M_{max} = \left[-\frac{w}{2}(a+1/2)^2 + \frac{w(1+2a)}{2} \times 1/2 \right]$$

$$= \frac{w}{2}\left[\frac{1^2}{4} - a^2 \right]$$

If a<l/2 then M_{max} will be +ve and B.M. diagram shall be as shown in Fig.15(a)

If a=l/2 then M_{max} shall be zero and B.M. diagram shall be as shown in Fig.15(b).

If a>l/2 then M_{max} shall be negative and B.M. diagram shall be as shown in Fig.15(c)

If B.M. is zero at a distance x from either end then

$$-\frac{wx^2}{2} + \frac{w(l+2a)}{a}(\times - a) + 0$$

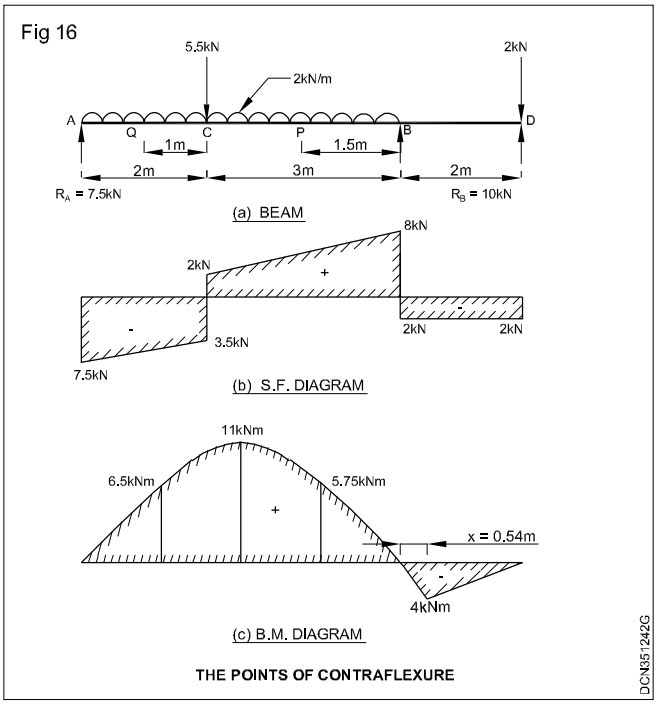
9 The points of contraflexure

The bending moments of opposite nature always produce curvatures of beams in opposite directions. In a beam if the bending moment changes sign at a point, the point itself having zero bending moment, the beam changes curvature at this point of zero bending moment and this point is called the point of contraflexure. So at a point of contraflexure the beam flexes in opposite direction. The point of contraflexture is called the point of inflexion or a virtual hinge. The point of contraflexure can be found by setting the bending moment equation in terms of x equal to zero for part of a span where bending moment is likely to change sign.

Overhanging beams

Example: Draw S.F. and B.M. diagram for the loaded beam shown in Fig.16(a) Sol. To determine reactions RA and RB, taking moments about A, we get

Fig 16



$$R_B \times 5 = 5.5 \times 2 \pm 2 \times 5 \times \frac{5}{2} \pm 2 \times 7$$

=11+25+14=50

$$\therefore R_B = 10kN$$

But RA+RB=5.5+2x5+2=17.5 kN

R_A=17.5-10=7.5 kN

S.F. calculations

S_{D-B}=-2kN

S_B=-2+10=8kN

S_C=8-2x3-5.5=-3.5 kN

S_A=-3.5 - 2 x 2 =-7.5kN

S.F. diagram is shown in Fig 16(b)

B.M. calculations

M_D=0

M_B=-2x2 = -4kNm

B.M. mid way between B and C

$$M_P = -2 \times 3.5 + 10 \times 1.5 - 2 \times 1.5 \times \frac{1.5}{2}$$

=-7+15-2.25=5.75kNm

Mc=-2x5+10x3-2x3x3/2

=-10+30-9=11kNm

B.M. midway between A and C

M_Q=-2x6+10x4-2x4x4/2-5.5x1

=-12+40-16-5.5=6.5kNm

or $\left[M_Q = +7.5 \times 1 - 2 \times 1 \times \frac{1}{2} = 6.5\text{kNm...Fromleftside} \right]$

Since B.M. at B negative and at P+Ve, therefore, the B.M. will cross zero line between them. Let the point of contraflexture lie at a distance x from B.

$$M_X = -2(2 + x) + 10 \times x - 2 \times x \times \frac{x}{2} = 0$$

or -4-2x+10x-x2=0

or -4+8x-x2=0 or x^2-8x+4=0

or $\times = \frac{8 + \sqrt{64 - 16}}{2} = \frac{8 \pm 6.93}{2}$

From which x=0.54m, the other value of x being inadmissible. B.M. diagram is shown in Fig 16(c)

Reinforcement details concrete mixes and ratios

Objectives: At the end of this lesson you shall be able to
- **state steel reinforcement and assembly reinform**
- **state bar bend, hook**
- **state cross sectional area of bar and weight**
- **state the grade of concrete**
- **state period of storage of cement.**

- Plain cement concrete is too strong in taking compression. but on the other hand it also too weak in taking tension.
- By taking tension by the concrete members, steel is used in it.
- The concreting which has steel in it for taking tension is known as “Reinforced cement concrete”.

Reinforced cement concrete work shall comprise of the following.

- Form work. (Centering and shuttering)
- Reinforcement
- Concreting cast -in situ pre- cast

Materials

- The raw materials for concrete are water, cement, fine and coarse aggregate.

Steel reinforcement

- The steel used for reinforcement shall be
- Miled steel and medium tensile bars conforming to IS 432 part - I
- High strength deformed steel bars conforming to IS:1786
- High drawn steel wire fabric conforming to IS 1566
- Structural steel conforming to grade A of IS: 2062
- Thermo mechanically treated bars TMT bars (high strength deformed steel bars)

Steel reinforcement shall be stored in such a way as to prevent distoring and corrosion. Care shall be taken to protect the reinforcement from exposure atmosphere during storage .

It may be achieved by treating the surface of reinforcement with cement wash.

Assembly reinforcement

Bar shall be bent correctly and accurately to the size and shape as shown in the detailed drawing.

Preferably bars of full length shall be used.

The overlaping bars shall not touch each other and these shall be kept apart with concrete between them by 25mm. or 11/4 times the maximum size to the course aggregate whichever greater but where this not possible the overlapping bars shall be bound together at internals not exceeding twice the dia.

Bonds and hooks forming end anchord

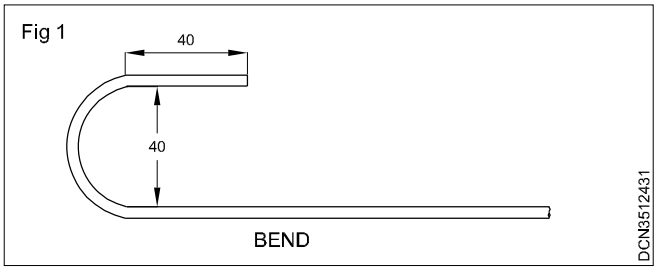
Reinforcement shall be bent fixed in accordance with procedure specified in IS 2502 code of practice for bending and fixing of bars for concrete reinforcement.

The details of bend and hooks

‘U’ type hook

In case of mild steel plain bars standard ‘U’ type hook shall provided by bending ends of rod into semicircular hooks having clear diameter equal to four times of diameter of the bars, as shown in (Fig 1).

Fig 1



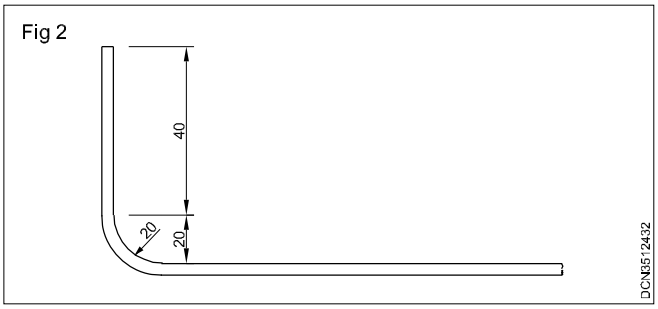
Bends

Bends forming anchorage to a m.s plain bar shall be bent with an internal radius equal to two times the diameter of the bar with a minimum length beyond the bend equal to four times of the diameter of the bar.(Fig 2)

Anchoring bars in tension:

Deformed bars may be used without end anchorage provided development length requirement is satisfied. Hooks should normally be provided for plain bars in the tension development length of bars will be determined as per IS 456 - 2000.

Fig 2



Anchoring bars in compression

- The anchorage length of straight bar in compression shall be equal to the "development length" of bars in compression as specified in IS 456 - 2000.
- The projected length of hooks bends and straight lengths beyond bend, if provided for a bar in expression, shall be considered for developement length.

Cross sectional area and mass or steel bar.

Nominal size mm	Cross sectional area Sqmm	Mass per meter run kg
6mm	28.3	0.222
7mm	38.5	0.302
8mm	50.3	0.395
10mm	78.6	0.617
12mm	113.1	0.888
16mm	201.2	1.58
18mm	254.6	2.00
20mm	314.3	2.47
22mm	380.3	2.98
25mm	491.1	3.85
28mm	616.0	4.83
32mm	804.6	6.31
36mm	1018.3	7.99
40mm	1257.2	9.85
45mm	1591.1	12.50
50mm	1964.3	15.42

Grades of concrete

Group	Grade Designation	Compressive strength of 150mm cube at 28 days in N/mm2
	M - 5	5
Lean concrete	M - 7.5	7.5
	M - 10	10
Ordinary	M - 15	15

Concrete	M - 20	20
Standard	M - 25	25
Concrete	M - 30	30
	M - 35	35
	M - 40	40
	M - 45	45
	M - 50	50
	M - 55	55
High	M - 60	60
Strength	M - 65	65
concrete	M - 70	70
	M - 75	75
	M - 80	80

Concrete mix “M” refers to the mix and specified compressive strength of 150mm size cube at 28 days expressed in N/mm^2

The volumetric mix proportions are to the grades of concrete as specified in the IS 456 . 1964

Concrete mix proportions.	**Grades of Concrete**
1:4:8	M - 7.5
1:3:6	M - 10
1:2:4	M - 15
1:11/2 :3	M - 20
1:1:2	M - 25

In the designation of concrete mix M - refers to mix.and the number to the specified compressive strength of 150mm size cube at 28 days expressed in N/mm^2

Proportion of total quantity of coarse and fine aggregate to 50kg of cement

No.	**Grade of concrete**	**Total quantity of sumof the masses of fine and coarse aggregate per 50kg of cement**
1	M- 5	800 kg
2	M - 7.5	625 kg
3	M - 10	480 kg
4	M - 15	330 kg
5	M - 20	250 kg

Reduction of strength of cement with passage of time

No.	Storage period of cement	Strength of reduction
1	Fresh	Nil
2	3 months old	20%
3	6 months old	30%
4	12 months old	40%
5	24 months old	50%

Table showing mix proportions by weight under normal mix for different grades of concrete

No.	Grade of concrete	Maximum size of coarse aggregate	Nominal mix proportion by weight			Usage
			Cement Kg	Sand Kg	Coarse aggregate Kg	
1	M - 5	40mm	50	230	570	Lean concrete Levelling course
2	M - 7.5	40mm	50	180	445	------ do ---------
3	M - 10	40mm		140	340	Plain concrete
		20mm	50	160	320	-------- do -------
4	M - 15	40mm		95	235	Plain concrete
		20mm	50	110	220	--------- do ------
		10/12.5 mm		130	200	---------- do --------
5	M - 20	20mm	50	85	165	Reinforced concrete work.

Converting concrete mix proportions by weight to mix proportions by volume for concrete and grades can be easily calculated by using the given tables above and it is more useful for calculation.

Form work for columns

Objectives : At the end of this lesson you shall be able to
- **describe form work of column moulds and centering column**
- **describe the requirements of form work**
- **state two materials used in the form work**
- **describe the removal of form work.**

Form work or shuttering

When concrete is placed in a plastic state. It is required a temporary supports and casings of the desired, shape The temporary supports sufficiently strong. This temporary casing is called as form work or shuttering

Moulds:

If the form work is in small units such as lintel, cornices etc is called as moulds.

Centering:

For circular work such as arch, domes etc. is called as centering.

Requirements of form work

Easy removal:

Form work can be removed easily, without damage of concrete. The operation of removing the form work is known as stripping. It can be reused.

Economy:

Form work materials is easily available at low cost. Form work materials can be reused for several times.

Less leakage:

There is minimum leakage through joints.

Quality:

It should be designed and built accurately

Rigidity:

The form work should be rigid enough so as to retain the shape without any deformation.

Smooth surface

Form work should be smooth so as to get good concrete surface. The inside surface should be applied crude oil. This makes easy to remove of form work.

Strength:

It should be strong enough to bear the load of wet concrete, weight of equipments and workman etc.

Supports:

It should be rest on sound and hard and non-yielding supports.

Materials used for form work

1 Timber for work

For small works, required less repetition timber form work is used.

This is cheap in initial cost.

The timber form work can be used for 10 to 12 times

The ply-wood form work can be used for 20 to 25 times

2 Steel form work

Steel form work is used several times.

The intial cost is high

Erection and removal are simple

It presents a smooth surface on removal

The Cost of form work may be upto 20 to 25% of the cost of the structure

Removable of form work in

1. Walls, columns, and vertical side of beam 1 to 2 days
2. Slabs ---------- 3 days
3. Beam soffit ---------- 7 days

Removable of probs to slab

Spanning upto 4.5m ---------- 7 days

Spanning over 4.5m ---------- 14 days

Removable of probs to beam and Arches

spanning upto 6m --- 14 days

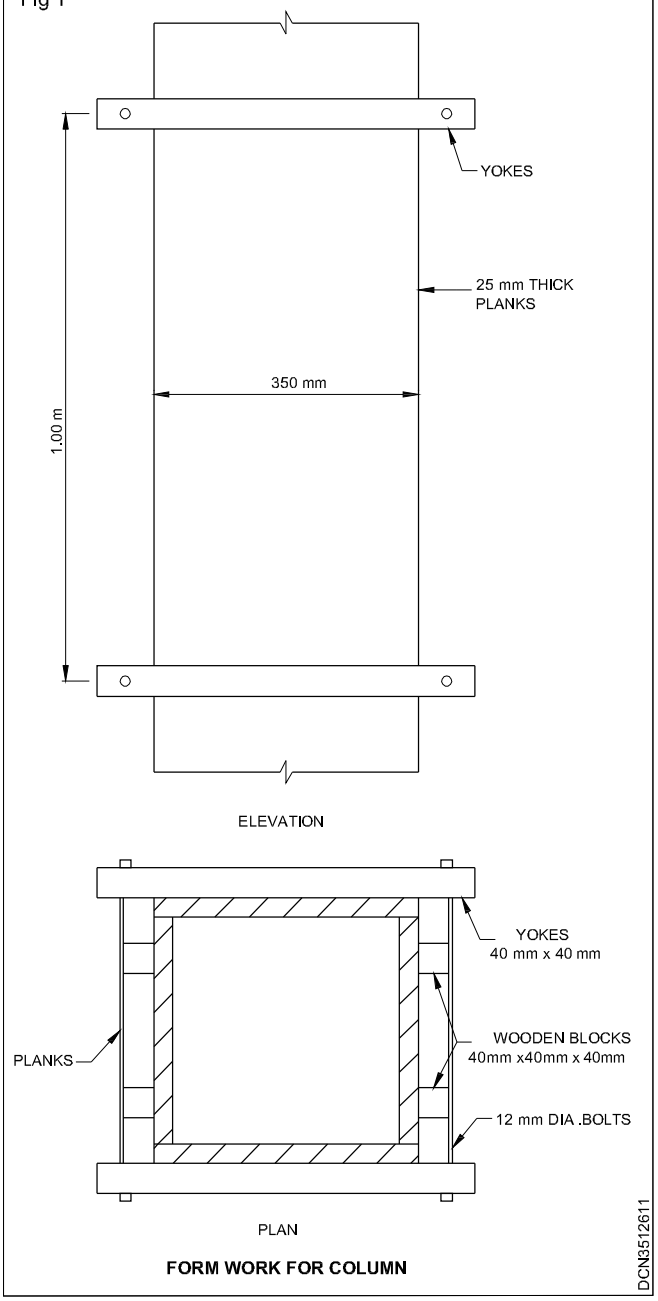
Spanning over 6m ----- 21 days

Column:

- The column form work consists of a box prepared four separate sides.(Fig 1)
- The four sides of box are held in position by wooden block, bolts and yokes.
- The spacing of yokes is about 1m
- Depending upon the shape of the column, the box can be prepared.

- A hole is provided at the bottom of the form work of column to remove the waste which might have fallen before concrete is placed. This is called as cleanout (or) washout hole
- The hole is filled up before placing of the concrete starts.
- Easy to remove the form work, the nails are kept projecting instead of being firmly driven.
- For circular column is made of narrow vertical bounds are called staves.
- Staves are correctly shaped to the required curvature.

Fig 1



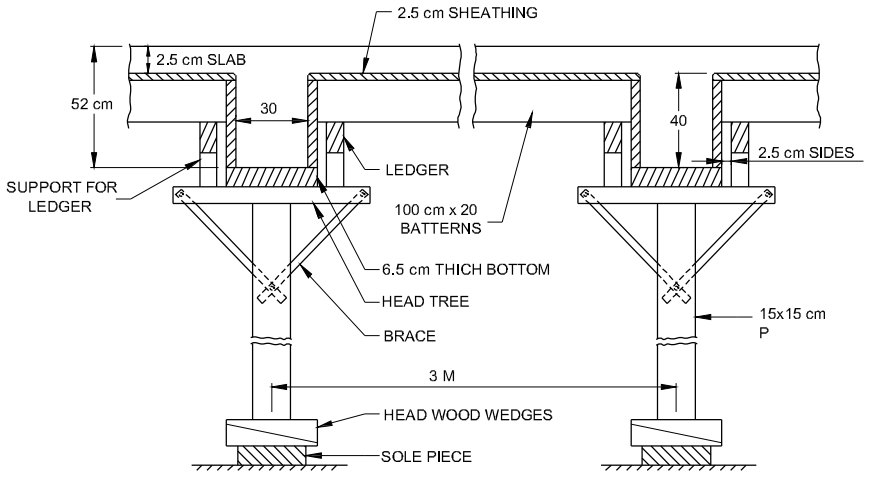
FORM WORK FOR COLUMN

Form work for beams and slabs

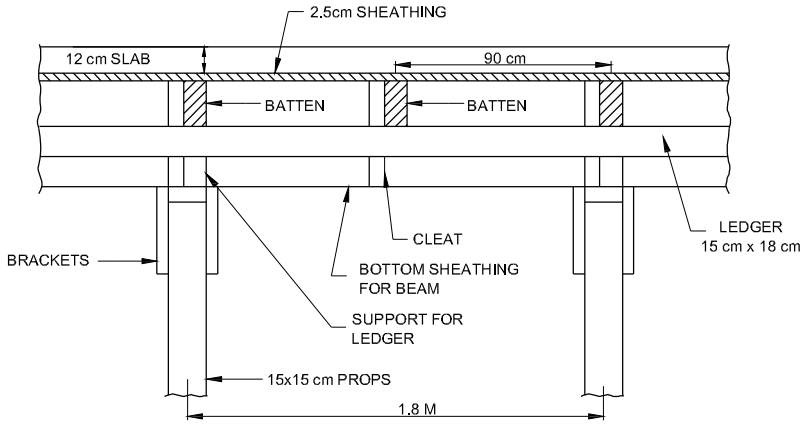
Objective: At the end of this lesson you shall be able to
- **describe form work of Floors and beams.**

- The form work for an R.C.C floor consists of a skeleton to receive the concrete. (Fig 2)
- It consists new vertical posts.
- The vertical post carry small wooden beams at their tops.
- The planks are provided for slabs on these beams
- The boxes for beams are provided from two sides and one bottom.
- The laterals, blocks, beams and struts are provided to make the form work.

Fig 2



(a) SECTION ACROSS BEAMS



(b) SECTION ALONG BEAMS

DCN3512612

Reinforced brick work

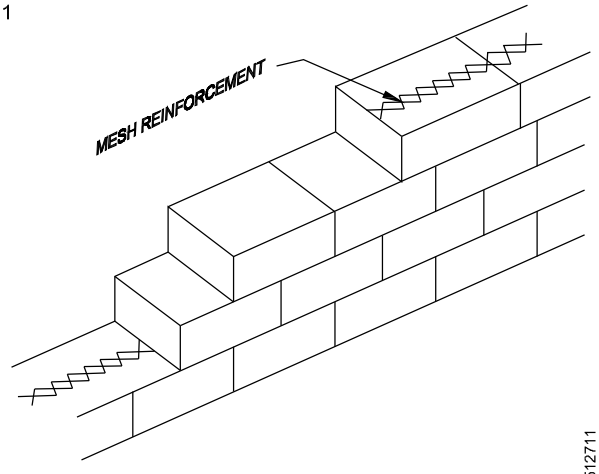
Objectives : At the end of this lesson you shall be able to
- **state reinforced masonry**
- **state reinforced masonry wall**
- **state reinforced masonry column**
- **state reinforced masonry lintel**
- **state reinforced masonry slab.**

Reinforced masonry

- Reinforced masonry is essentially well materials
- Beams, Slabs lintel, column, have been built in reinforced masonry
- Reinforced masonry is a cheap, durable, fire proof, easy to construct and increase of floor space due to adoption of brick work of lesser thinkers

Reinforced masonry walls (Fig 1)

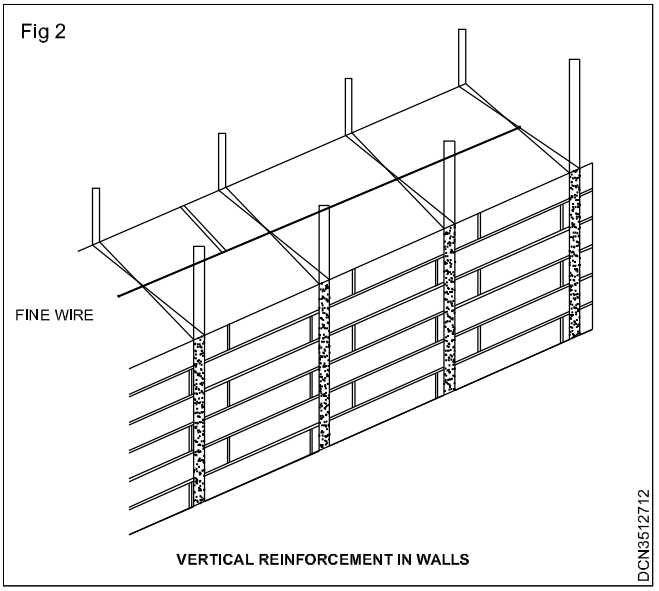
Fig 1



MESH REIN FORCEMENT MASONRY WALLS

- Iron bars or expanded metal much is provided at every third or fourth course
- Before starting the next course steel fabric is spread flat on the cement mortar
- Flat bar section about 25mm x 2 mm be used as hoop iron reinforcement for walls
- Flat bars are hooked at corners and junctions.
- Flat bars are dipped in tar and sanded, soas to resist against rusting.
- Vertical rein for cement provided by using special bricks (Fig 2)
- 6mm diameter mild steel bars can be used as longitudinal reinforcment in walls.

Fig 2



VERTICAL REINFORCEMENT IN WALLS

Masonry reinforced columns (Fig 3)

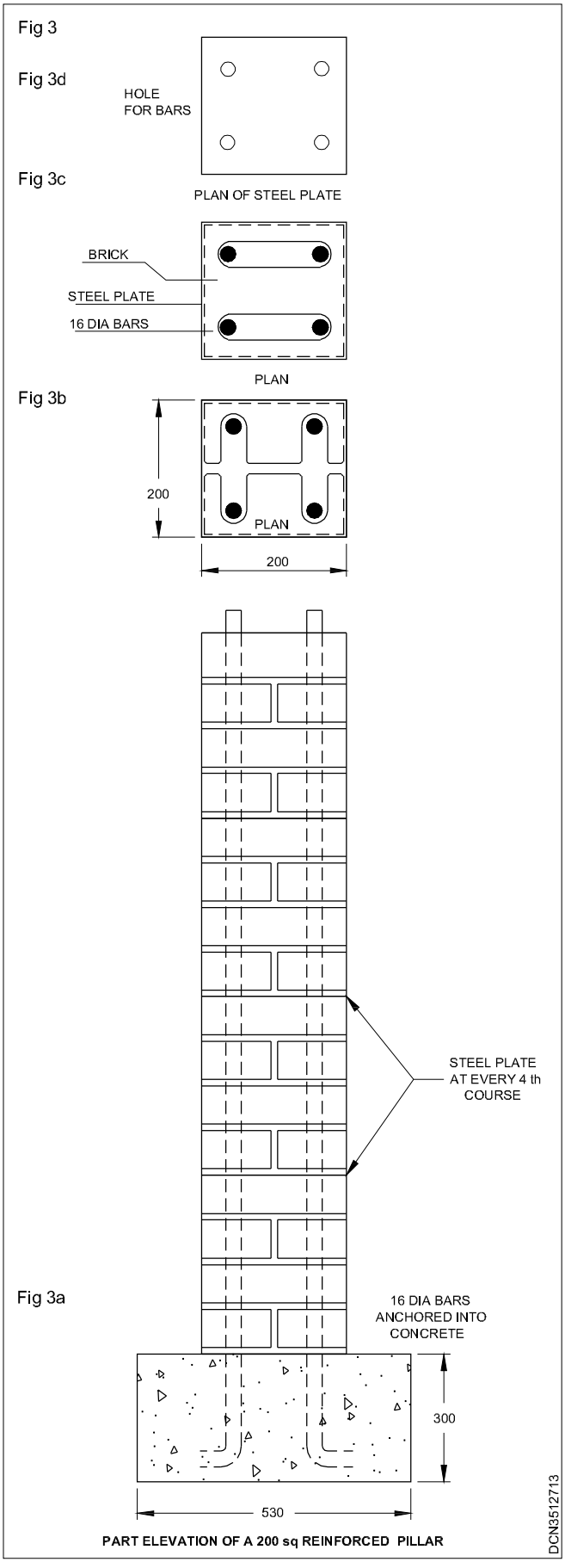
- In steel reinforced columns are provided with steel plate of about 6mm thickness at every fourth course
- Vertically reinforced bars are placed between special type of blocks used
- The steel bars are fixed in the foundation concrete block

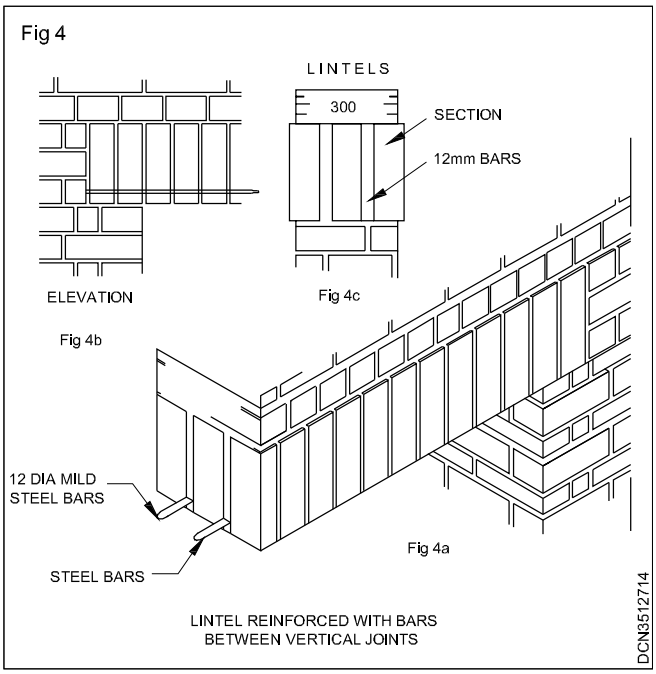
Reinforced masonry lintels (Fig 4)

- 6 to 12 mm diameter bars are provided longitudinally in between the vertical joint
- 6mm diameter stirrups are provided at every third vertical joint to take up the vertical shear

Reinforced masonry slab

- For construction of reinforced masonry slap, centering should be provided.
- The centering is covered with beaten earth and fine sand.
- The centering is covered with well-beaten earth and fine sand is sprinkled over it.





- Reinforced placed in position.
- Bricks are laid in one or two courses.
- Joints should be properly filled with motar.
- The slab is kept wet for two to four weeks.
- Centering should be removed after 28 days.
- Top and bottom surfaces of slab are finished with cement mortar.

Method of mixing concrete-machine mixing & hand mixing

Objectives : At the end of this lesson you shall be able to
- **state method of mixing cement**
- **state placing compaction and curing of concrete**
- **state joint in concrete.**

Mixing

All concrete should be mixed throughly until it is unifrom in appearance and all ingredients are uniformly distributed.

- Mixing will be done either.
- Hand mixing.
- Machine mixing.

Hand mixing

- Hand mixing of concrete is done on hard plarform.
- This method is mainly employed at such places where the quantities of concrete to be mixed in small.
- Cement and sand are first mixed together in dry condition.
- The coarse aggregate is spread on the platform in uniform thickness varying from 20 to 30 cm.
- The mixed cement and sand are spreaded in a uniform thicj layer over the stack of coarse aggregate.
- These are mixed toghether first in dry state.
- Then measured quantity of water is sprinkled over it and the mass is continously mixed till uniform workable concrete is obtained.

Machine mixing

- Machine employed for mixing concrete are known as “Concrete mixers”
- These mixers may be of continous mixing type or batch mixing type. For big projects where lrge quantity of concrete is required continuous mixing type mixers are used.
- The ingredients of concrete may be fed in the mixture by mens of continuous moving conveyor belts or by other suitable methods.
- For small works of building mostly tilting drum type mixtures are used.
- While mixing concrete with mixtures first the coarse aggregates are fed in the mixture, then sand and then cement.
- After dry mixing the measured quanity of water is poured in the mixture and the concrete is mixed for 2 to 3 minutes to obtain the desired workable concrete.
- Before placing concrete in position care should be taken that proper mould is prepared alaround where the concrete is to be laid
- All the faces of moulds coming in contact with concrete properly coat with crude oil. So that it may not absorb water from concrete and it is difficulty while removing batterns.

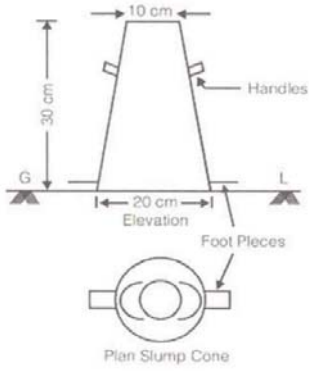
Slump test

Objectives : At the end of this lesson you shall be able to
- **state slump test**
- **state the advantages of slump test**
- **state the limitation of slump test.**

Slump Test:

- The standard slump concrete as shown in fig 1. And placed firmly the ground.
- The concrete is filled with about one-fourth portion.
- Rammed with a rod which is provided with ballet nos at the lower end.
- The dia of rod 16 mm and length is 60cm.
- The strokes to be given for ramming vary from 20 to 30.
- The remaining portion of the cone is filled in with similar layers
- The top of concrete surface is stuck off, so that the cone is completely full of concrete.
- The cone is gradually raised vertically removed.
- Concrete is allowed to sub side

Fig 1



- Measure the height of the concrete
- Slump of concert is obtained by deducting height of concrete after subsidence form 30 cm.

Table 1

Commended slumps of concrete

Sl No.	Types of concert slump	Slump
1.	Concrete for road construction	20 to 40 mm
2.	Concrete for parapet, slab, walls and piers	40 to 50 mm
3.	Mass concrete	25 to 50 mm
4.	R.C.C work	80 to 150 mm
5.	Concrete for arch work	90 to 100 cm

Advantage of slump test

1 It gnarls the facility to easily detect the difference in water content of successive batches of concert of the same identical mix

2 The apparatus is portable and convenient to be used at site .

Imitating of slump test

1 There is no direct relationship between the workability and the value of slump

2 The maximum size of the aggregate should not excel 40 mm.

3 The stump occurs only in case of plastic mixes. It does not occur in case of dry mixer.

R.C.C lintel & sunshade

Objectives: At the end of this lesson you shall be able to
- **define R.C.C lintel**
- **express type of R.C.C lintel**
- **describe structural concept and structural detailing of lintels and sunshades.**

Introduction

It becomes necessary to provide openings in walls for doors, windows, cupboards, etc. Such opening must be bridged over so as to support the load of the wall above them. This is accomplished by providing a lintel.

Definition

RCC lintel is small beam provided over the door, window or openings to support the masonry wall built above it.

Types of R.C.C lintel (Fig 1)

1 Break lintel

2 Continuous lintel

Break lintel

Break lintel is the lintel which provides only over the opening with minimum bearing on jambs.

Continuous lintel

The lintel running continuous over all openings and supporting wall is called continuous lintel. This will provide more stability to the wall as - well - as fulfills the function of a lintel.

Design datas

The lintel has to be designed for a triangular load if the wall above lintel is greater than 1 ¼ h, where 'h' is the height of the triangle, if the height is less than 1 ¼ h, then the lintel has to be designed for complete load of full length of masonry.

Loading for which a lintel must be designed are

1 When the length of wall on each side of opening is at least equal to half the effective span.

2 When one end of the lintel is close to the end of the wall.

3 When both ends are close to the ends of the walls.

4 When the wall carries a slab.

5 When there are opening above the lintel.

Reinforcement arrangement

In break lintel main bars are provided just like in simply supported beam while in a continuous lintel, it will be same as that of continuous beam. In both case usual forms of stirrups are provided.

Structural concepts and detailing of lintels

a Load acting on lintels: Lintels span between the openings for doors, windows, ventilators etc. They carry the loads of the triangular portion of masonry above them. When this triangle intercepts the floor slab the loads over the entire length of the lintel come over it. Lintel beams in framed construction carry the weight of the masonry infill between the lintel and floor beam above. (Fig 2)

b The structural behavior: A lintel is subjected to bending and shearing action. In the tension zone reinforcement is provided in concrete, to resist the tensile stresses. The shearing action is taken care of by vertical stirrups or cranked bars as indicated.

Fig 1

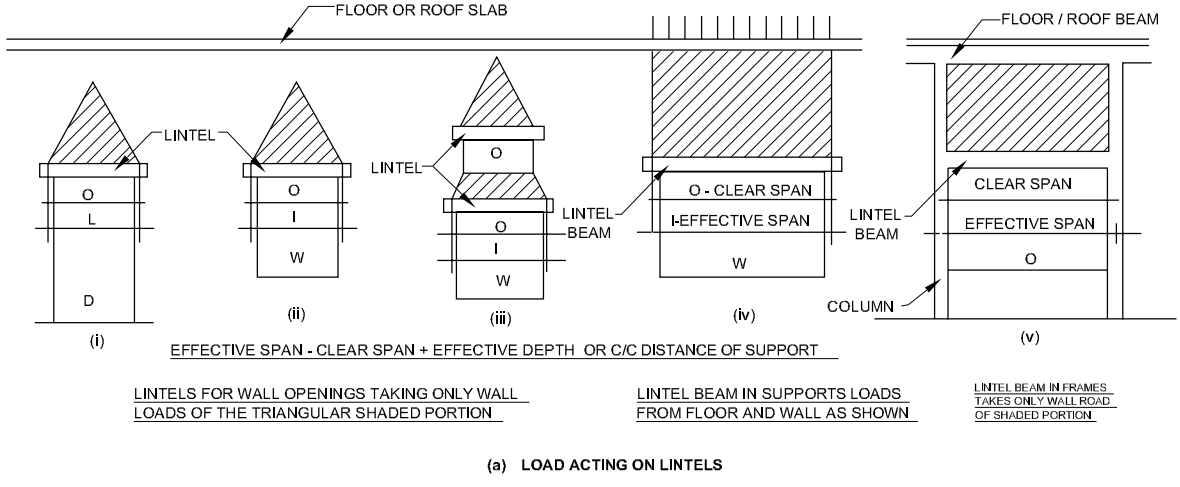
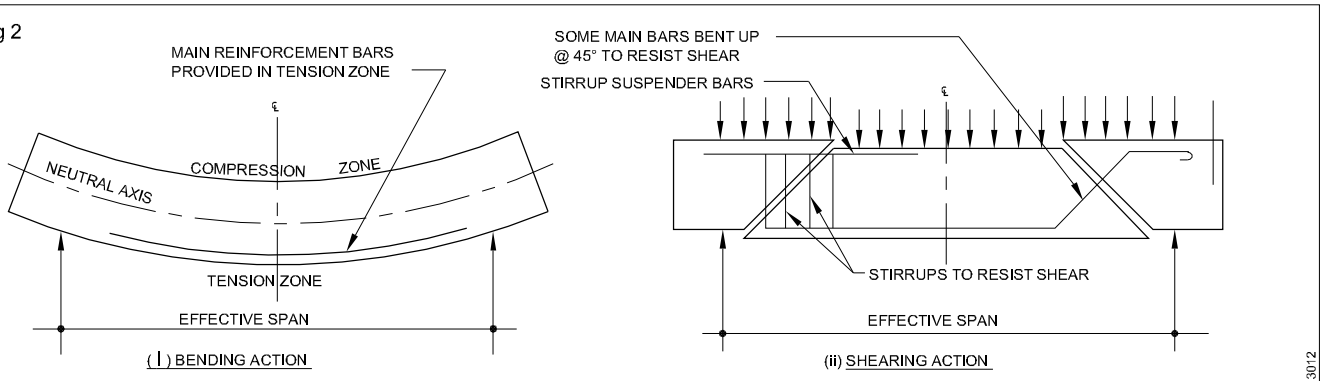


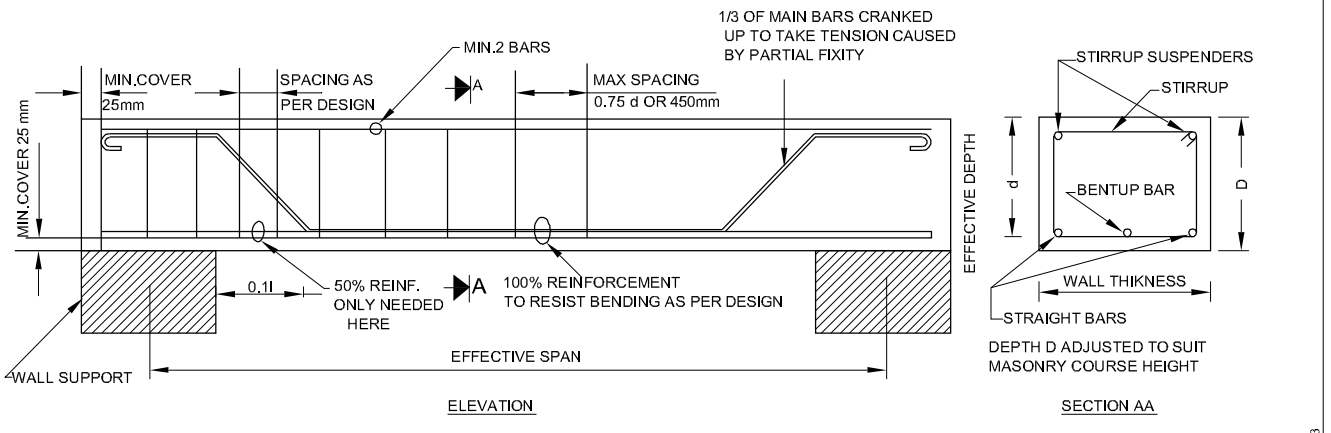
Fig 2



STRUCTURAL BEHAVIOUR OF A SIMPLY SUPPORTED LINTEL (BEAM)

Method of detailing: All information regarding the size of the lintel, type, number and position or reinforcements, the cover for reinforcement bars etc. are presented in a longitudinal elevation and one or more cross sections. Note the two types of main reinforcement (straight and cranked bars), stirrup suspenders, stirrups at varying spacings (closer near the end), position of cranks etc. in the drawing. (Fig 3)

Fig 3



SIMPLIFIED STRUCTURAL DETAILING FOR A LINTEL

Work specification for lintels and sunshades

1 lintel thickness shall be of 2 brick thickness (20 cm)

2 sunshade projection shall be 70 cm

3 concrete of M15 grade of nominal mix with 350 kg. of aggregate to 50 kg. of cement and 32 liters of water is assumed.

4 Proportion of fine aggregate to course aggregate shall be 1:2 by weight.

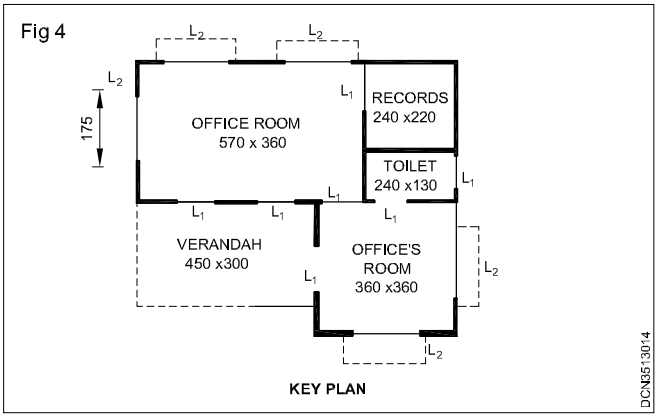
5 Aggregate shall be well graded with a max size of 20 mm.

6 MS bars of fy 230N/mm^2 is assumed.

7 Wall thickness or width of lintels 250.

8 Clear spans L1 - 100 cm, L2 - 135 cm.

Fig 4



KEY PLAN

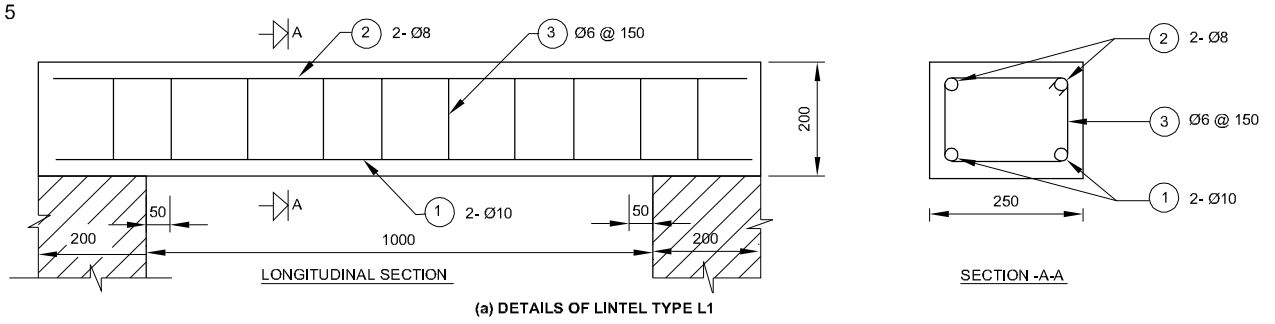
Drawings of lintels and sunshades

The key plan indicates two types of lintels (L1 and L2) and positions of sunshades.

Details of lintel type I (LI): This has a clear span of 100 cm. Three different types of bars marked 1,2 and 3 within circles are used for this member. (Figs 4&5)

Details of lintel type II (L2): This lintel has a clear span of 135 cm, and is attached to sunshade. The longitudinal section shows only reinforcement in the lintel. The cross section gives bar details of lintel as well as sunshade. (Fig 6)

Fig 5



(a) DETAILS OF LINTEL TYPE L1

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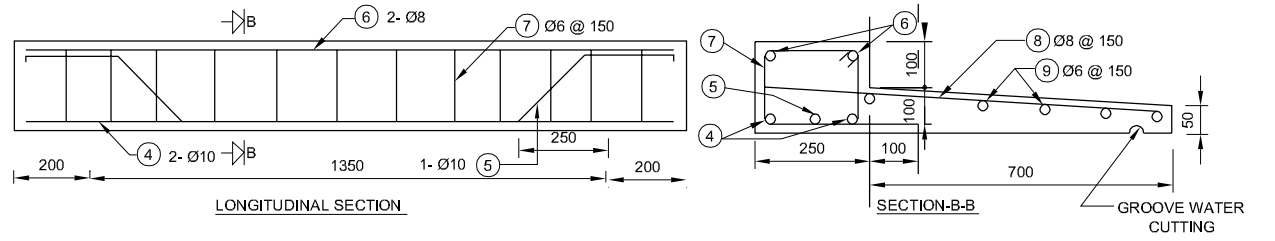
Fig 6



(B) DETAILS OF LINTEL TYPE L2

DCN3513016

R.C.C Columns and footings

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

- **define R.C.C column and footings**
- **explain general and reinforcement detailing of R.C.C columns and footings**
- **explain type of columns and footings.**

Columns introduction

Columns support primarily axial load but usually also some bending moments. The combination of axial load and bending moment defines the characteristic of column and calculation method. A column subjected to large axial force and minor moment is design mainly for axial load and the moment has little effect. A column subjected to significant bending moment is designed for the combined effect. The column is subjected to compression only compression force may cause lateral bursting because of the low - tension stress resistance. To resist shear, ties or spirals are used as column reinforcement to confine vertical bars.

Definition

Columns are vertical supports which take the loads of floors, beams, walls, lintels and transmit to ground. The failure of a column can thus endanger a whole structure. These are carefully designed, planned and constructed. These can be made into any of the following shapes. Reinforcing of a concrete column helps in restricting the size of a column and thus helps in designing a most economical section.

a Square or rectangular

b Round circular

c L - shape

d Hexagonal

e Octagonal

General

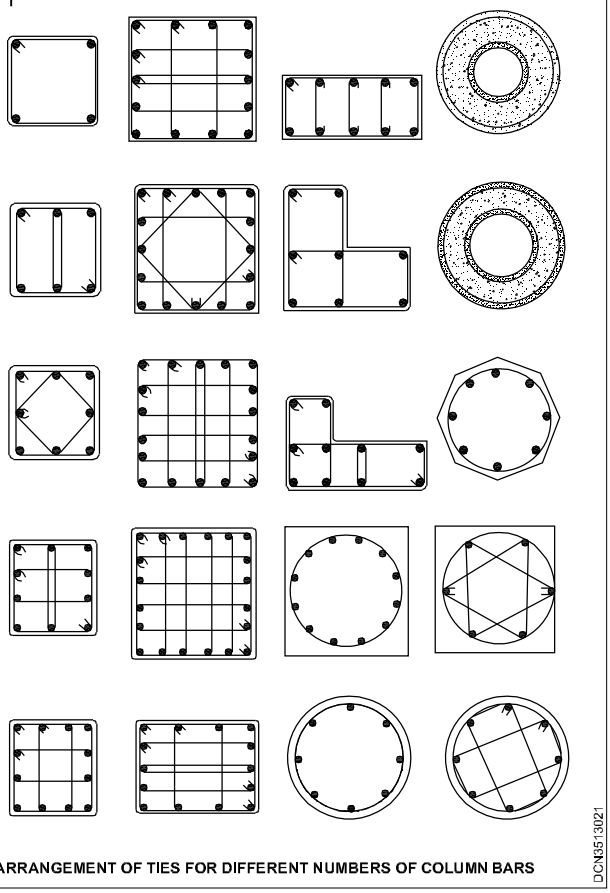
A reinforcement concrete column is said to be subjected to axial load when the line of the resultant thrust of loads supported by the column is coincident with the line of CG. of the column in the longitudinal direction. Depending upon the architectural requirements and the loads to be supported, R.C. columns may be cast in various shapes i.e. square, rectangular, hexagonal, octagonal or circular. Columns of L- shape or T - shape are also sometimes used in multistoreyed buildings. The longitudinal bars in columns help to bear the load in combination with the concrete. These bars are uniformly spaced along the perimeter of the column as near the surface as permissible. The longitudinal bars are held in position by transverse reinforcement, or lateral binders. The binders prevent displacement of the longitudinal bars during concreating operation and also check the tendency of their buckling outwards under loads. The transverse reinforcement, or binders are of two types. Type (1) consists of separate small diameter steel binders bent around the longitudinal bars. The diameter, centre to centre spacing and the arrangement of the separate binders, depend upon the number and diameter of longitudinal bars and the size of the column. In the second type, reinforcing bar forming the tie, is wound round the longitudinal bars in the form of a closely spaced continuous helix and is termed as spiral or helical reinforcement. The helical reinforcement in addition to rendering support to longitudinal bars against buckling and displacement also act to confine the concrete within it in the form of a core thereby increasing the load carring capacity of the column.

Different arrangements of separate binders and helical reinforcement are shown in figure 1.

The following points should be kept in view while designing a column to effect saving in cost.

1 Column with separate lateral ties work out cheaper than columns with spiral reinforcement.

Fig 1



ARRANGEMENT OF TIES FOR DIFFERENT NUMBERS OF COLUMN BARS

DCN351302 1

2 Axially loaded columns with a low percentage of steel work out more economical per tonne of load supported than columns with a higher percentage of steel.

3 The richer the concrete the more economical in the design.

Types of columns (Fig 2)

Depending upon the slenderness ratio or length to diameter ratio, columns can be divided into three classes.

1 Short columns:

Columns which have lenghts less than 8 times their respective diameters or slenderness ratio less than 32 are called short columns or stocky struts. When short columns are subjected to compressive loads, their buckling is generally negligible and as such the buckling stresses are very small as compared with direct compressive stress. Therefore it is assumed that short columns are always subjected to direct compressive stressess only.

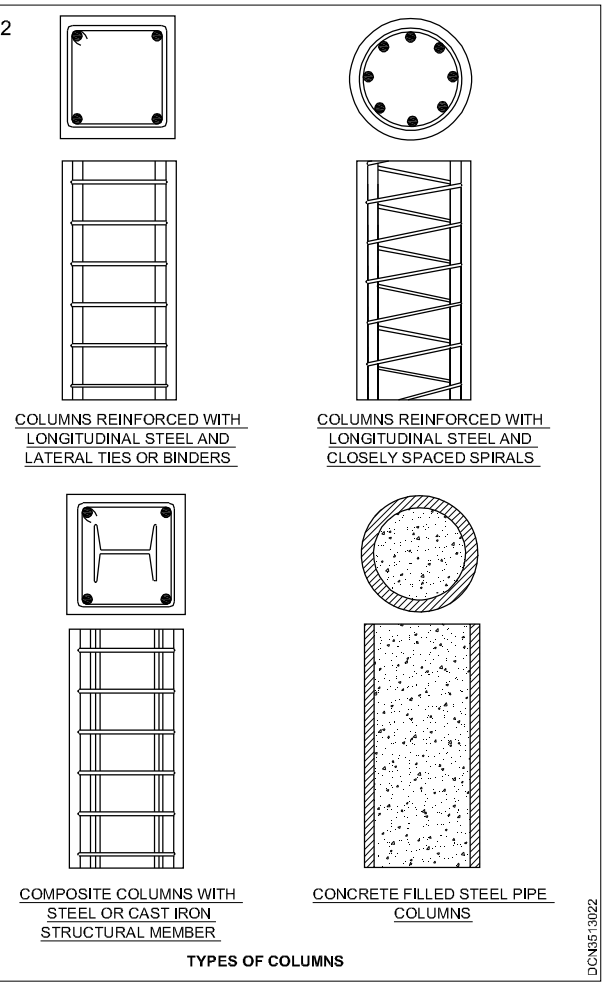
2 Medium size columns

The columnswhich have their lengths from 8 times their diameter to 30 times their respective diameters or their slenderness ratio lying between 32 and 120 are called medium size columns or intermediate columns, both the buckling as well as direct stresses are of significant values. Therefore, in the design of intermediate columns both these stresses are taken into account.

3 Long columns

The columns having their lengths more than 30 times their respective diamters or slenderness ratio more than 120 are called long columns. They are usually subjected to bucking stress only. Direct compressive stress is very small as compared with buckling stress and hence it is neglected.

Fig 2



TYPES OF COLUMNS

DCN351302 2

Reinforcement

a Longitudinal

i Area of main vertical bars to be not less than 0.8% of the area of concrete section and not more than 8% of the gross, cross - sectional area of concrete. From practical point of view it should not be more than 4% of the gross - cross sectional area of concrete.

ii Diameter of bar to be not less than = 12 mm.

iii A circular column having spiral or helical reinforcement will have at least 6 number vertical bars.

2 Transverse reinforcement: It is of two types.(Fig 3&4)

i Lateral ties or polygonal links

ii Spiral, or helical or hoop reinforcement.

Lateral ties

Spacing = 16 times the dia of longitudinal reinforcement.

= the least lateral dimension of column.

= 300 mm

Diameter = Minimum 5 mm.

OR = ¼ th of vertical bars diameter.

Spiral

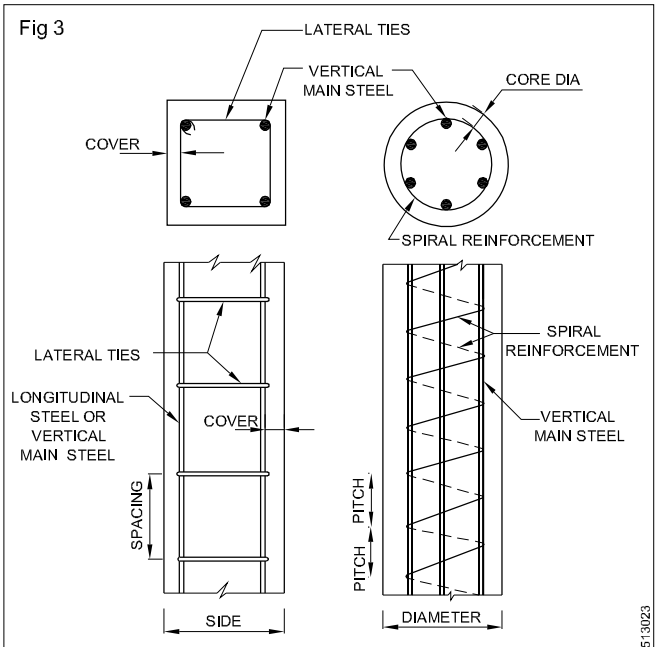
Pitch = not less than 75 mm.

OR = 1/6 th of core diameter of column.

Diameter = Minimum 6 mm.

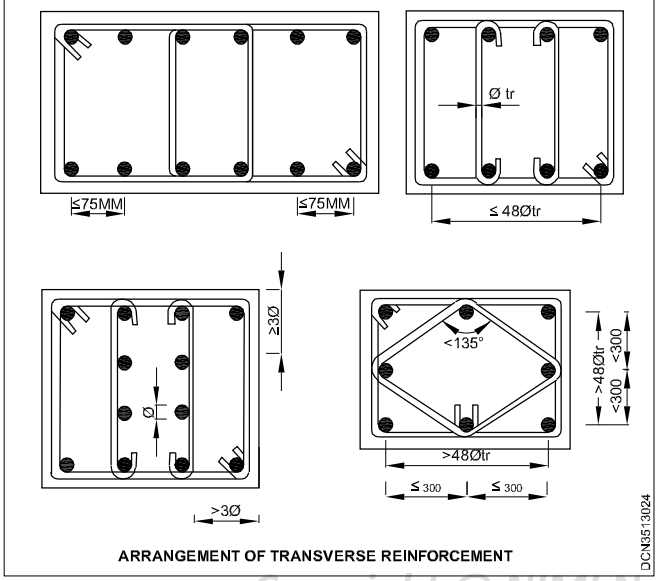
OR = ¼ th of vertical bars diameter.

Fig 3



COLUMN WITH VERTICAL BARS HOOP IRON TIES AND SPIRAL REINFORCEMENT

Fig 4



ARRANGEMENT OF TRANSVERSE REINFORCEMENT

Cover

For longitudinal bars = min.40 mm. or diameter of bar whichever is greater.

For columns of 20 cms. dia. or under, where the diameter of vertical steel is not more than 13 mm. cover is to be taken as 25 mm.

Lap in vertical bars

Splice or lap = 24 x dia. of longitudinal bar.

Drawing of a column

i **Plan** in it foundation - raft is shown. Vertical bars, size of column and lateral reinforcement are shown by thick lines.

ii **Vertical section** Vertical section shows the height of column, longitudinal bars, spacing of ties, foundation concrete, foundation steel, plinth, depth below ground level and splicing of longitudinal bars, if any.

Footing

Introduction

The foundation of a building is the part of a structure that transmits the load to ground to support the superstructure and it is usually the last element of a building to pass the load into soil, rock or piles. The primary purpose of the footing is to spread the loads into supporting materials so the footing has to be designed not to be exceeded the load capacity of the soil or foundation bed. The footing compresses the soil and causes settlement. The amount of settlement depends on many factors. Excessive and differential settlement can damage structural and nonstructural elements. Therefore, it is important to avoid or reduce differential settlement. To reduce differential settlement, it is necessary to transmit load of the structure uniformly. Usually footings support vertical loads that should be applied concentrically for avoid unequal settlement. Also the depth of footings in an important factor to decide the capacity of footings. Footings must be deep enough to reach the required soil capacity.

Definition

The complete sub - structure with reinforcing cement concrete transmitting load of super structure to the bearing soil at shallow depth is called RCC footing.

Types of footings

The most common types of footings are strip footings under walls and single footings under columns.

Common footings can be categorized as follow

1 **Individual column footing (Fig 5a)**

This footing is also called isolated or single footing. It can be square, rectangular or circular of uniform thickness, stepped, or sloped top. This is one of the most economical types of footing. The most common type of individual column footing is square of rectangular with uniform thickness.

2 **Wall footing (Fig 5b)**

Wall footings support structural or nonstructural walls. This footing has limited width and a continuous length under the wall.

3 Combined footing (Fig 5c,d &e)

They usually support two or three columns not in a row and may be either rectangular or trapezoidal is shape depending on column. If a strap joins two isolated footings, the footing is called a cantilever footing.

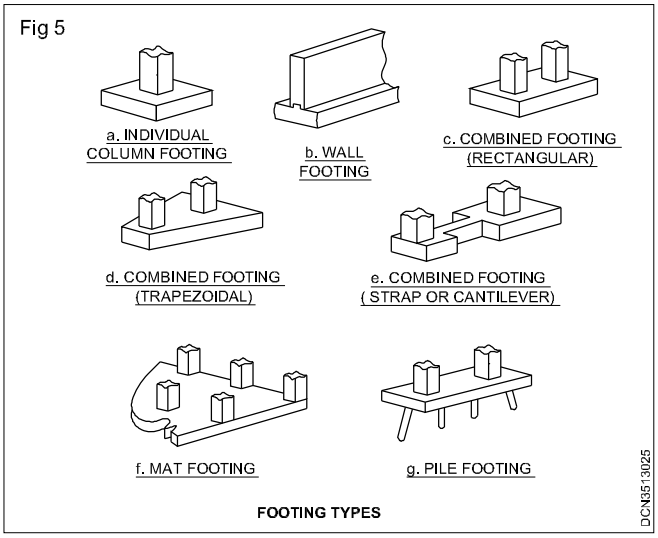
4 Mat foundation (Fig 5f)

Mats are large continuous footings, usually placed under the entire building area to support all columns and walls. Mats are used when the soil bearing capacity is low, column loads are heavy, single footings cannot be used, piles are not used, or differential settlement must be reduced through the entire footing system.

5 Pile footing (Fig 5g)

Pile footings are thick pads used to tie a group of piles together and to support and transmit column loads to the piles.

Fig 5



Is code provisions

1 Footing shall be designed to sustain applied loads, moments and forces and induced reaction and to ensure that any settlement which may occur shall be as nearly uniform as possible, and the safe bearing capacity of the soil is not exceeded.

2 Thickness at the edge of footing shall not be less than 15 cm for footings on soil, nor less than 30 cm above the tops of piles for footing on piles.

i Thickness at the edge to be ⩽15cm

ii Min. cover to main reinforcement to be 50mm for surfaces in contact with earth face and ⩽40mm for other exposed surfaces

iii Max. cover to reinforcement 75mm.

iv Min. diameter of main bars 10mm.

v Min. reinforcement in either direction 0.15 percent (plain bars) or 0.12 percent (deformed bars) of gross sectional area of concrete.

Code provisions for designing and detailing (Fig 6 & 7)

Simple isolated column footings transfer the column load to soil by bearing. The soil pressure generates bending and shearing actions on the footing slab. The concrete section and reinforcements resist the resulting stresses. Important code provisions for designing and detailing of the footing are listed.

Fig 6

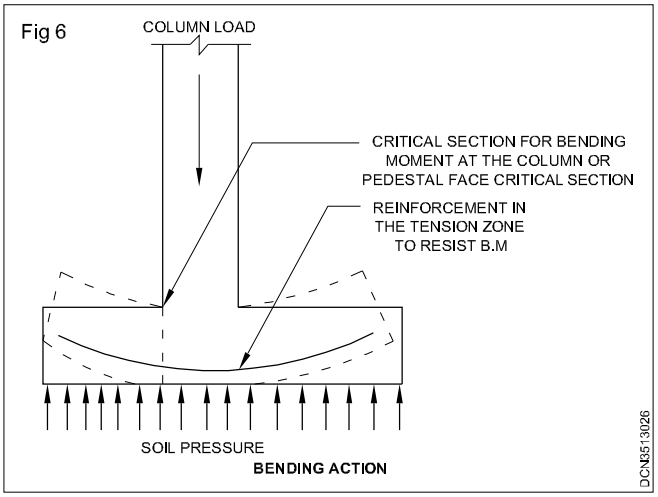
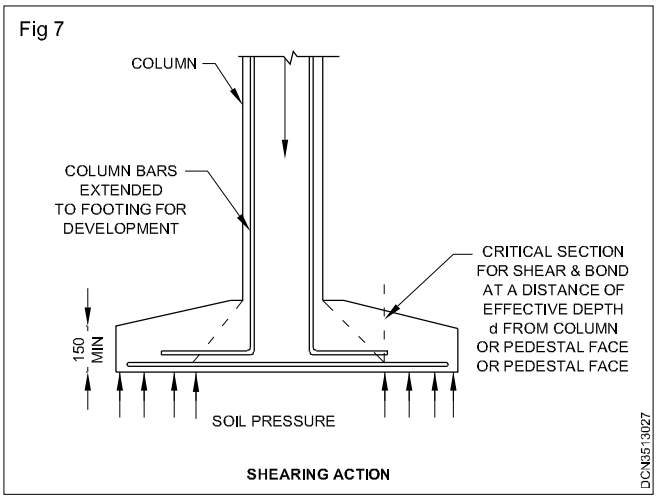
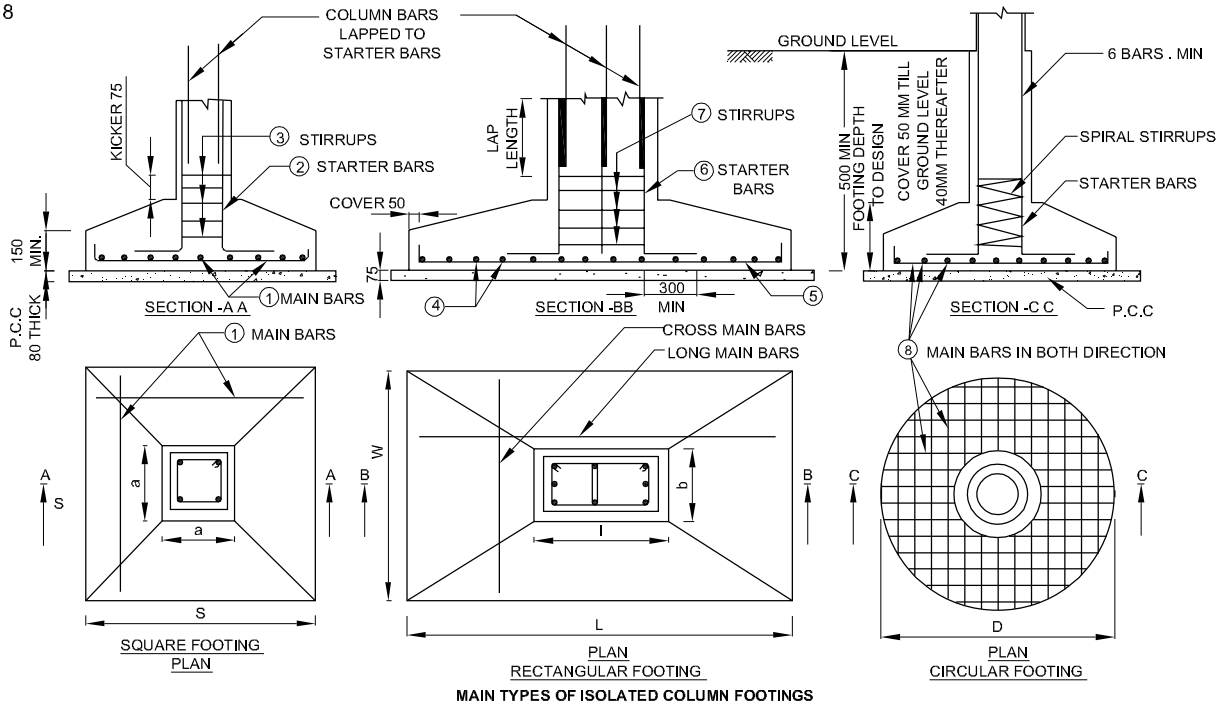


Fig 7



Method of detailing: The footing for square, rectangular and circular columns are shown in Fig.8. A circular column may also be provided with a square footing. For each type of footing a plan and sectional view are given to clearly detail the bars. The plan gives the dimensions of the footing slab and column section. The section gives the dimensions of the footing in relation to the ground level. The spacing and direction of bars are marked in the plan. The section gives full details regarding the cover, positions, arrangement and splicing of the bars. Each of the bars is identified by a specific bar mark, for relating its position in two views and for preparing the bar bending schedule.

Fig 8



R.C.C beam

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

- **define R.C.C beams**
- **explain classification of R.C.C beam**
- **explain detailing of reinforcement of R.C.C beam.**

Introduction

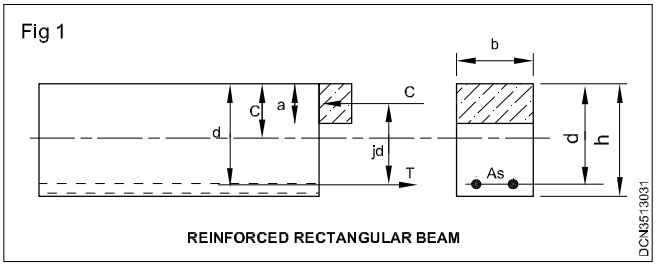
Beams can be described as members that are mainly subjected to flexure and it is essential to focus on the analysis of bending moment, shear, and deflection. When the bending moment acts on the beam, bending strain is produced. The resisting moment is developed by internal stresses. Under positive moment, compressive strains are produced in the top of beam and tensile strains in the bottom. Concrete is a poor material for tensile strength and it is not suitable for flexure member by itself. The tension side of the beam would fail before compression side failure when beam is subjected a bending moment without the reinforcement. For this reason, steel reinforcement is placed on the tension side. The steel reinforcement resists all tensile bending stress because tensile strength of concrete is zero when cracks develop. In the ultimate strength design (USD), a rectangular stress block is assumed.

As shown Fig.1 the dimensions of the compression force is the product of beam width, depth and length of compressive stress block. The design of beam is initiated by the calculation of moment strengths controlled by concrete and steel.

Definition

It is an R.C.C member, which bridges two, or more walls or columns and supports the structural member coming over it.

Fig 1



Classification of R.C.C beams

1 Simply supported

In this type of beam there is no fixity at supports. The value of BM at supports will be zero and the beam is designed with maximum BM on the span. As per IS: 456 the minimum depth required to this type are span/20. Arrangement of reinforcement is given in the figure (2).

2 Fixed beams

Beam having some kind of fixity at ends with the supporting column or wall is called fixed beams. The beams coming in a framed structure are best example for this type. BM value in the span as well as in supports also should be considered for design of this. Main reinforcement is provided at bottom in span and at top on supports. For this 50% of main reinforcement is cranked and taken to top. The crank distance may be 1/5 of span from the

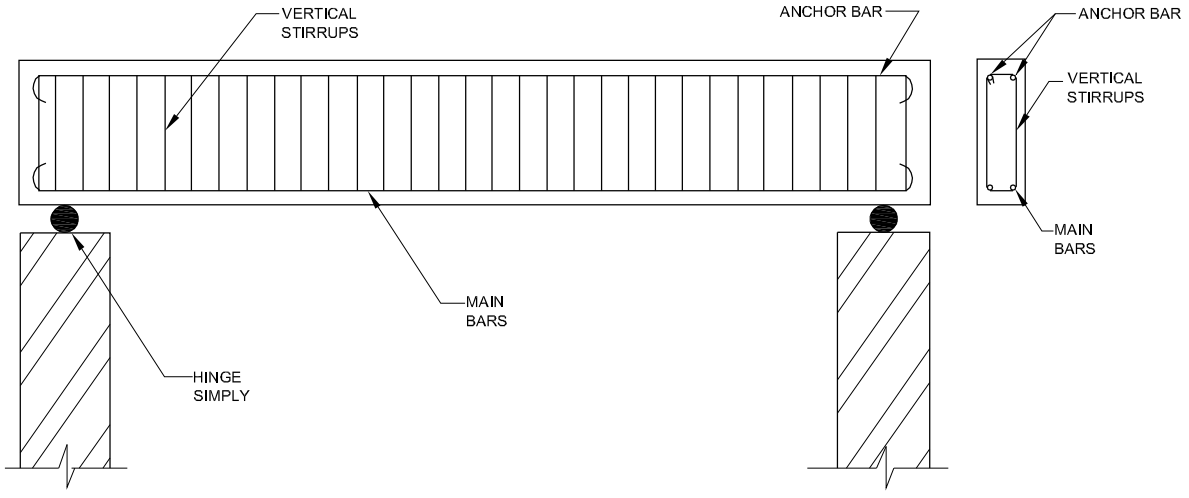
face of the support. Minimum depth of beam should be span/26.

The beams coming over masonry walls are called partially fixed. The hogging movement at support will be less than the totally fixed beams. In this case the cranking may be done at a distance of 1/7 span from support face. Detail of reinforcement arrangement is given in the following Fig 3

3 Continuous beams (Fig 4)

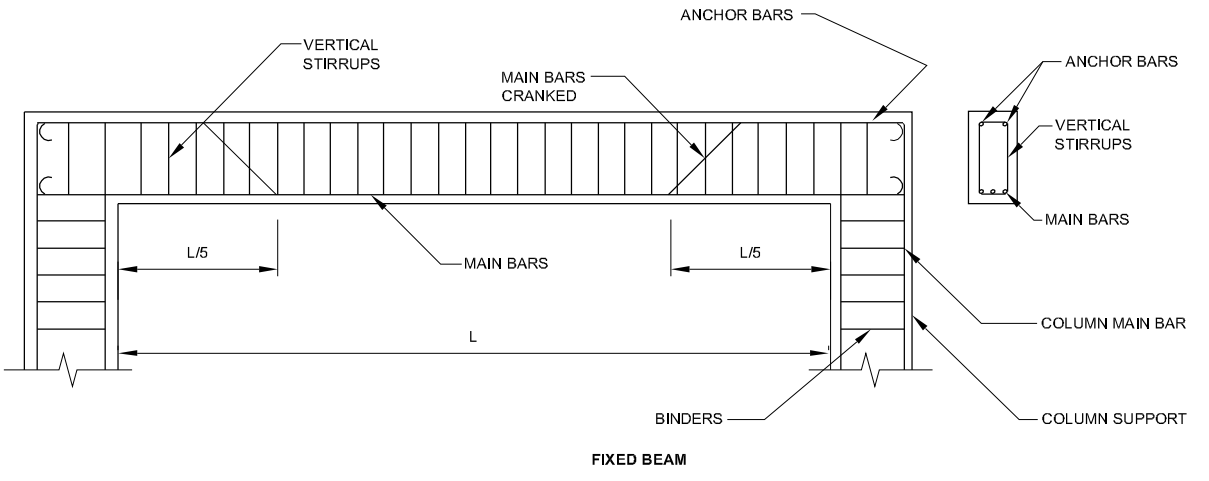
Beams, which rest more than two supports, are called continuous beams. In this case the intermediate support are treated just like totally fixed support and the end support may be either totally fixed or partially fixed or simply supported. The simplicity of execution cranking is obsolete and extra bars of length, span/4 to each span from support face are provided at where ever the hogging moment occurs.

Fig 2



SIMPLY SUPPORTED BEAM

Fig 3



FIXED BEAM

4 Cantilever beams (Figs 5 & 6)

Beams in which one end is fixed and other end is free is called cantilever beam. Beams provided to support projection slabs of verandah, balcony etc are some example for this. In a cantilever beam the moment will be hogging and maximum amount of it occurs at fixed end. So the main reinforcement should be provide in top at fixed end of the beam. If the span is more no need to provide same quantity of reinforcement throughout, according to the moment variation bars can be curtailed.

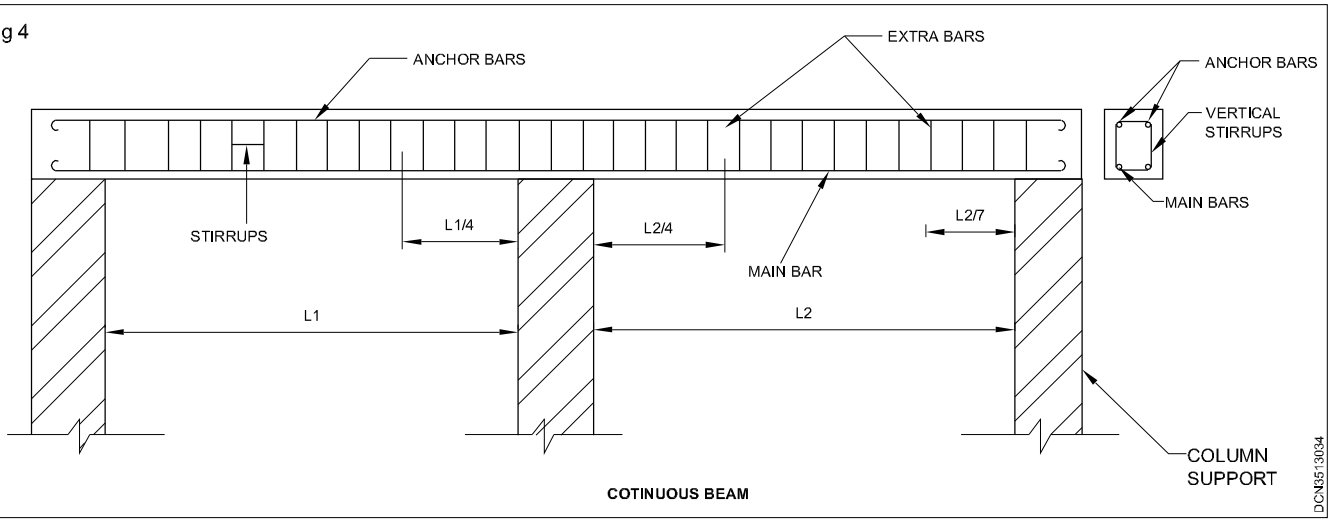
If the fixed end is over a masonry wall necessary anchor weight should be provided at support. Also the length of beams behind the support should not less than 1.5 times the span. Thickness at support should not less than span/ shear force and bending moment are zero at free and, reinforcement as well as size of beam also can be reduced to a minimum. Reinforcement arrangements for typical cantilever beams are given in the figures 5 & 6. Stirrups should provide with a closer spacing at support face and can increase the spacing towards the free end.

Classification according to shape

1 Rectangular beams (Fig 7)

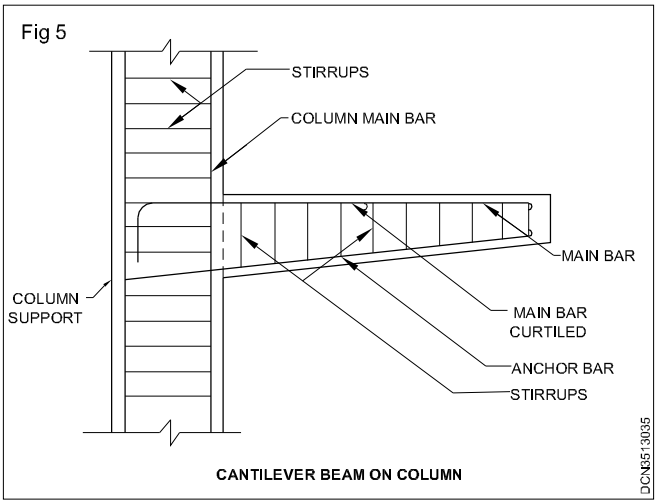
These are the beams having cross section in the shape of a rectangle. This can be adopting for any type of beam in the first category and it is the popular shape of R.C.C beam. Main reinforcements are provided at its corners. Near the periphery shear reinforcement in the form of stirrups are also provided.

Fig 4



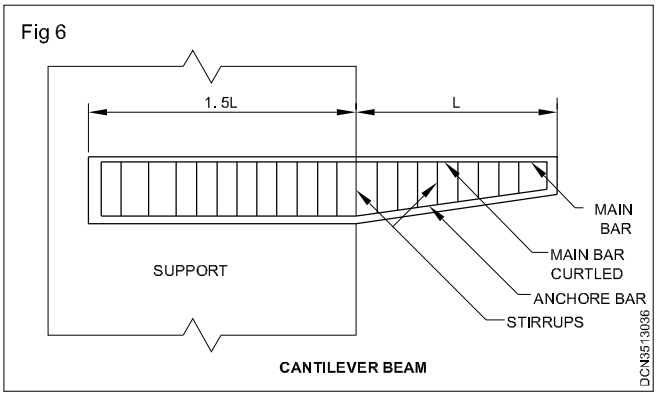
COTINUOUS BEAM

Fig 5



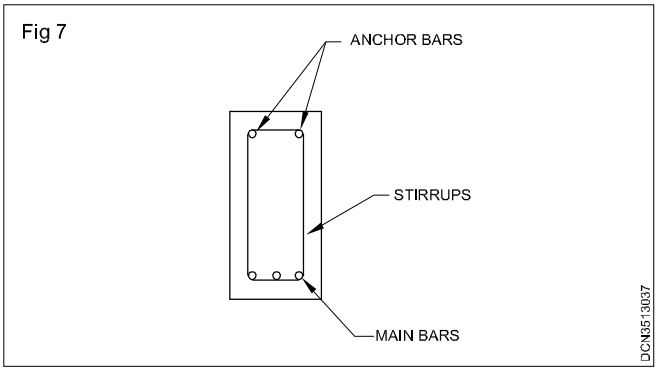
CANTILEVER BEAM ON COLUMN

Fig 6



CANTILEVER BEAM

Fig 7



2 T - beam (Fig 8)

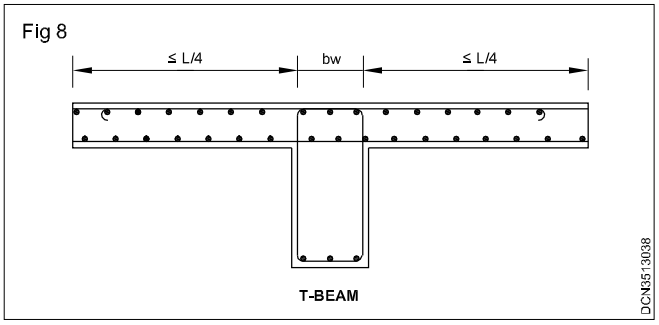
In beam and slab construction if beam and slab are cast at one time, the construction becomes monolithic. The slab above beam takes compression and thus the rib derives strength from the slab, which acts as a compression flange called T beam. The slab portion is called 'flange' and the beam 'web'.

The width of a flange effective for taking compression may be taken as follows, but in no case it should be greater than the c/c spacing of beams.

$B_f = L_o/6 + bw + 6df$

B_f = Width of flange.

Fig 8



T-BEAM

L = the distance between point of zero moments (For continues beams L may be assumed as 0.7 length)

bw = Breadth of web
df = thickness or flange.

Minimum effective depth should be as follows:

1 D ≥ L/20.

2 For light load D ≥ L/15 to L/20.

3 For medium load D ≥ L/12 to L/15.

4 For head load D ≥ L/12.

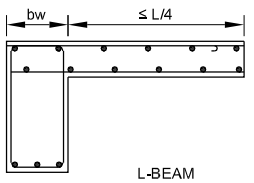
Minimum tensile reinforcement shall not be less than 0.3% of the area equal to overall depth multiplied by the width of the web.

If the main reinforcement of the slab is parallel to the beam, traverse reinforcement shall be provided as in fig.8, such reinforcement shall not be less than 60% of the main reinforcement at mid span of the slab.

3 L- Beam (Fig.9)

Beam cast monolithic with slab, to use the slab as the compression flange on one side of the rib only is called L beam.

Fig 9



Effective depth condition are same as to T- beam flange width should be as follows.

B_f=L/12+bw+3df

For rotated beam, the effective flange width shall be obtained as below but in no cease grater the actual width.

B_f=[0.5l/(l/b)+4]+bw

Singly reinforcement beam

Beam designed such a way that, main reinforcement provide only in tension zone is called a singly reinforced beam. Any of the above beams can be designed in this way. So the minimum requirement of depth is same as that of each given earlier.

Doubly reinforcement beam

When the dimensions of a beam are restricted by architectural or structural consideration the section will have insufficient area of compressive stresses. Steel is placed in the compression part of the section to supplement, beam having tensile and compressive reinforcement are known as doubly reinforced beam.

Circumstances under which doubly reinforced section have to be used are enumerated as follows.

1 When overall size of a section is limited according to structural head room and architectural requirement.

2 When the section is subjected to reversal of BM. e.g. pile, braces in water towers etc.

3 When members are subjected to shock, impact or accidental lateral loads.

4 When members are subjected to eccentric loading as in case of columns subjected to wind load.

5 When beams continuous over several supports, it has to be designed as double reinforced at supports.

In the design of doubly reinforced beams all the basic rules which are given in previous case are applicable.

The compressive reinforcement shall not more than 4% of the cross sectional area of rib. The compressive bars should be accord effectively by providing stirrups. The spacing of stirrups should be as follows.

1 16 times the dia of compression bar.

2 48 times the dia of stirrups. Whichever is less should be adopted.

Covers in R.C.C beams

Beams may be simply supported, singly or doubly reinforced, continuous or cantilever, covers are provided as under.

1 End cover for each reinforcing bar is not less than 25 mm. or twice the diameter of bar whichever is greater.

2 Clear cover for longitudinal bars is not less than 25mm. or diameter of the bar whichever is greater.

Effective span

In case of freely supported beams, the distance between centres of supports i.e. clear span plus one bearing is taken as effective span. For design purposes the effective span is taken as clear span plus the effective depth of beam.

In case of cantilever beams

The distance between free end and the edge of support i.e. portion projecting beyond support is termed as effective span.

Beam dimensions

Following ratio between span to the depth of beams are kept as a measure of effective design.

Beams description	Max. value of span ratio/depth
Simply supported beams	20
Continuous beams	25
Cantilever beams	10

Reinforcement details

The minimum area of tension reinforcement shall not be less than that given by the following.

$A_{st}/b\ d = 0.85 / f_y$

Ast = minimum area of steel

b = breadth of beam

d = Eff. depth

f_y = characteristic strength of reinforcement in N/mm^2

Maximum reinforcement in tension zone shall not exceed 0.04 bd

Side face reinforcement

Where the depth of the web in a beam exceeds 750 mm side face reinforcement shall be provide along the two faces. The total area of such reinforcement shall be not less than 0.1% of the web area and shall be distributed equally on two faces at a spacing not exceeding 300 mm or web thickness whichever is less.

Transverse reinforcement

Minimum shear reinforcement in the form of stirrups shall be provided such that

$[A_{sv}/b_{sv}] = [0.4/0.87\ fy]$.

A_{sv} = cross sectional area of stirrup leg effective in shear.

S_v = Stirrups spacing along the length of the member.

b = Breadth of the beam or breadth of the web of flanged beam.

f_y = Characteristic strength of the stirrup reinforcement in N/mm^2.

Reinforcement

i Minimum tensile steel = 0.3% of the gross sectional area of the beam. [For plain mild steel bars]

ii Minimum tensile steel = 0.2% of the gross sectional area of the beam. [For deformed or ribbed steel bars]

Gross sectional area means the product of overall depth and width.

iii Minimum steel at top near the support = 2 times the main steel at bottom.

iv Minimum steel to be carried straight on supports = 50% of main steel used for tension.

v Diameter of main bars = 10 mm. to 40 mm.

Minimum 2 number of bars are provided in a beam as main bars.

vi Diameter of stirrups = 6 to 10 mm.dia.
Min. spacing of stirrups = 100 mm.
Max. spacing of stirrups = Lever arm of the beam.

Spacing between main bars

a Horizontally = Maximum diameter of bar or size of coarse aggregate plus 6 mm. Whichever is greater.

b Vertically = Due to restricted space the main bars are sometimes placed in layers or tiers one above the other with space in between. This is termed as vertical spacing.

Vertical spacing = 15 mm.

OR = Max. size of coarse aggregate.
OR = Max. size of the bar.

To achieve this, spacer bars are placed at 1.00 m.c/c interval and tied down with main bars.

Shear reinforcement

Shear reinforcement in the form of inclined bars and vertical stirrups are provided when q i.e. shear stress is in between the safe limit and 4 times limit.

i Bending up of bars or cranks: The distance from centre of span to the bending up bars is determined as:

$x = \frac{1}{2}\sqrt{\frac{N_X}{N_o}}$, Where bars are bent only for shear stresses and not for bending stresses.

x = distance from the centre of span

l = effective span

N_x = Number of bars to be bent up

N_o = Number of main bars at centre.

ii As a thumb rule bars are bent at l/7 to l/4 near supports, where l is the effective span.

iii Maximum spacing of shear reinforcement: i.e. spacing between stirrups: IS: 456 - 1978

a For vertical stirrups = 0.75 d or 450 mm whichever is less.

b For inclined stirrups; d or 240 mm whichever is less.

iv Dia. of vertical stirrups = 6 mm to 12mm.

v Shapes of stirrups - see fig.10 (a) to (e).

Preparing drawings of R.C.C beams

The detailed drawing of a beam consists of:

i A longitudinal sectional elevation: It shows the effective and clear spans, main longitudinal bars bending up of bars, stirrups, hanger bars end and side covers and bearings. Stirrup are shown in dotted lines or thin - single lines. Compression longitudinal bars are also shown in case of doubly reinforced beams.

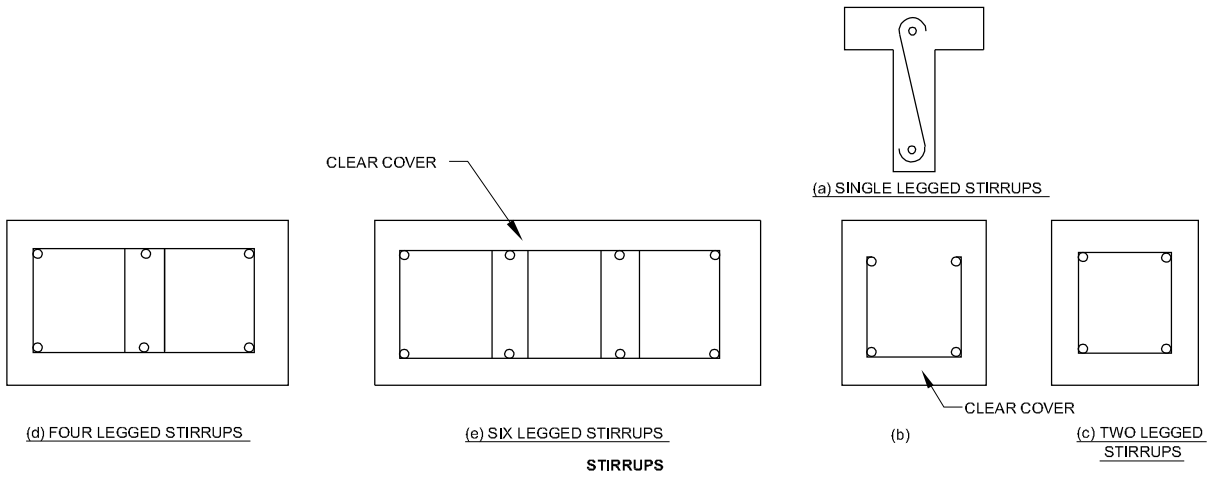
Important note: In case of torque steel no end hooks are provided.

ii Mix 20 i.e. 1:1 ½:3 is used throughout. Same be shown in all solutions. Vertical stirrups in beams and horizontal stirrups in column be shown by thin lines, in all solutions.

Cross - sections: Cross sections are taken near the centre and near the supports. These show overall and effective depths, width and number of bars of a beam. If longitudinal bars are placed in tiers is one above the other, these are also shown in x - sections. Side face reinforcement is also shown.

Stirrups are also shown in the X - sections by solid thin lines.

Fig 10



Tee - beam and inverted 'T' beam

Objectives: At the end of this lesson you shall be able to
- **define tee - beam and inverted beam**
- **explain general detailing of tee beam and inverted beam.**

Introduction

In this type of beams, the R.C.C floor or roof slab is cast monolithic with the beam. The stirrups and the bent up bars of the beam extend into the slab and a portion of the slab acts with the beam for resisting compressive stresses. This results in increasing the moment of resistance of the beam.

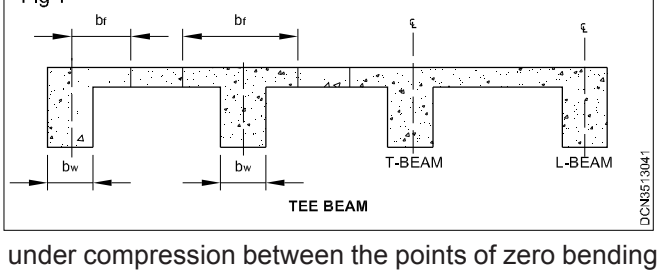
Definition

The slab cast integrally with the beam is called flange of the beam and the part of the beam projecting below the slab or flange is known as rib or web of the beam.

In general (Fig 1)

In case of simply supported beams the bending moment is of sagging nature throughout its length. Hence the slab forming the flange of the T- beam is subjected to compression all along the span and the beam behaves as a T- beam throughout the span. On the other hand in case of continuous beams the bending moment is of sagging nature at mid - span and it is of hogging nature at the supports. In the span portion the beam top remains

Fig 1



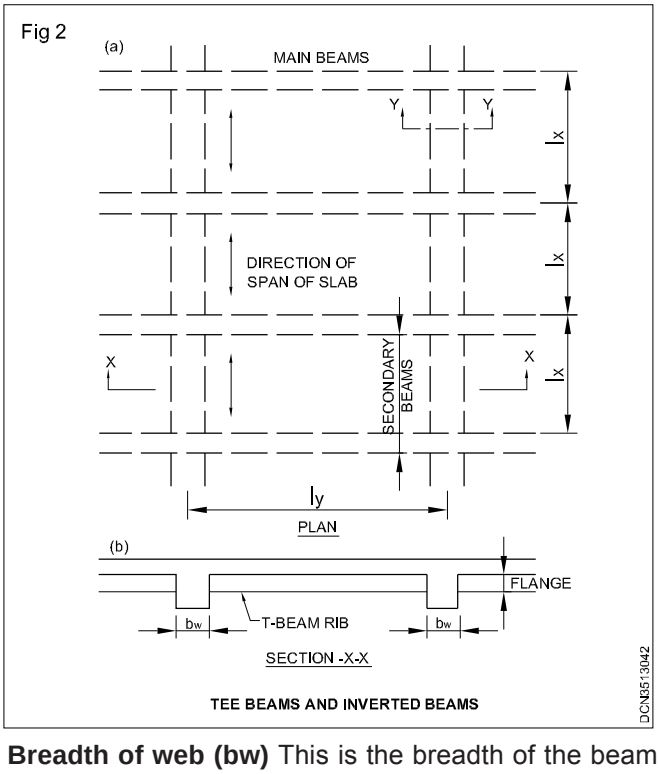
under compression between the points of zero bending moment and hence the contribution of flange remains effective within the mid - length (l_o) of the beam upto the points of zero bending moment. (This length can be assumed to be equal to 0.7 times the effective span) and the beam thus behaves as T- beam only for this length.

Beyond the points of zero BM and over the supports, the flange of the beam is subjected to tension.

Dimensions of a T - beam Figure 2 & 3 shows the important dimensions of a T - beam which are as under:

Thickness of the flange (df). This is equal to the overall depth of the slab forming the flange of the T - beam.

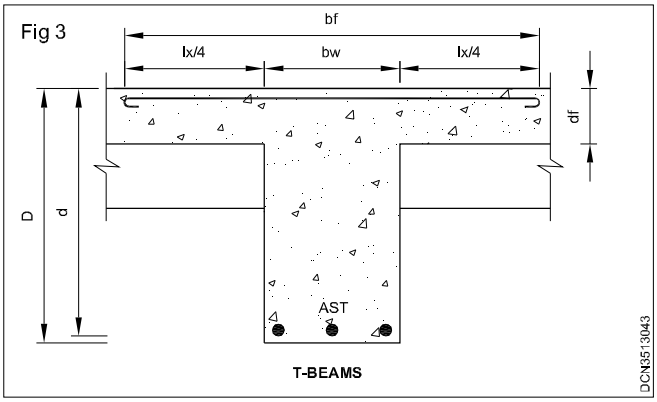
Fig 2



Breadth of web (bw) This is the breadth of the beam projecting below the slab. The breadth of web should be sufficient to accommodate the tensile reinforcement in the beam with suitable spacing between the bars.

Over - all depth of beam (D) The over - all depth of the beam depends upon the span as well as loading conditions. In case of simply supported beams it may be assumed to be 1/12 to 1/15 of the span. In case of continuous beam, the assumed overall depth may be taken as 1/15 to 1/20 of span for light loads; 1/12 to 1/15 of span for medium loads and 1/10 to 1/12 of span for heavy loads.

Fig 3



T-BEAMS

Effective width of flange (bf). It is obvious that the portion of slab (acting as flange) away from the beam web is stressed lesser than the portion immediately above the web. In order to simplify calculations certain width of flange (which normally works out to be less than actual width) is considered to be under uniform stress and hence effective for resisting compression in the beam. This width is termed as effective width of flange. The effective width of flange mainly depends upon the span, breadth of web and the thickness of slab acting as flange.

For continuous beams and frames l_o may be assumed as 0.7 times the effective span.

Inverted 'T' beam (Fig 4)

Technically speaking, in inverted beam the top reinforcement is heavier than bottom reinforcement as the top reinforcement is in tension & bottom reinforcement is in compression, however in normal beam the loading conditions are reverse.

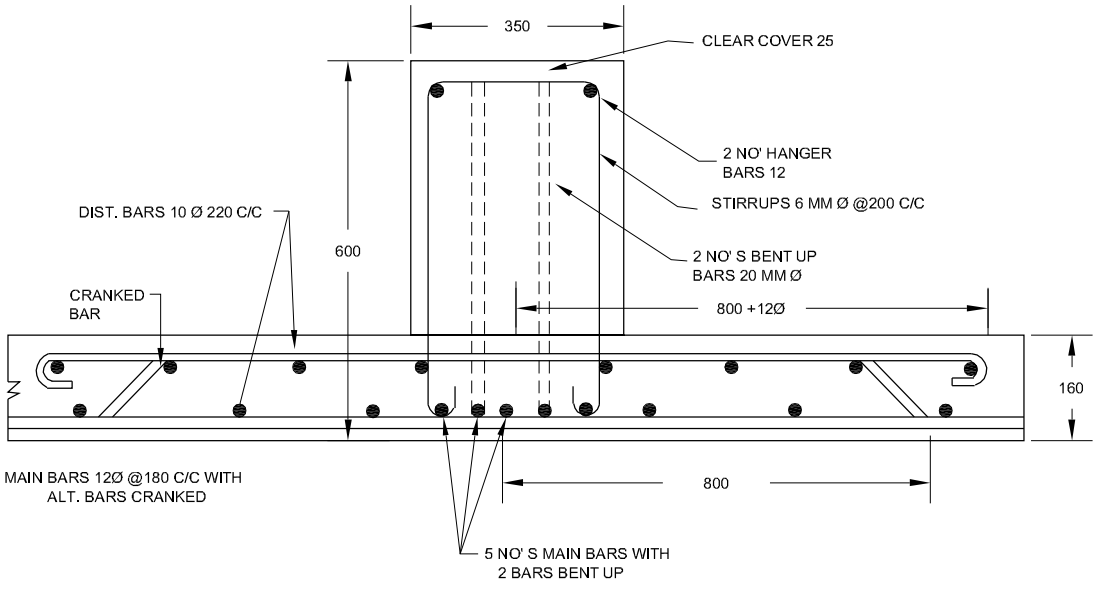
Generally inverted beam is used in cantilever slabs & for special architectural effects.

In inverted beam the deflection will take place in top of the beam. So, major reinforcement will be provided very opposite to the normal beam as load bearing condition is reverse.

Definition: We have seen that if the size of room is large, we may use monolithic beam slab, construction, forming the tee - beam roof. However in some cases the provision of the beam (i.e rib) below the slab may be undesirable from architectural point of view. In this case the beam is provided above the slab, forming what is known as the inverted T - beam system. In such a case , the ceiling composed of roof slab, is plane and the beam projects above the top of the slab. The slab is thus provided at the "tension" side of the beam and is therefore, not helpful in resting the tensile stresses in the beam. The beam therefore, acts as a simple rectangular beam, which may be either be singly reinforced or doubly reinforced. The depth of these beams is equal to the depth measured between top of the beam and bottom of the slab. Though the slab is cast monolithic with the beam, it is tied to the beam by providing suitable vertical ties or stirrups. The design of the slab however, is done in the same as for any ordinary T - beam roof.

Design of inverted T - beam roof : In some cases the ceiling of the roof slab is required to be plain (i.e, without any beam projections below) to meet the architectural requirements. In case the size of room is small one can provide one - way or two - way slab depending upon the length to breadth ratio. In case the size of room is large, beam and slab type of construction becomes inevitable. As explained earlier, in case the beams project below the

Fig 4



INVERTED BEAM

slab, the slab contributes to bear the compressive stresses and the beam behaves as a T - beam. In case the beam cannot be projected below the slab (to have plain ceiling) the roof slab can be supported by providing upstand or inverted beams projecting above the roof slab. In such a case the slab and beams are cast monolithically and the slab virtually hangs from the beams.

This type of construction is termed as inverted T - beam and slab construction. In this case the slab is designed exactly in the same manner as in case of T- beam and slab construction. However, the slab being located on the tension face of the beam, is not able to bear the compressive stress and hence the beam acts as a simple rectangular beam. The depth of the beam is considered upto the bottom of the slab.

R.C.C one way slab

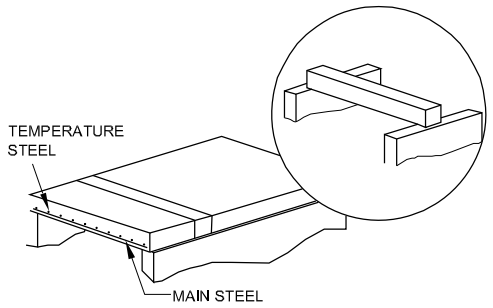
Objectives: At the end of this lesson you shall be able to
- **define one way slab**
- **explain types of one way slab**
- **describe reinforcement detailing and arrangement of one way slab.**

Introduction

The slab provides a horizontal surface and is usually supported by columns, beams or walls. Slabs can be categorized into two main types: one - way slabs and two - way slabs.

One - way slab is the most basic and common type of slab. One - way slabs are supported by two opposite sides and bending occurs in one direction only. Two way slabs are supported on four sides and bending occurs in two directions. One - way slabs are designed as rectangular beams placed side by side (Fig.1).

Fig 1



ONE - WAY SLAB DESIGN CONCEPT

However, slabs supported by four sides may be assumed as one - way slab when the ratio of lengths to width of two perpendicular sides exceeds 2.

Even though such slabs supported in four directions, nearly all load is transferred in the short direction.

Definition

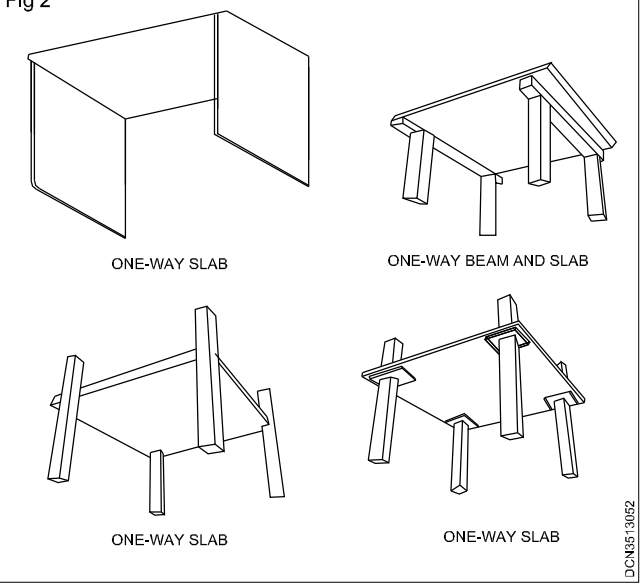
A concrete slab is said to be spanning in one direction when it is supported on two opposite sides. A slab, when supported on all four sides and if the length of the slab exceeds two times its width, is also said to be spanning in one way slab.

General: For small spans say upto 3.75 m in width, which are not subjected to heavy loadings, a simple slab may suffice. When the ratio of the length of a room to its breadth is greater than 2, most of the load is carried by the short span (i.e. the width the room) and as such the slab is designed to span along the width of the room as a one - way slab. In case of one - way slab the main reinforcement of the slab, span along the width of the room while the distribution bars, laid at right angles to the main reinforcement, lie parallel to the length of the room.

One - way beam and slab / one - way flat slab (Fig.2)

These slabs are supported on two opposite sides and all bending moment and deflections are resisted in the short direction. A slab supported on four sides with length to width ration greater than two, should be designed as one way slab.

Fig 2



One - way joist floor system

This type of slab, also called ribbed slab, is supported by reinforced concrete ribs or joists. The ribs are usually tapered and uniformly spaced and supported on girders that rest on columns.

Effective span

Effective span = clear span + effective depth.

= distance between the centre of supports.

or

The smallest of the two values is adopted for design purposes.

Slab depth

Minimum depth of slab, d = span/30.

Effective depth = 4 cm. per metre of span for load intensity upto 500 kg/m^2

6 cm. per metre of span for load intensity upto 1000 kg/m^2

The ratio of effective span to overall depth should not exceed the following value.

Slab type	Maximum of effective span/over all depth
Simply supported	30
Continuous	35
Cantilever	12

Minimum reinforcement

The reinforcement in either direction shall not be less than 0.15% and 0.12% of the cross sectional area of the concrete when using mild steel bars and deformed bars respectively.

Maximum diameter

The diameter of reinforcing bars shall not exceed one eight of the total thickness of the slab.

Spacing of main steel

Spacing of the bars of main tensile reinforcement in solid slabs shall not be more than three times the effective depth or 450 mm whichever is small. Alternate bars should be cranked at a distance of L/7 and L/5 from face of support for partially fixed and continuous slab respectively.

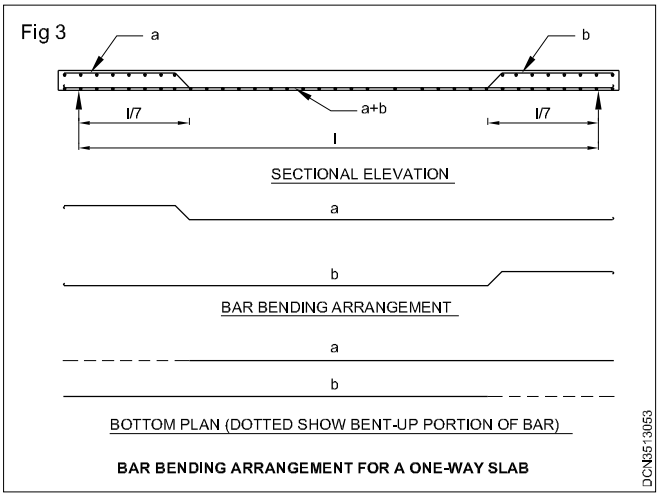
Distribution steel

Spacing of the distribution or secondary steel provided for shrinkage and temperature shall not be more than five times the effective depth of such slabs or 450 mm whichever is smaller. Details of reinforcement arrangement are given in the figure attached.

Arrangement of reinforcements in slabs

A standard bar bending arrangement of the designed reinforcement for a one-way slab has been shown in Fig.3

Fig 3



Two way slab (R.C.C)

Objectives: At the end of this lesson you shall be able to
- **define two way slab**
- **explain types of two way slab**
- **explain the reinforcement details of two way slab**
- **explain torsion reinforcement.**

Introduction

When the length of slab is less than twice the breadth, slab have tendency to bend along both the spans. So the amount of maximum BM and deflection are very much reduced and as such comparatively thinner slabs are required. But reinforcement has to be provided in both the directions.

Definition

A slab which supported on all four edges and the ratio of long span to short span is not more than two is called a two way slab.

Two- way slabs carry the load to two directions, and the bending moment in each direction in less than the bending moment of one-way slabs. Also two-way slabs have less deflection than one-way slabs. Compared to one way slabs, calculation of two-way slabs is more complex.

In case the slab is supported along all the four sides, it has tendency to bend into a dished surface when loaded. Thus at any point the slab is curved in two principle directions or develops bending moment in two directions. Such a slab has to be reinforced at the bottom for tension in two direction perpendicular to each other. The load from the slab in such a case is obviously transferred on all the four supporting sides.

This type of behaviour holds good when the ratio between length and breadth of the slab is less than two. For increased ratio of sides, the slabs virtually spans along the shorter side and it is designed as one way slab.

Types of two way slab

Two way slabs may be divided into following three categories.

1 Simply supported on all four edges and corners are free to lift.

2 Simply supported on all four edges and corners are held down.

3 Edges fixed or continuous.

Roof slab of an individual room of a single storied building is best example for category- 1. In this slab corners are free to lift and so no torsion stresses are developed and as such no torsion reinforcement is required.

Category -2 is the intermediate floor slab of a multistoried building having single room on each floor or slab monolithic with beams on all edges. Here the corners are held down or corners not free to lift and so torsion stress will develop. Torsion reinforcement in the form of mesh both near top and bottom should be provided at each corner.

Continuous or fixed slabs are usually coming in framed structures. These slabs may have different end conditions as follows.

1 One edge continuous other edges discontinuous.

2 All edges continuous.

3 Adjacent two edges continuous other two edges discontinuous.

4 Three edges continuous one edge discontinuous.

According to these conditions coefficients for BM and SF are obtained from the IS code and proper design steps are adopted.

Typical type of two way slab

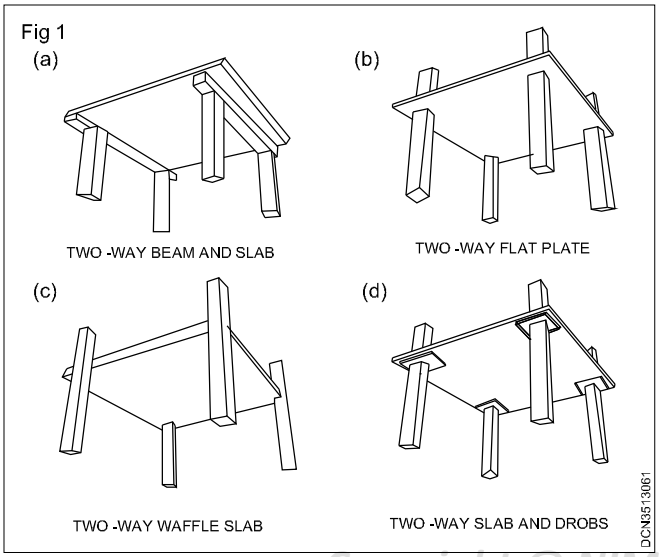
1 Two - way beam and slab (Fig 1a)

If the slab is supported by beams on all four sides, the loads are transferred to all four beams, assuming rebar in both directions.

2 Two - way flat slab (Fig 1b)

A flat slab usually does not have beams or girders but is supported by drop panels or column capitals directly. All loads are transferred to the supporting column, with punching shear resisted by drop panels.

Fig 1



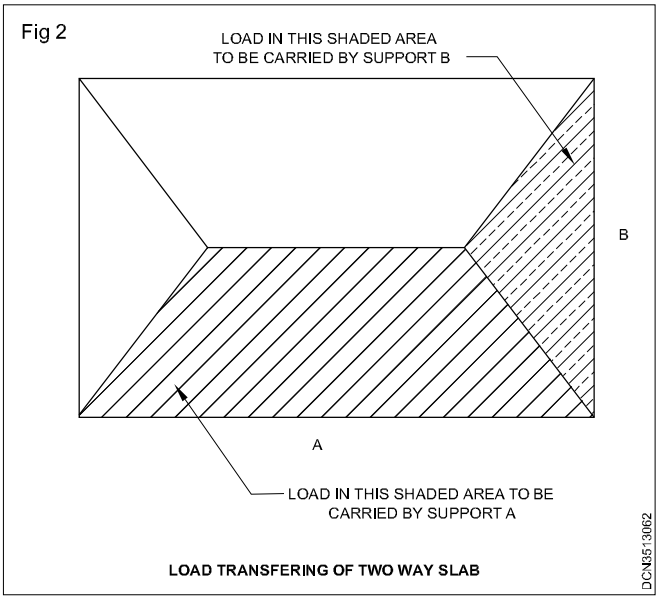
3 Two - way waffle slab: (Fig 1c)

This type of slab consists of a floor slab with a length - to - width ratio less than 2, supported by waffles in two directions.

Load transferring of two way slab (Fig 2)

The loads on beams or walls supporting solid slabs spanning in two directions at right angles and supporting UDL may be assumed to be in accordance with the figure given below.

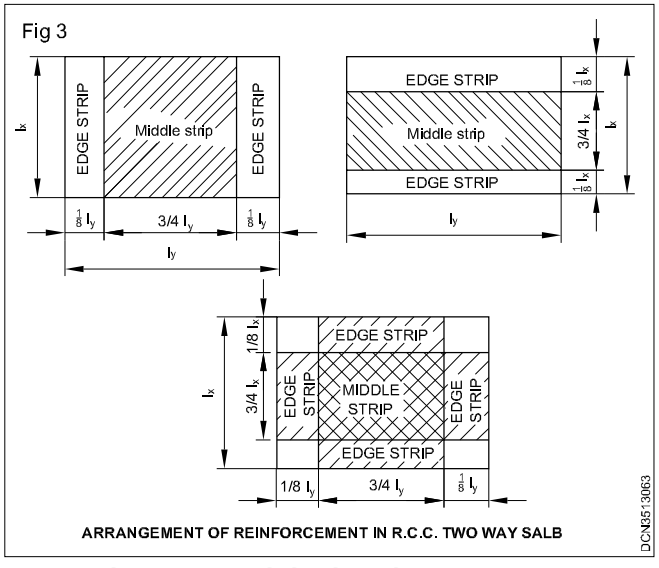
Fig 2



Arrangement of reinforcement in R.C.C two way slab

For providing reinforcement, the slab is considered to be divided in each direction into middle strips and edge strips. The width of the middle strips along each span (long or 3/4th short span) is 3/4th width of slab in the respective span. The width of each edge strip is similarly 1/8th of the width of slab in the respective span. Each middle strip contains the reinforcement calculated based on consideration of maximum bending moment for the respective strip. (Fig 3)

Fig 3



In the edge strip minimum area of reinforcements as per rules should be provided.

The following point as given in code have to be taken note of while detailing reinforcement in the slab.

1 The maximum bending moment worked out based on above formula apply only to the middle strips and no distribution is allowed.

2 The tension reinforcement provided at mid - span in the middle strip, shall extend in the lower part of the slab to within 0.25 l of a continuous edge or 0.15 l of a discontinuous edge.

3 Over the continuous edges of a middle strip, the tension reinforcement shall extend in the upper of the slab a distance of 0.15l from the support and at least 50% of the bars shall extend a distance of 0.3l.

4 At the discontinuous edge, - ve moments may arise. They depend on the degree of fixity at the edge of the slab but, in general, tension reinforcement equal to 50% of that provided at mid - span extending 0.1 l into the span will be sufficient.

Torsion reinforcement

Reinforcement which is provided to counteract the tensional stress developed at corners of slabs is called torsion reinforcement. They should be provided as follows.

1 Torsion reinforcement shall be provided at any corner where the slab is simply supported on both edges meeting at that corner. Size of torsion mesh should be 1/5th of short span and the area of steel should be 75% of the area at mid span in short span.

2 Torsion reinforcement equal to half of above shall be provided at a corner contained by edges over only one which the slab is continuous.

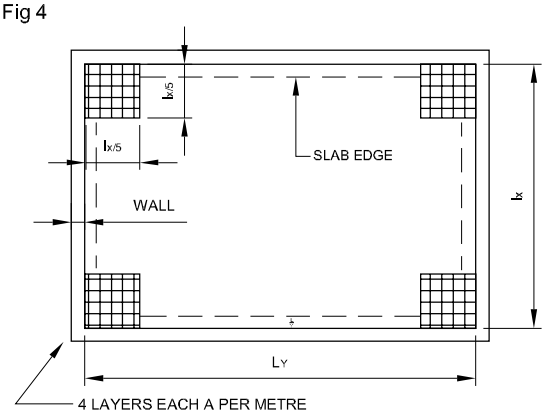
3 Torsion reinforcements need not be provided at any corner contained by edges over both of which the slab is continuous.

For the design purpose slabs is considered as divided in each direction into middle strips and edge strips, the middle strip being 3/4 of corresponding span. Edge strips are 1/8 on each. Reinforcement arrangement of each of slab is given in figures attached.

Provision of torsion reinforcement. According to Indian standards code of practice (I.S. 456-1978) torsion reinforcement must be provided at the corners of restrained two way slab except at corners contained by edges over both of which the slab is continuous. The area of torsion reinforcement to be provided under different conditions of slab is given in Fig 4,5

Incase of isolated slab, having no continuous edge, torsion reinforcement is provided in the form of square mesh placed both at the top and bottom face of the slab at each corner. Each square mesh of reinforcement consists of two layers of bars placed parallel to sides of the slab and extending in these directions for a distance equal to one-fifth of the shorter span. The area of bar per unit width of the slab in each layer of the mesh should be 3/4 of the area of steel required for the maximum positive bending moment in the slab.

Fig 4



PLAN SHOWING ARRANGEMENT OF TORSIONAL REINFORCEMENT IN A NON-CONTINUOUS RESTRAINED SLAB WHERE A= $\frac{3}{4}$ AREA OF STEEL REQUIRED PER METRE WIDTH OF SLAB FOR MAXIMUM POSITIVE B.M. IN SLAB

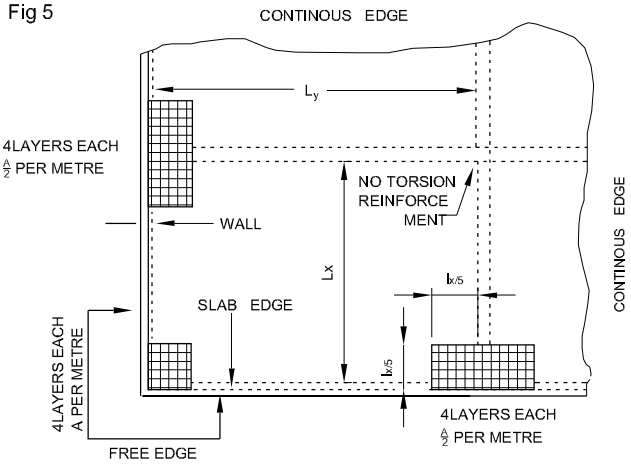
PROVISION OF TORSION REINFORCEMENT

DCN3513064

At corners contained by the edges over only one of which slab is continuous, the area of bars per unit width of the slab in each layer of the mesh of torsion reinforcement should be 1/2 of the area of steel required in 9.4.2 (i) above. This is shown in Fig.8

The reinforcements available in the edge strips, which extend to the corners of the slab may be treated as a part of torsional reinforcement.

Fig 5



PLAN SHOWING ARRANGEMENT OF TORSIONAL REINFORCEMENT IN A CONTINOUS RESTRAINED SLAB WHERE A = $\frac{3}{4}$ AREA OF STEEL REQUIRED PER METRE WIDTH OF SLAB FOR MAXIMUM POSITIVE BM.IN SLAB

PROVISION OF TORSION REINFORCEMENT

DCN3513065

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 rebending 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 diametre of bars but minimum 2.5 mm.

2 Clear cover for slabs = 15 mm or diametre of bar whichever is more.

3 Clear cover for beams = 25 mm or diametre of bar whichever is more.

4 Clear cover for columns = 40 mm or diametre 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 dispends 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%

Bream - 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 open. 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 end cover

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

= l + 2 x length of one hook

= l + (2 x 9ϕ) = l + ϕ18

'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 x 0.42 d = l+18ϕ+0.84d

length of distributor bar = l + ϕ18

(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

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

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

Therefore, total number of distributor bars

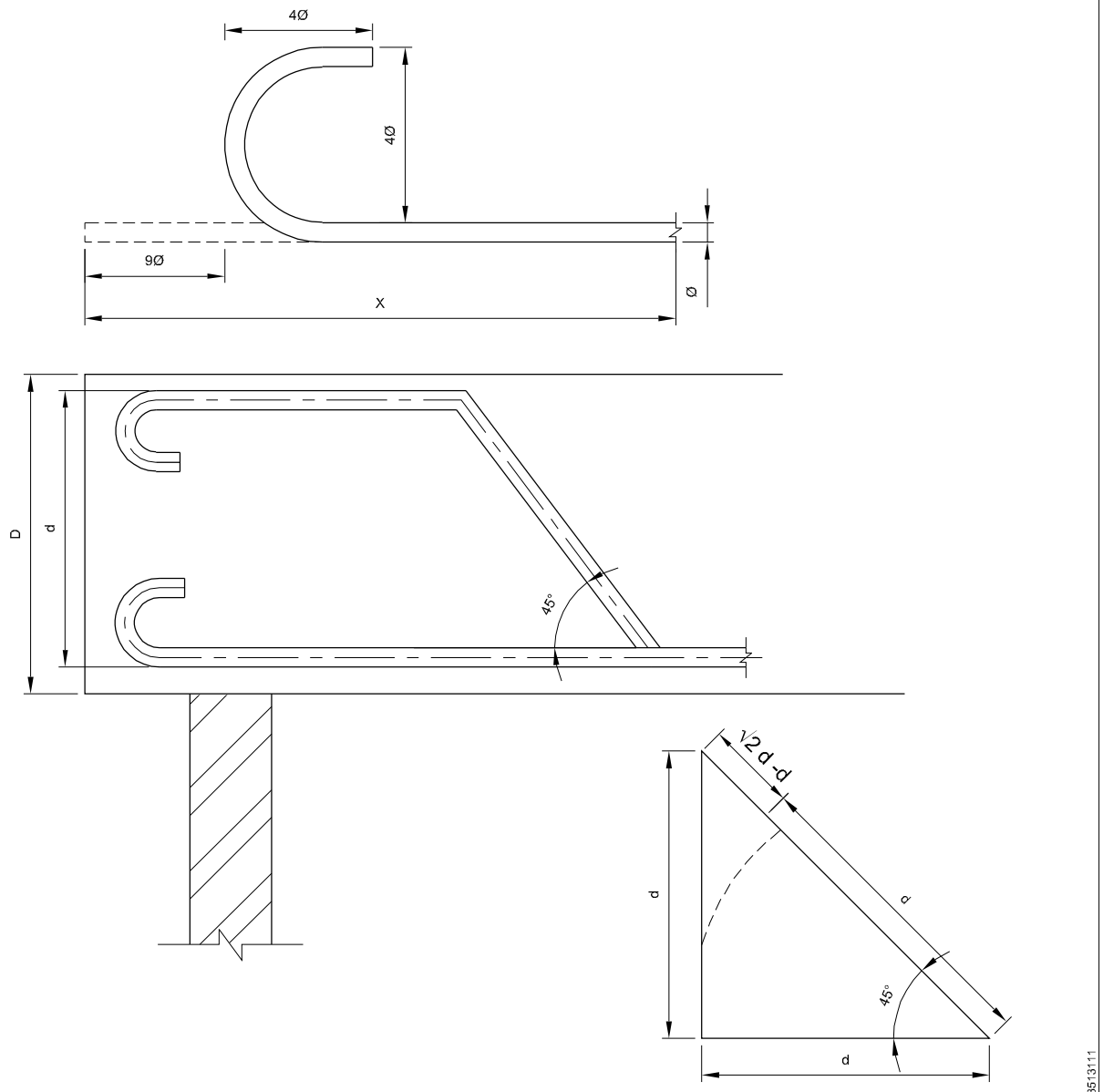
$$= \left[\frac{l}{\text{Spacing}} + 1\right] + 2\left[\frac{X}{\text{Spacing}} + 1\right]$$

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, barbending 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

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 ready made 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) (Fig 2 & 3,4)

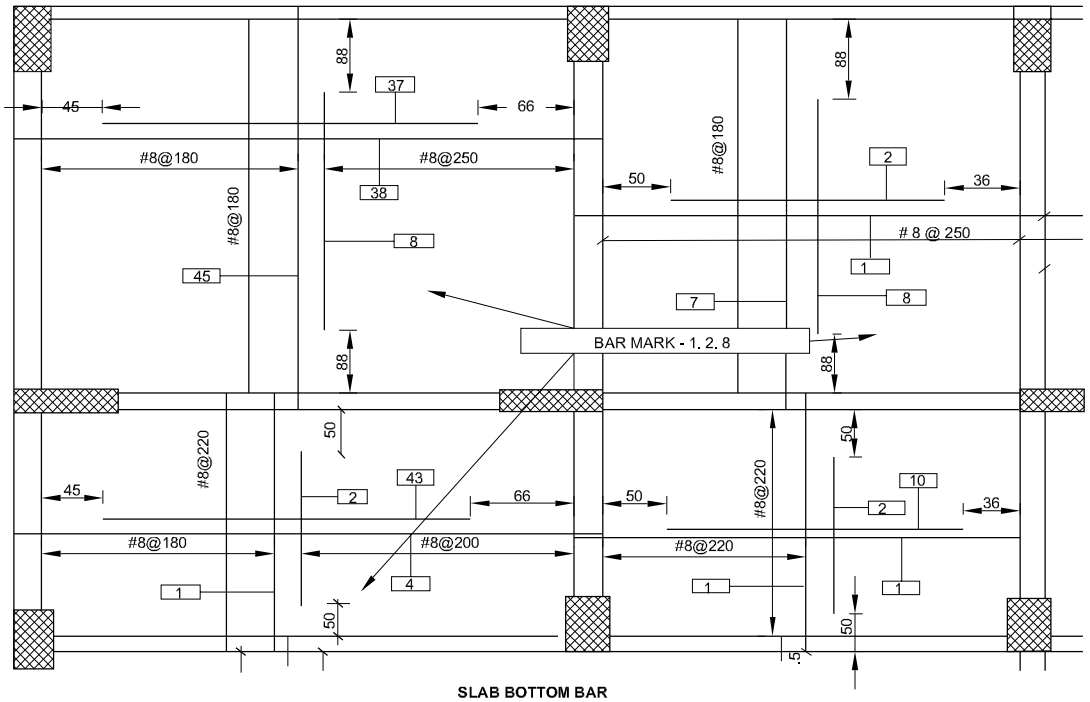
Part drawing of slab bottom reinforcement details is shown. As more details are put in the drawing it is ideal to show top and bottom bar separately in the drawings. Every bar is also marked with a number called 'bar mark' (Exambles-1, 2, 8 etc). This bar mark is the identifier for the bar in the BBS. 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.

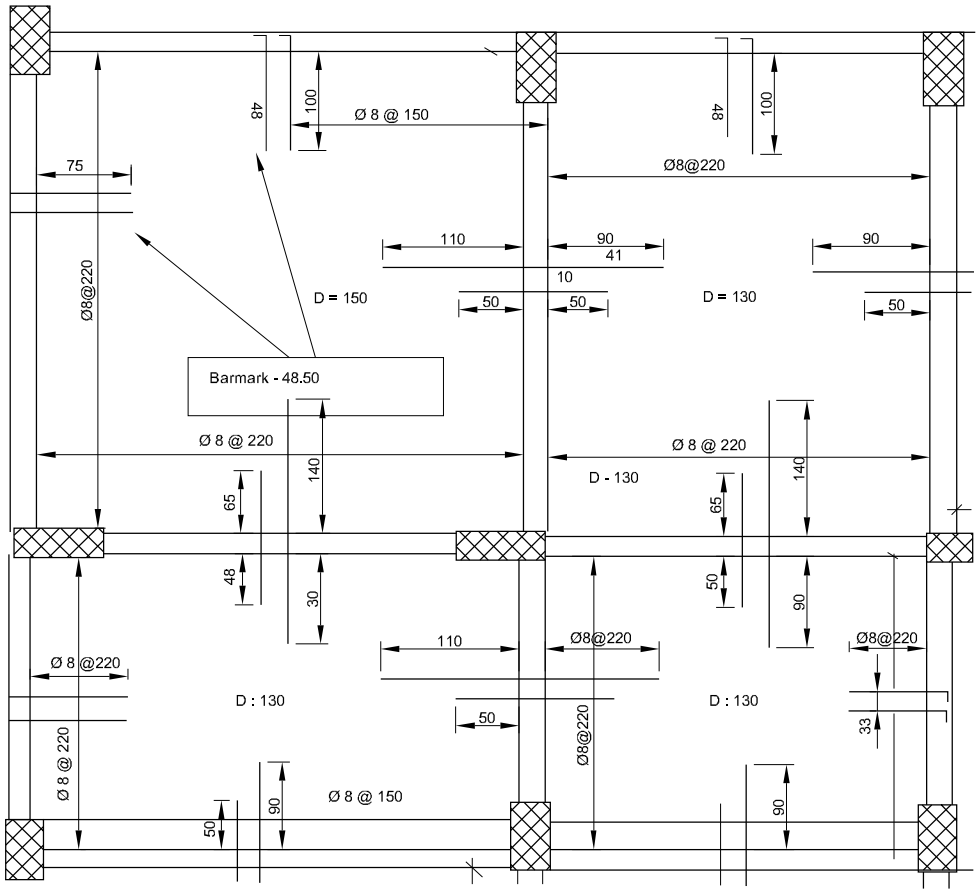
2 Cutting and bending in a cut and bend factory avoids the wastage completely (5-7 %). With BBS, bars can be cut with planning to reduce the wastage in a site with even the present setup.

Fig 2



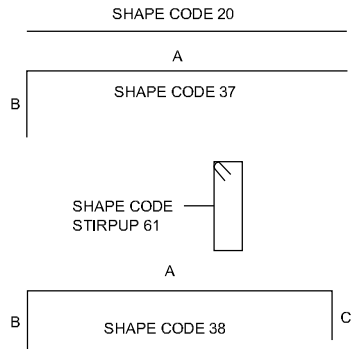
SLAB BOTTOM BAR

Fig 3



SLAB TOP BAR

Fig 4



BAR BENDING AND SCHEDULING

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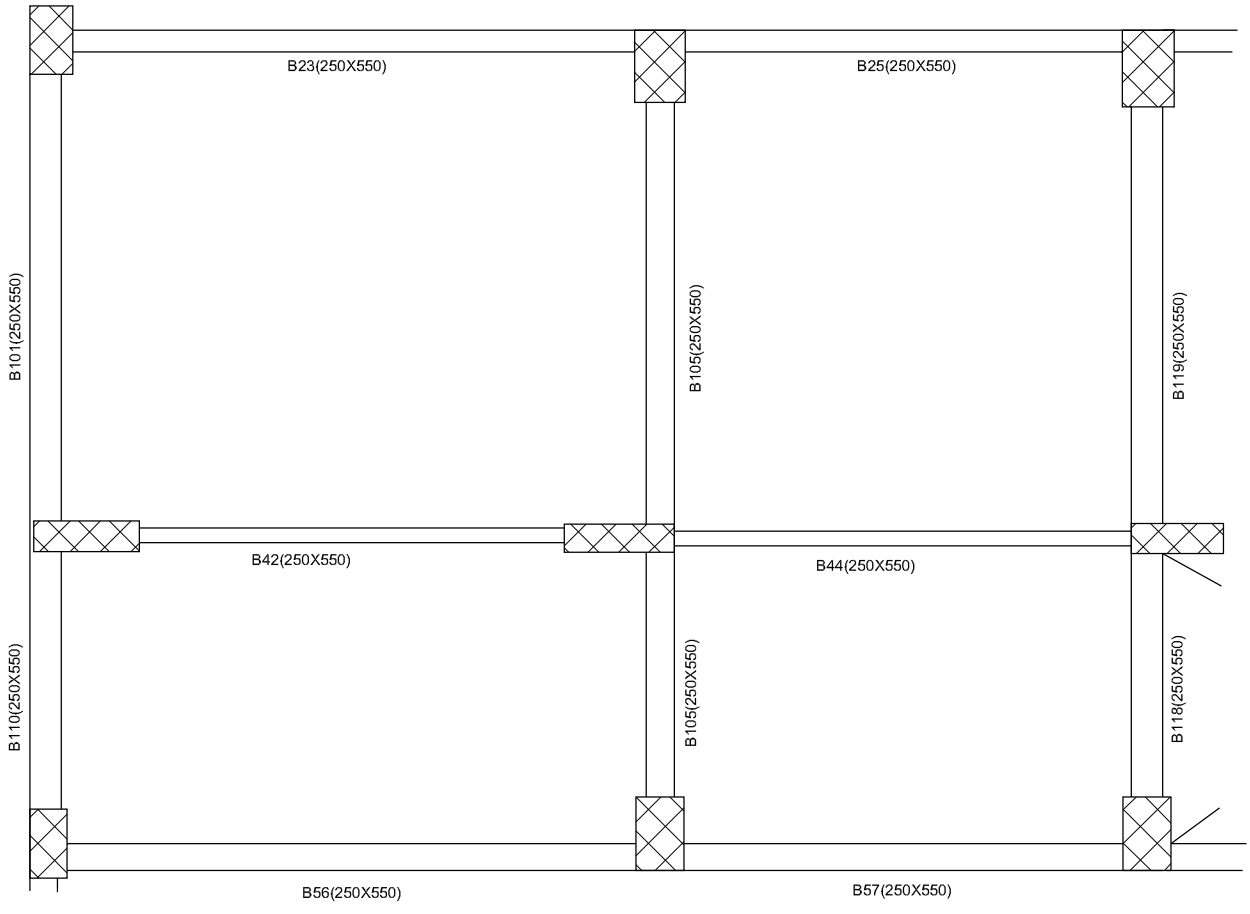
Fig 5



BEAM LAYOUT

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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. (Fig 5 & Fig 6)

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

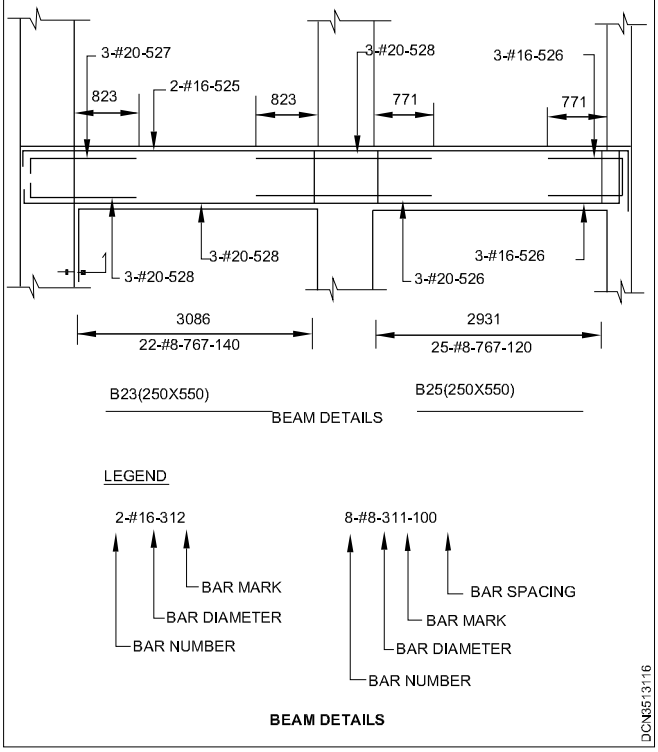
10 Bench marking quantity and quality requirements.

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 is space limitations.

Fig 6



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 paper less 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 landscapping 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 will 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.

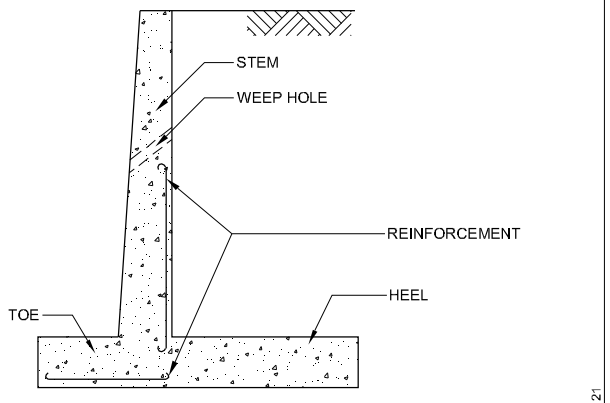
4 Counter fort walls.

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.

Fig 1



SEMI - GRAVITY RETAINING WALL

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, steam, 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 steam. 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 Figure 2. To resist the temperature stress at the outer face of steam, 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.

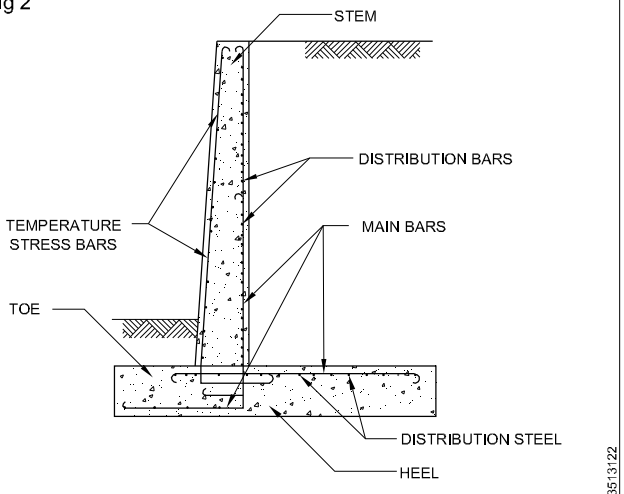
Thickness of base slab.

Minimum .....0.1H.

Toe projection beyond the outer face of the stem.

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

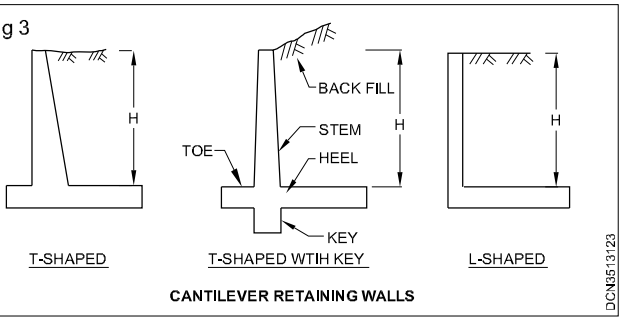
Fig 2



CANTILEVER RETAINING WALL

Cantilever retaining walls are R.C.C. walls made in the form of an invented 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)

Fig 3



CANTILEVER RETAINING WALLS

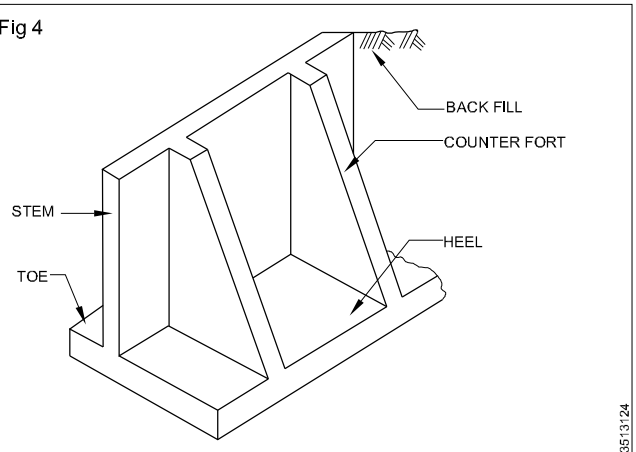
the stem, the toe and the heal. Each of these components are designed as a cantilever. The stability of the wall is partially provided by the weight of earth on the heel. Sometimes the cantilever wall is constructed in the form of L.

Counter - fort retaining wall (Fig 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 ½ to 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

Fig 4

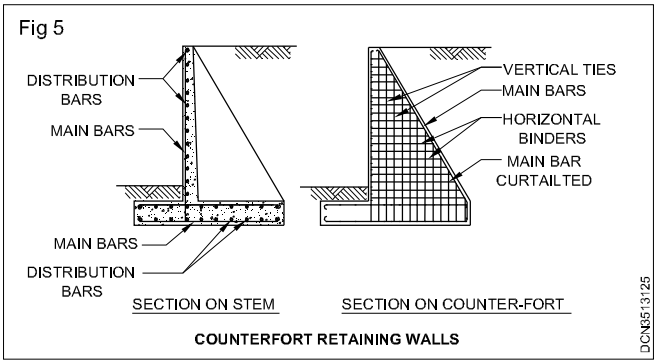


COUNTERFORT RETAINING WALLS

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.

Fig 5



COUNTERFORT RETAINING WALLS

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 very from 1/3 to ½ of the height of wall. The more the height of the wall, the closer should be the spacing of counterforts.

R.C.C formed structure

Objectives: At the end of this lesson you shall be able to
- **define portal frame**
- **explain method of portal frame**
- **illustrate advantages and advantages 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 filld 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.

Defenition

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

Connection of frame with foundation

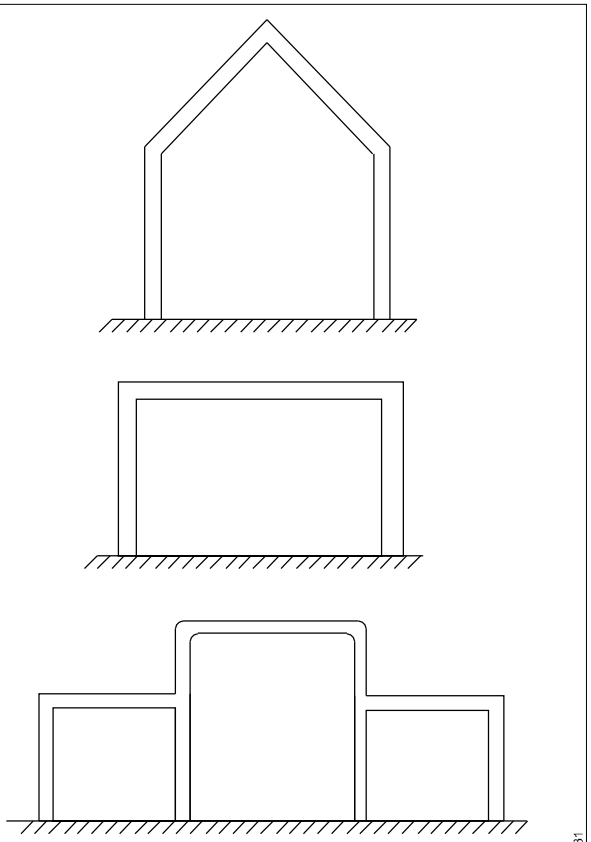
In a portal frame column base is connected in foundation by any of the following method.

Fixed connection.

Hinged connection.

In fixed connection column is directly connected to footing as in the case or 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 Figure 2 & 3.

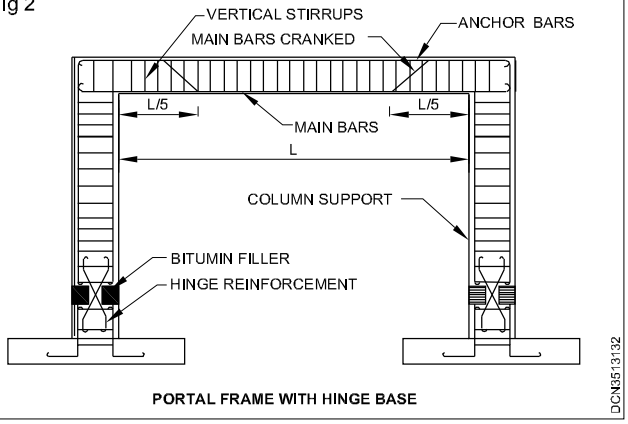
Fig 1



PORTAL FRAMES

DCN3513131

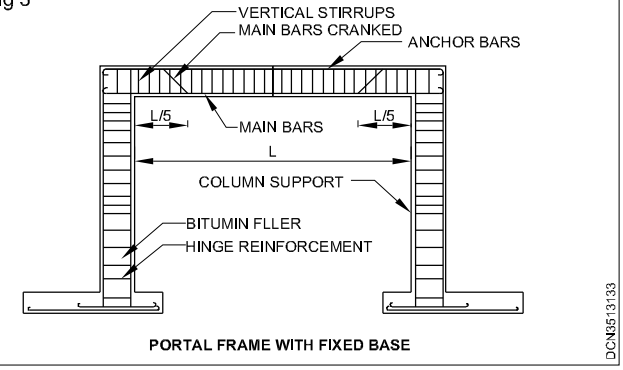
Fig 2



PORTAL FRAME WITH HINGE BASE

DCN3513132

Fig 3



PORTAL FRAME WITH FIXED BASE

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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.

i Portal frames are easy to construct than walls or any other structures. It require less time to construct the portal frames.

ii They are economic in nature. The cost of maintenance is low.

iii They provide good floor to ceiling heights.

iv Portal frames saves time and money.

v Portal frames are easily available at all the places.

vi 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.

vii Portal frame structures provide good ventilation and lighting.

Disadvantages

Following are some limitations of the portal frames.

i It is not easy to build the portal frame anywhere. They can be constructed only hill, valley, and sloppy areas.

ii Sometime, they also depends on the type of structure. Building shape should be square, rectangular only.

iii Roof pitch should be shallow, steep, mono - pitch.

iv 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.

v Only skilled workers are required to construct the portal frames.

vi The strength of portal frame structure is less than RCC structure. It is very difficult to compare it with the reinforcement structure.

vii 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 the construction work. Portal frames are easy to construct, so they are commonly used at all places.

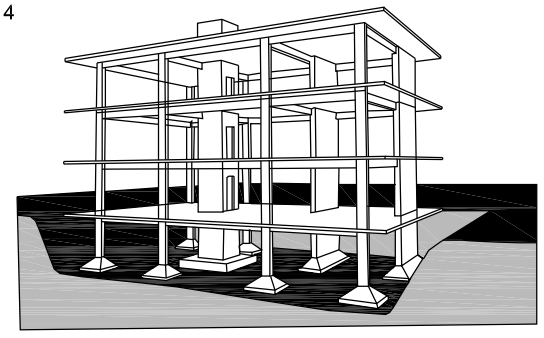
Conclusion

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 days, most of portal frames structure are used in the industries. Portal frames save money and time.

R.C.C framed structures (Figs 4,5)

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.

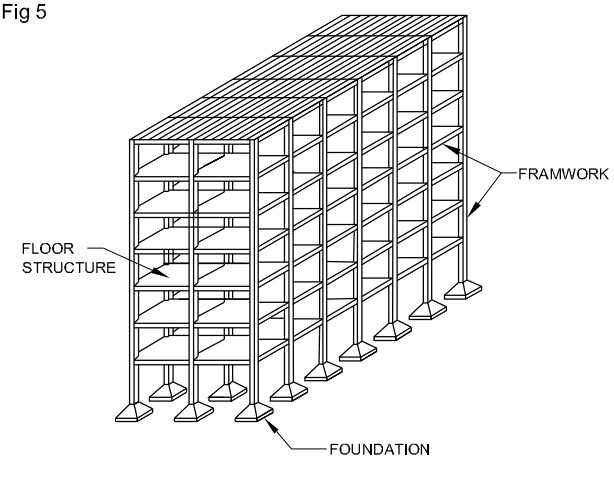
Fig 4



R.C.C FRAMED STRUCTURE

DCN35131134

Fig 5



R.C.C FRAMED STRUCTURE

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When we say concrete in the building trade, we actually mean reinforced concrete. It 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 formwork, 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 nplace 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/m^2, offices to be 250 kg/m^2, and industrial to be 1000/m^2, which is the same as 1T/m^2. 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 windspeeds, and are specified in building codes. A building can commonly be required to resist a wind force of 150 kg/m^2, 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 inthe 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 are 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.

Common form of steel sections

Objectives: At the end of this lesson you shall be able to
- **explain the term steel structures**
- **explain the advantages and disadvantages of steel structures**
- **explain the types of steel structures**
- **explain the various steel sections used for steel structures.**

Introduction

Steel structure is an assemblage of a group of members expected to sustain their share of applied forces and to transfer them safely to the ground.

Structural steel has been used in the construction of structures for well over a century. It is perhaps the most versatile of structural materials and has been used extensively in the construction of multistoreyed buildings, bridges, industrial structures, towers and other structures.

Advantages

The main advantages of structural steel are as follows

1 **High strength**: Due to the high strength of steel per unit weight, dead loads will be small.

This fact is of great importance for tall buildings and long span bridges, and for structures having poor foundation conditions.

2 **Adaptation to prefabrication:** Components of steel structures could be fabricated in workshop and transported over long distances and assembled at the site.

3 **Speed of erection:** Even long span structures can be erected in a very short time and structural steel is preferred to any other material when the construction is to be completed in a few hours or days.

The other advantages of structural steel are

4 Elasticity 5 Ductility 6 Weldability 7 Toughness and fatigue strength 8 Possible reuse after a structure is dismantled and 9 Suitability to provide additions to existing structures.

Disadvantages

The disadvantages of steel as a structural material are as follows

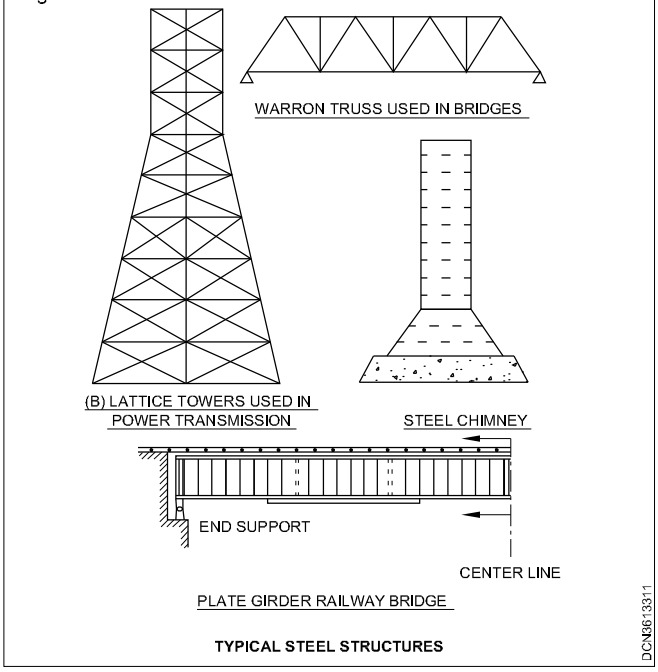
Maintenance costs: structural steel tends to corrode when freely exposed to air and must be periodically painted.

Fire-proofing costs: The strength of steel is greatly reduced at temperatures which are commonly attained in fires. It is desirable that the steel frame of a building must be fire - proofed to get an appreciable fire rating which involves considerable additional expenditure.

Types of steel structures

Buildings, bridges, tanks, silos, cranes, transmission line towers etc. are examples of steel structures. Fig 1 shows how some typical steel structures. Although these structures are three dimensional, they are essentially made of one dimensional members (beams and columns) and two - dimensional members (frames, plates). These members are designed assuming that they behave independently to each other.

Fig 1



TYPICAL STEEL STRUCTURES

Standard sections

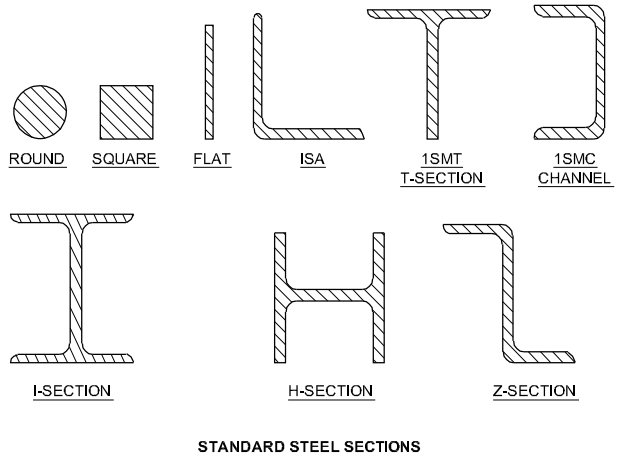
Steel structures are constructed using hot rolled steel sections of various shapes, which are readily available. Often composite sections are made by combining standard sections. The use of these standard sections is recommended for economical reasons.

Available standard sections are shown below

The properties of standard rolled sections are given in the hand book for structural engineers. SP:6(1) and in steel tables.

A structural member can be a standard rolled section given in Fig 2 or it may be built - up from a number of standard rolled shapes by connecting them by welding, riveting or bolting. Some built up sections are shown in Fig.3.

Fig 2



STANDARD STEEL SECTIONS

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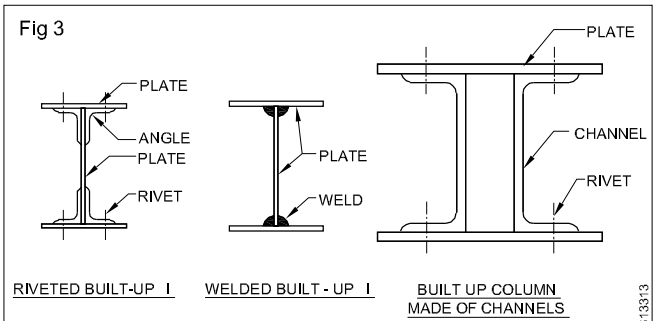
Fig 3



BUILT UP SECTIONS

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Structural fasteners and joint

Objectives: At the end of this lesson you shall be able to
- **explain the term beam to beam connection and types**
- **explain the term column to beam connections and its types.**

Beam to beam connections

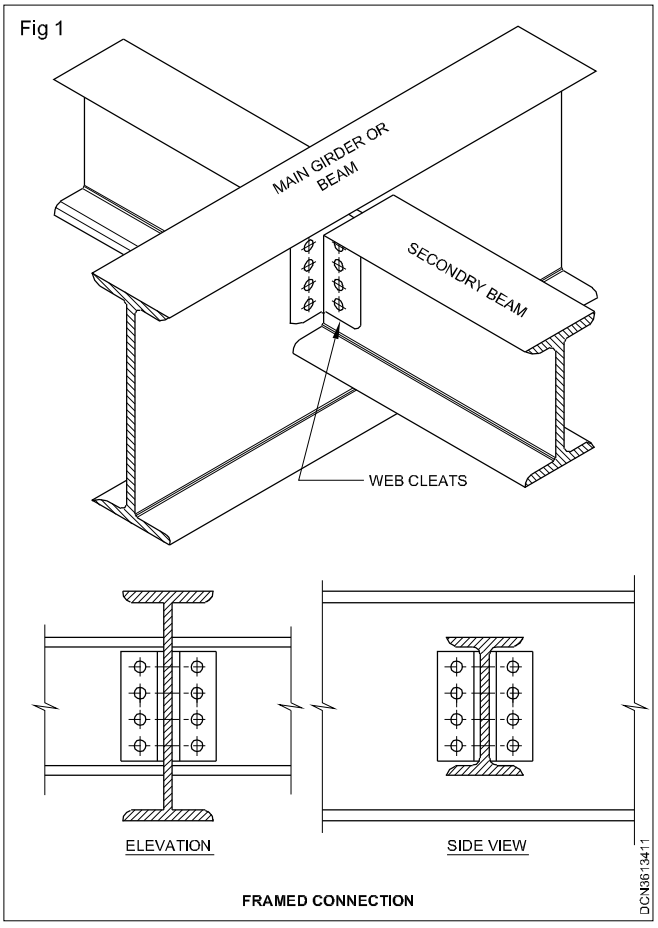
Steel structures are preferred for large spans. Secondary beams of smaller sections are provided between the main beams so as to divide the covering area in small bays and thereby loads may be broken up in smaller units. This helps in selecting higher sections for the fabrication of frame work. To achieve thin smaller beams are to be connected to the main beams. Such connections are known as beam to beam connections. This beam to beam connection may be of two types.

i. Framed connection ii. Seated connection

Framed connection (Fig.1)

In this type of beam to beam connection two angles placed on either side of the web of the beam are connected to the web of the main beam.

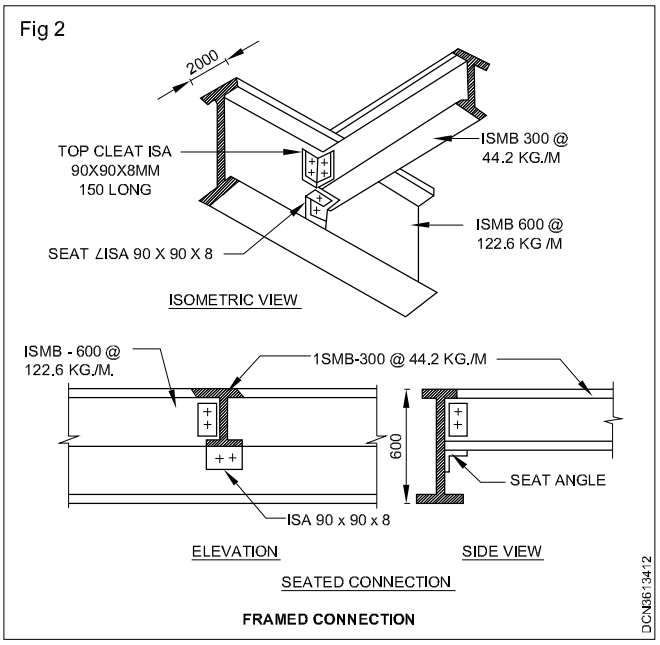
Fig 1



Seated connection (Fig 2)

In this type of beam to beam connection two angles are connected to the flanges of the beam also.

Fig 2



Column to beam connections

Steel beams are supported at the ends by masonry wall or steel columns. Mainly steel columns are used to supports the beams. A skeleton in the form of a frame is thus formed by vertical columns and horizontal beams. The beams may thus be riveted to the flanges or web of vertical column. Column to beam connections are of two types.

i Framed connections ii Seated connections

Framed connections (Fig 3)

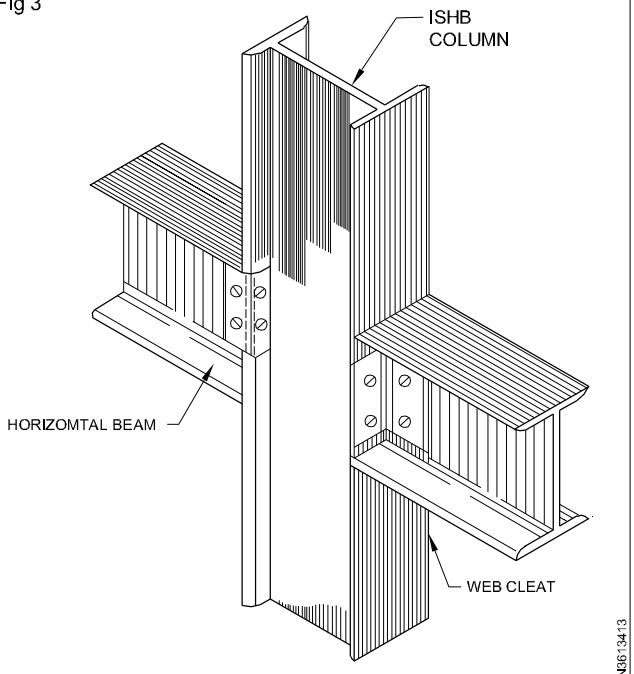
When beam is connected to the column flanges by placing cleat angles on either side of the web of a beam, the connection is called framed connection.

Seated connections (Fig 4)

When beam is connected to the column by cleats with the flanges of the horizontal beam for joining it to column, the connection is called a seated connection. Beam may be connected to the web or flange of the column.

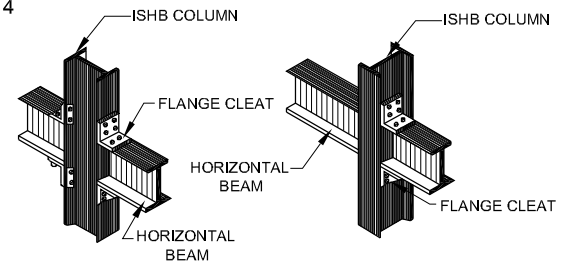
When the beam reaction is large, then the seat angle alone will not be sufficient. In such cases, the horizontal leg of the seat angle is stiffened by means of a vertical angle. Such a connection is called a stiffened seat connection. This is generally provided for reactions exceeding 150 KN.

Fig 3



COLUMN TO BEAM FRAMED CONNECTION

Fig 4



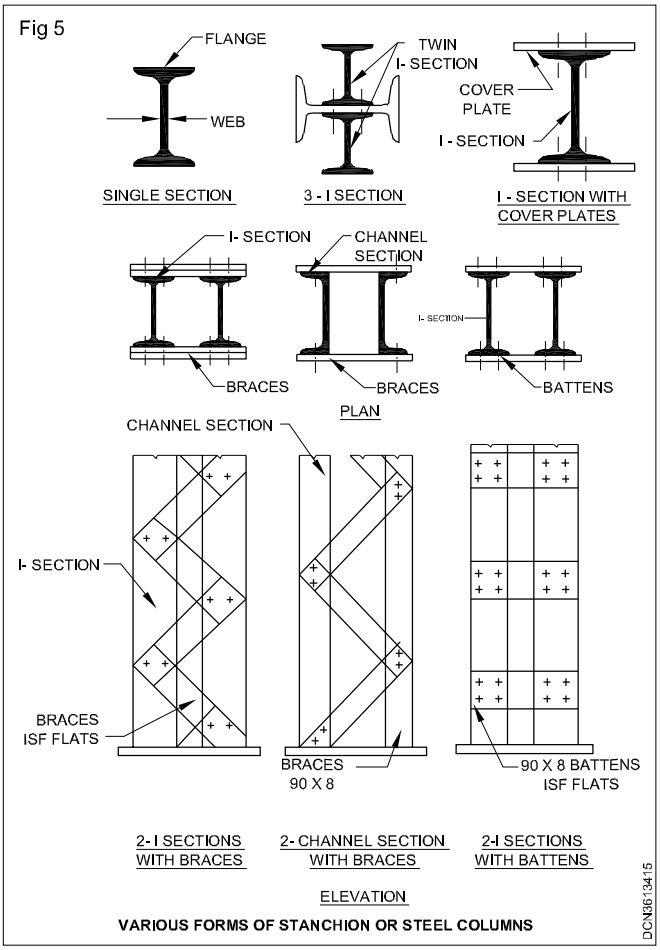
COLUMN TO BEAM SEATED CONNECTIONS

Steel stanchion

When vertical supports is of circular cross section and of approximately cylindrical form it is known as column. Vertical compression members in a building if cast into rectilinear form or built up form rolled steel sections of rectilinear outlines, it is termed as stanchions.

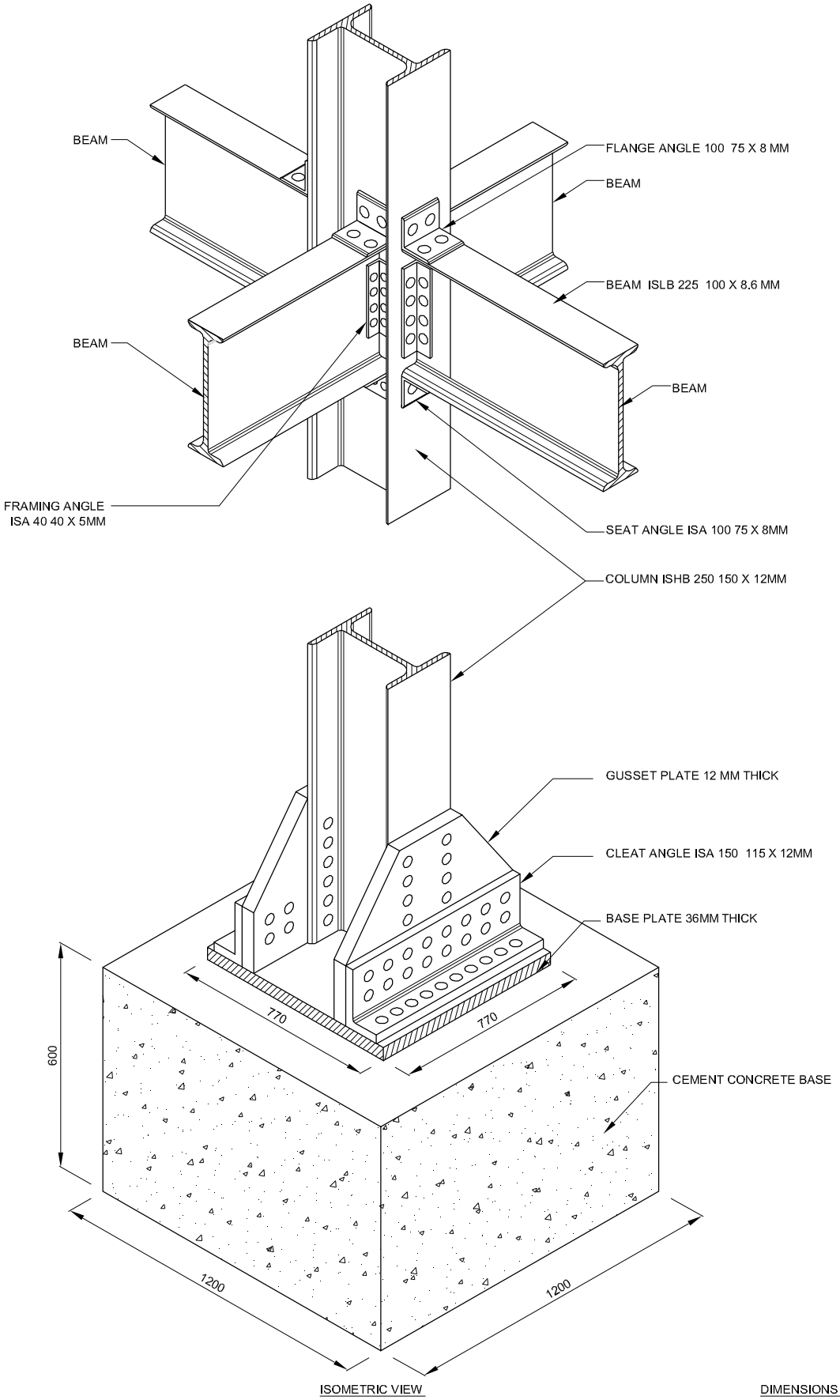
Steel stanchions may be of a single rolled steel section or compound sections of suitable sizes. Various forms are show in Fig 5 & 6.

Fig 5



VARIOUS FORMS OF STANCHION OR STEEL COLUMNS

Fig 6



STEEL STANCHION

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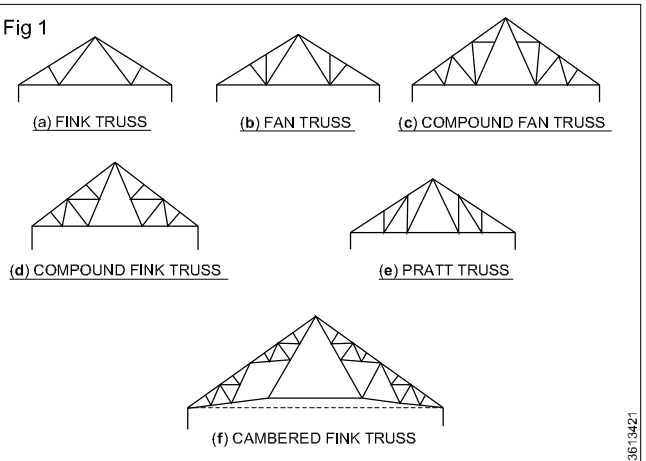
Roof truss

Objectives: At the end of this lesson you shall be able to
- **explain the term roof truss**
- **enumerate common types of steel trusses used now a days.**

Truss may be defined as a large deep beam with open web. They are usually formed by members arranged in triangles or groups of triangles. Some of the popular type of roof trusses are shown in Fig.1. They are designed to support the roof coverings or ceiling over long spans thereby avoiding the intermediate columns. Roof trusses are used in workshops, industrial buildings, auditoriums, godowns, warehouses and building where large column free spaces are required.

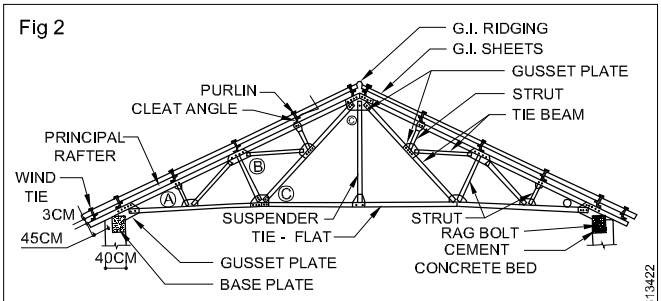
Fig 1



TYPICAL SKETCHES OF ROOF TRUSS

Details of the components of steel roof truss (Fig 2)

Fig 2



COMPONENTS OF STEEL ROOF TRUSS

Light gauge steel structures

Objectives: At the end of this lesson you shall be able to
- **explain advantages of cold formed steel structural members**
- **over hot rolled steel structural members**
- **explain the application of cold formed steel.**

Introduction

In cold forming, steel sheets of thickness generally in the range of 0.4 mm to 12.5 mm are formed into structural shapes. Cold formed structural members are being used in transportation and construction industry. The steel sheets conform to IS:1079 - 1968. The minimum guaranteed yield strength for such steels is 232 N/mm^2 and the ultimate strength is 390 N/mm^2.

Advantages of cold formed steel structural members over hot - rolled steel structural members

i Cold formed steel members can yield more economical designs for relatively light loads and for shorter spans.

ii Sections can be made to requirement resulting in favorable strength to weight ratio.

iii They provide surfaces and enclosed spaces for electric and other conduits.

iv Cold formed steel wall panels floors and roof decks, in addition to transferring loads normal to their surface, may also be used to withstand in - plane shear as diaphragms.

v if properly inter - connected with each other and with supporting members. This is commonly called as stressed skin design.

Advantages of cold formed steel members over reinforced concrete and timber

i Lighter with higher strength and stiffness

ii May be easily prefabricated in mass production

iii Amenable to fast and easy erection without delay even during bad weather

iv More accurate detailing and maintenance of uniform quality and tolerance are possible

v Non-shrinking and non-creeping at ambient temperature

vi Termite - proof and rot proof

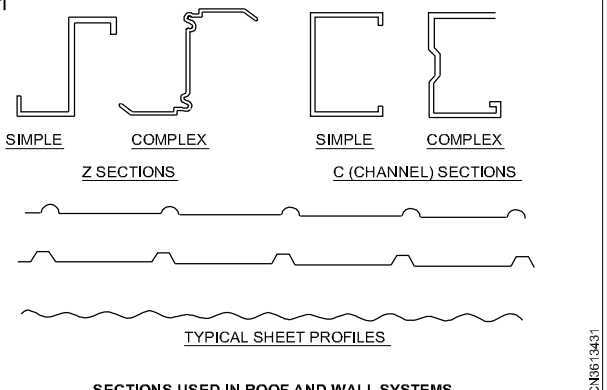
vii Requires no formwork and it may be used in composite construction with concrete slabs thus eliminating formwork and tension reinforcement.

Application of cold formed steel

Normal uses of cold formed steel structural members are

a Roof and wall systems of industrial, rural and commercial buildings: Examples of sections used in roof and wall systems are Z and C sections used as purlins, C section used as bracing, shallow and deep sheeting profiles spanning across purlins and screw fasteners or concealed fasteners used for the connections. (Fig 1) Channels are used for columns and trusses, and corrugated sheets for side clads. Fabricated box section using heavy channels are used in crane girders and columns and corrugated profiles are used for crane walkways. (Fig 1)

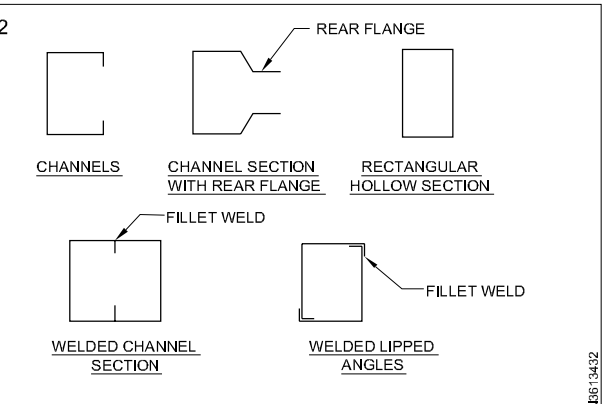
Fig 1



SECTIONS USED IN ROOF AND WALL SYSTEMS

b Storage racks: Channels with or without rear flanges are used for uprights of storage racks (Fig 2)

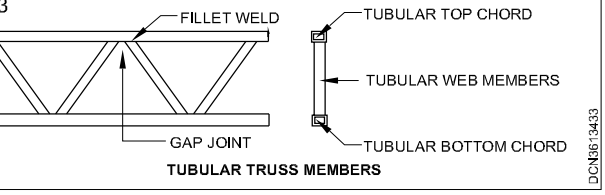
Fig 2



STORAGE RACK SECTIONS

c Plane and space trusses: Circular, square or rectangular hollow sections may be used as chords and webs, with welded joints. Channels section chord members can also be used with tubular braces bolted or welded into the open sections. Trusses can also be fabricated from cold formed angles. (Fig 3)

Fig 3

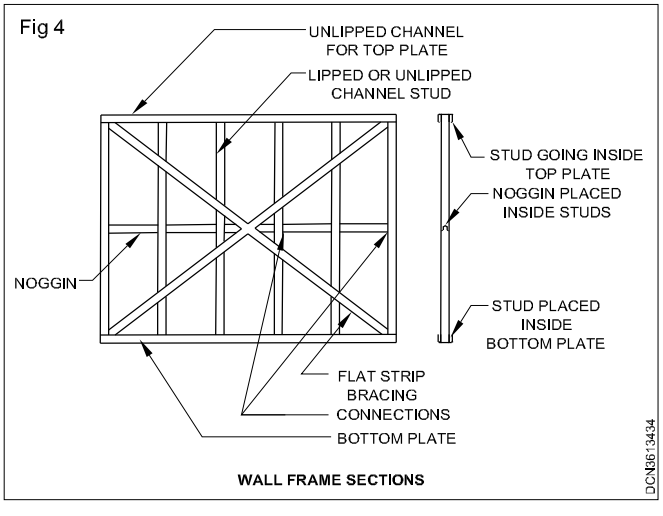


TUBULAR TRUSS MEMBERS

d Frameless stressed skin buildings sheet profiles with stiffened edges are used to form small structures like garden sheds.

e Housing lipped and unlipped channel sections are used as wall studs, top and bottom plates, hoggins etc. (Fig 4) flat steel straps may be used as bracing. Door and window frames are also fabricated using different sections.

Fig 4



WALL FRAME SECTIONS

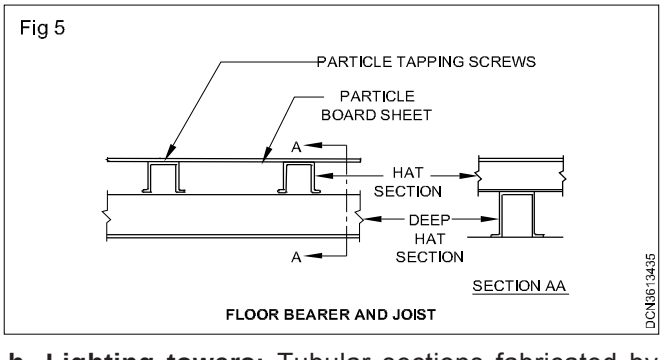
f Floor bearer and joist

Usually hat sections are used. Alternately Z sections can also be used.

g Steel decking for composite construction (Fig 5)

Profiled sheeting with indentations is used in composite construction. The indentations enable proper bonding between concrete and steel to achieve composite action.

Fig 5



FLOOR BEARER AND JOIST

h Lighting towers: Tubular sections fabricated by welding are used. The section shape may be circular or polygonal.

i Automotive applications: All the major sections can be used but hat sections or box sections are more common. Channels are used for chairs, and corrugated panels for floor panel of light commercial vehicles (LCV). Channels and angles are also used for the rear body components of LCV. In bus body, chaises and top hat sections are used.

j Grain storage silos consists of shallow profile sheeting stiffened by hat or channel sections.

k Tubular members and hollow flange beams.

l Pollution control: Collecting electrodes for dust collection are made of rolled sections. Large channel are used as gas distribution screens.

m Rolling shutters: Side guide, Bottom plate and laths of rolling shutters are made of rolled sections.

n Railway coaches: Channels, Z sections, Top Hats, Floor Trough sections are used in rail coaches and wagon building industry.

o Electrical transmission towers: Heavy lipped and unlipped angles are used in transmission towers.

p Railway traction: Heavy channels fabricated into a box section are used as railway electrical masts.

q Marine container: Corrugated profiles, corner posts, channels and angles are used.

r Material handling: Heavy channels as conveyor frames, corrugated profiles as decking plates, trapezoidal sheets for boiler house structures, and channels for conveyer gallery structures are the main applications in material handling.

Tension and compression members

Objectives: At the end of this lesson you shall be able to
- **explain the classification of members based on the method of transmitting of force**
- **explain tension members**
- **explain compression members.**

Steel structures are three dimensional, they are mainly made of one dimensional members (beams and columns) and two dimensional members (frames, plates). These members are designed in such away that they behave independently to each other. Based on the method by which they transmit forces, they may be classified into

Tension members

Compression members

Beams

Beam - columns

Torsion members and

Plates

Tension members

A member which carries mainly a tensile force is called tension member. In practice tension members are often subjected to combined tension and bending actions. The bending moment is caused by eccentricity of connections, transverse loads, self weight of the members etc. Direct tensile load has tendency to straighten the member and reduce the eccentricity of load.

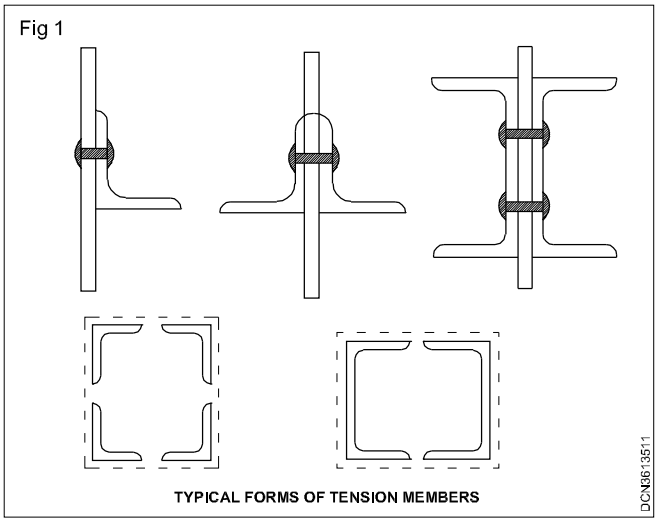
A member carrying direct tension is called a tie. Tension members are formed in roof trusses, towers, bridges and bracing systems. The distribution of stress on the cross - section of an axially loaded tie is uniform.

Typical forms of tension members

The form of a tension member is governed by the type of structure of which it is a part and the method adopted for joining it to the adjacent parts of the structure. The more common types are listed in table and fig 1.

Type	Use
Wire rope	Guy wires, floor suspenders in suspension bridges, hoisting lines.
Rods and bars	Bracing systems in towers, sagrods for purlins in sloping roof
Single angle	Roof trusses carrying light loads, brachings
Double angle/double channel	Roof trusses, foot bridge trusses
4 Angle members 2 channel members	Heacily loaded bridge trusses

Fig 1



TYPICAL FORMS OF TENSION MEMBERS

Compression members

A structural member which primarily transmits a compressive force is called a column. Vertical compression members in buildings are called columns. Posts are stanchions. Compression members in roof trusses are called struts.

A compression member has a tendency to bend even when the load is axial. This bending of column is called buckling. The load carrying capacity of a column depends on its slenderness ratio , which is the ratio of the effective length of the column and the least radius of gyration.

Choice of selection for compression members

The choice of section for a compression member depends on

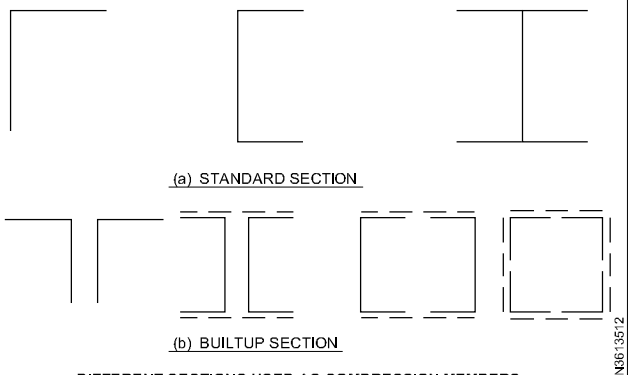
Magnitude of loads acting of the compression member, and whether the load is applied axially or eccentrically.

Fig.2 shows different standard and composite sections used as compression members.

Beams

Beams are structural members subjected to lending movement and shear force because transverse loads at on them. Normally no axial loads act on beams. According to their function, beams are called by different names. Some of the common types of beams are.

Fig 2



DIFFERENT SECTIONS USED AS COMPRESSION MEMBERS

Joist

A beam that support the flooring but no other beams.

Floor beam

A major beam supporting other beams.

Girder

Any major beam in a structure.

Lintel

A beam which supports the wall over windows, doors and verandah openings.

Purlins

A beam supported by roof trusses.

Simple beams

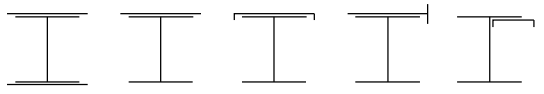
Beams which consist of a single I section carrying the loads applied on them safely and economically are called simple beams.

Compound beams

When the maximum bending moment induced in a beam due to the loading is greater than the moment of resistance of the maximum available rolled steel section, or when the depth of the beam is to be restricted, compound beams are used. Compound beams are rolled beams in which plates are welded or riveted to the flanges.

Typical sections of compound beams are shown in fig.3

Fig 3



TYPICAL SECTIONS OF COMPOUND BEAMS

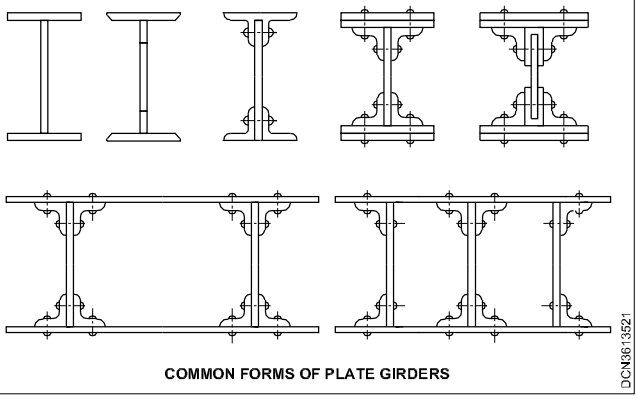
Plate girders

Objectives: At the end of this lesson you shall be able to,
- **explain the term plate girder**
- **explain the components of plate girder.**

Plate girder

When the span of the beam is large and load is heavy, rolled steel beam does not permit its use beyond a span of 20m. Plate girders are normally used for spans more than 20m. With the adoption of welded construction plate girders can be used upto 100 m span. Most common forms of plate girders are shown in Fig 1

Fig 1



COMMON FORMS OF PLATE GIRDERS

Components of plate girders

The components of plate girder are shown in Fig 2

They are

Web plate

Flange plates

Web splice

Flange splice

Vertical stiffeners

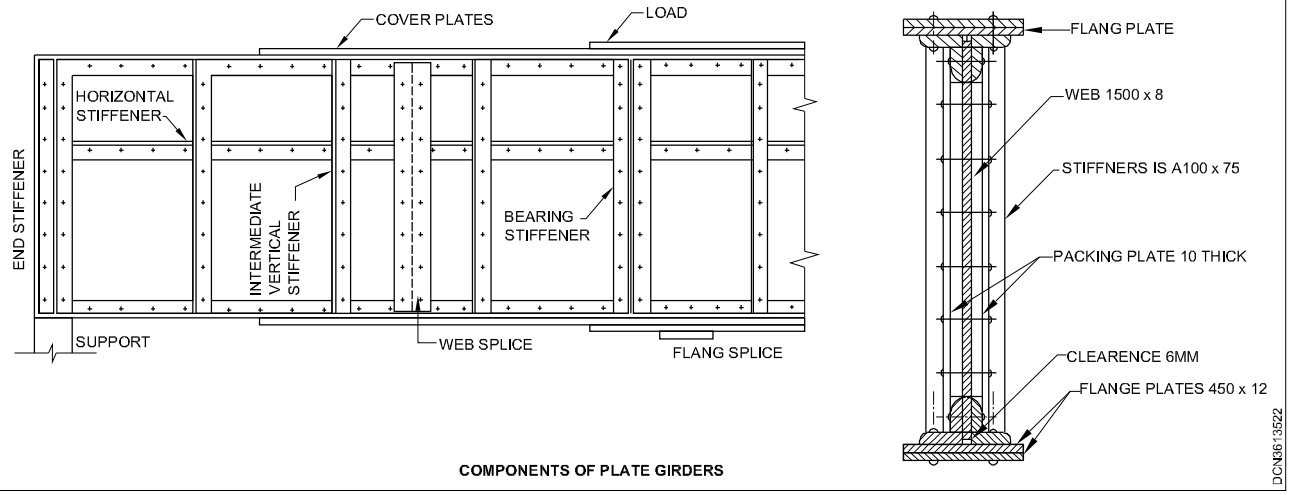
Horizontal stiffeners

Bearing stiffeners

Rivets connecting the flange and the web

Rivets connecting the flange angles and flange plates

Fig 2



COMPONENTS OF PLATE GIRDERS

Fabrication and construction details

Objectives: At the end of this lesson you shall be able to
- **explain the various connections used steel structures**
- **explain the various types of rivets.**

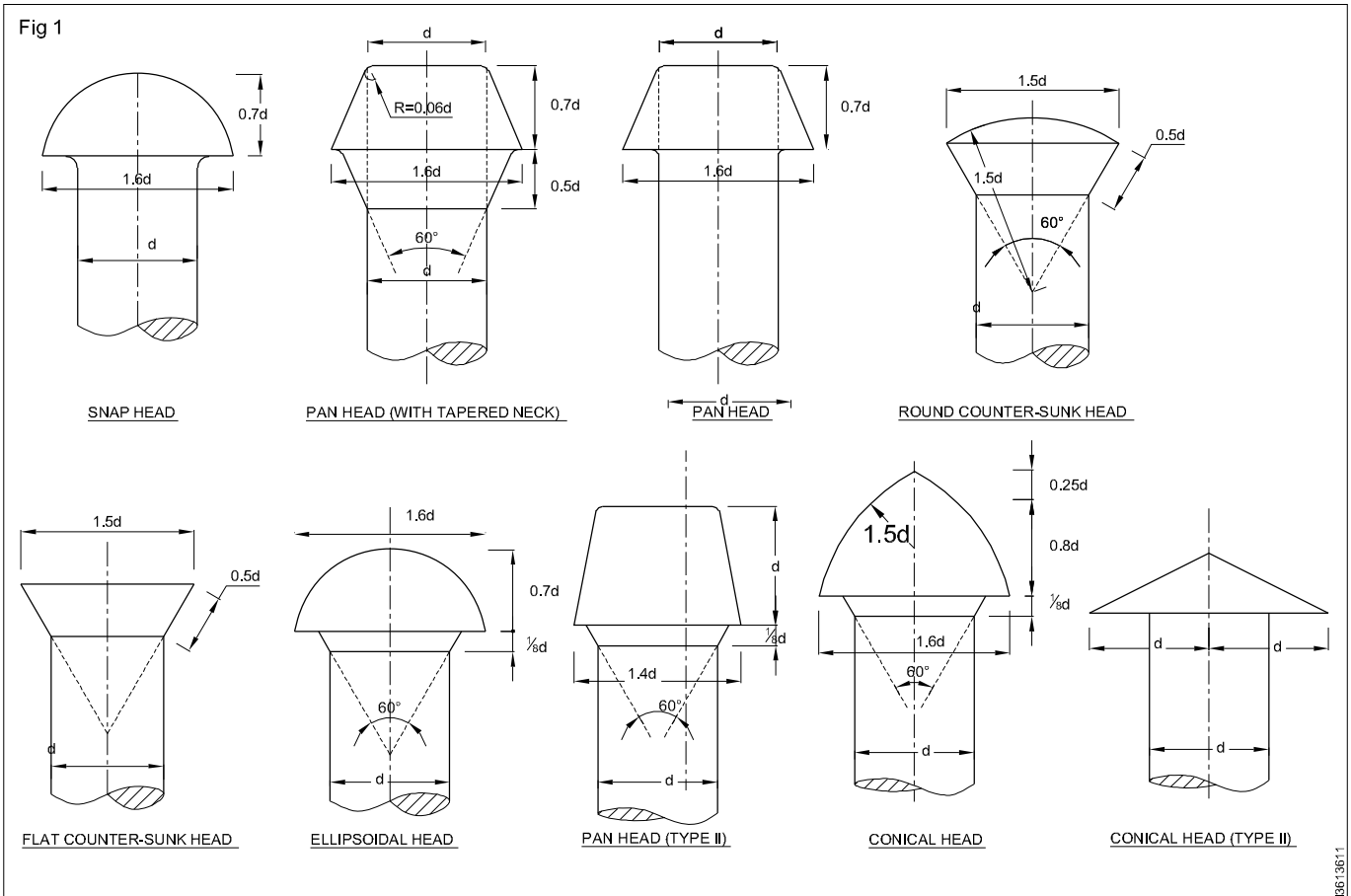
Connections

Structural members are composed of various standard sections. These members are connected to each other by means of rivets, welds, pins or bolts.

Riveted connection

Rivets are made from mild steel rivet bars by a machine which forms the head and cuts the rivet of the desired length. Normally the head is round and is called "button head". The head is flattened if the clearance is limited. If flush surface is desired, 'countersunk' rivets are used. Different types of rivet heads are shown in Fig 1.

Fig 1



RIVET HEADS

Process of riveting

Holes are drilled in the plates to be connected at the appropriate places. The heated rivets (red hot, 550 1000°C) are inserted into the holes (Fig 2). The other end of the rivet is made using a jack or riveter. When the riveter compresses the shank, the shank fills the hole completely and head is formed on the other side also. When the rivet cools, it shrinks and presses the plates together.

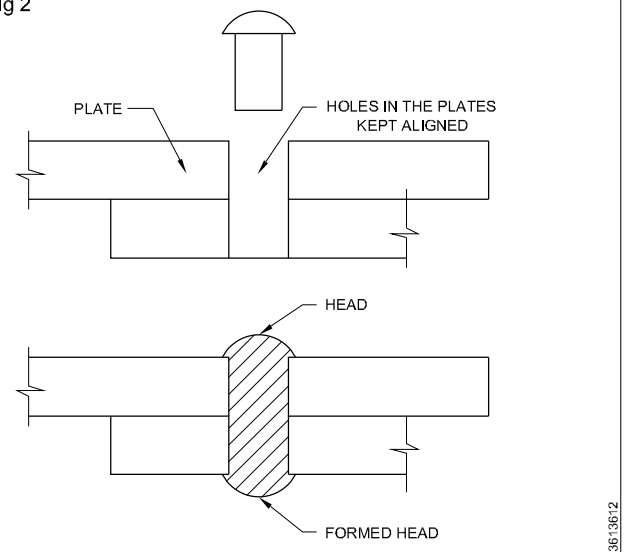
Care must be taken to heat the rivet uniformly throughout the length. This is essential for uniform filling of the rivet hole. Rivets can also be driven cold using special equipment.

The diameter of the hole is kept 1.5 mm larger than the nominal diameter of the rivet, if the nominal diameter of rivet is less than or equal to 25 mm. For larger diameter rivets, the diameter of the hole should be 2.0 mm larger than the nominal diameter of the rivet.

Classification of rivets

The rivets may be of power driven or hand driven and the riveting work may be done in the workshop or at the work site (field).

Fig 2



PROCESS OF RIVETING

Accordingly rivets are classified as

1 Power driven shop rivets

2 Power driven field rivets.

3 Hand driven shop rivets, and

4 Hand driven field rivets.

Power driven rivets are allowed larger permissible stresses than the hand- driven rivets, in view of better workmanship.

The permissible stresses for field rivets will be less than the permissible stresses for shop rivets by 10%.

Nominal diameter and gross diameter of rivet

The nominal diameter of a rivet means the diameter of the cold shank before driving. The gross or effective diameter of a rivet is the diameter of the hole or closed rivet. Strengths of rivets are based on the gross diameter.

Calculation of gross diameter

If nominal diameter $\leq$ 25mm

Gross diameter = nominal diameter + 1.5 mm

If nominal diameter > 25mm

Gross diameter = Nominal diameter + 2.0 mm

Calculation of diameter of rivet

Diameter of rivet depends on plate thickness. Several formula are available to calculate the diameter. The formulae are.

1 Unwin's formula

$d = 6.05\sqrt{t}$ where t is the thickness of the plate in mm.

Rivets are available in nominal diameters of 12,14,16,18,20,22,24,27,30 and 33 mm.

The french formula

d=1.5t+4

where t<15mm

The german formula

$d = \sqrt{50t - 2}$

Pitch of rivets

IS 800 - 1984 specifies the following.

Minimum pitch

The distance between centres of any two adjacent rivet holes should not be less than 2.5 times the nominal diameter of the rivet.

For convenience, this is often taken as 3 times the nominal diameter.

Maximum pitch

The distance between centres of any two adjacent rivets (including tacking rivets) connecting together members shall not exceed 32t or 300 mm whichever is less, where t is the thickness of the thinner plate.

The distance between centres of two adjacent rivets in a line lying in the direction of stress, shall not exceed 16t or 200 mm whichever is less in tension members and 12t or 200mm, whichever is less in compression members.

For compression members in which forces are transferred through butting faces, this distance shall not exceed 4.5 times the diameter of rivets for a distance from the abutting faces equal to 1.5 times the width of the members.

Edge distance

A rivet hole must be sufficiently distant from the nearest edge of the member. This is to prevent the cracking and subsequent failure of the plate along the edge, e.g., if diameter of hole is 13.5mm and below the distance to the sheared or hand flame cut edge shall be 19 mm.

Tacking rivets or stitch rivets

When truss members consist of combined sections like double angles, with some distance between them, it is necessary to connect the component members at suitable intervals along its length. Such rivets are called tacking rivets. This is to ensure, that the composite section acts as a single unit. This is very important in case of compression members.

Riveted joints

Objectives: At the end of this lesson you shall be able to
- **explain the different types of riveted joints**
- **explain the failure of riveted joints.**

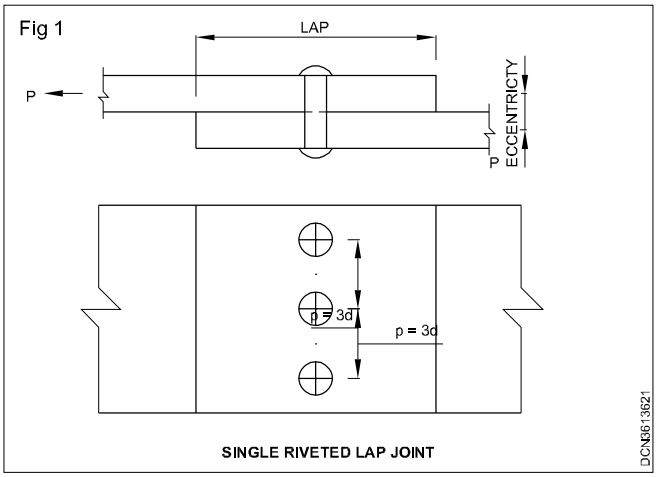
Types of riveted joints

There are two types of riveted joints namely:

- Lap joint
- Butt joint

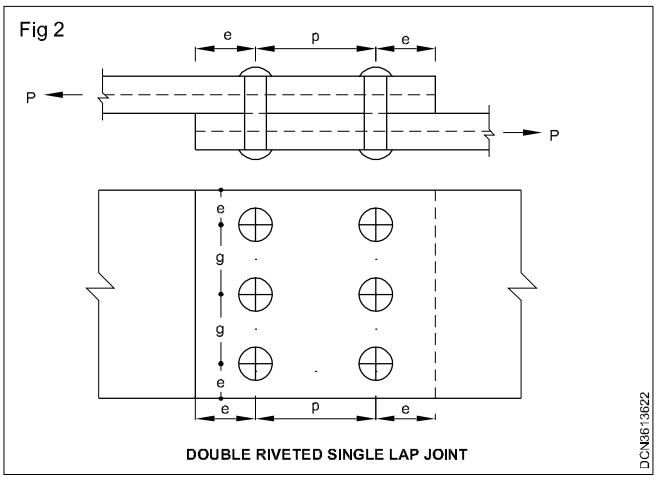
Single riveted lap joint

It consists of a single row of rivets parallel to the edge of the over lapped plates (Fig 1)

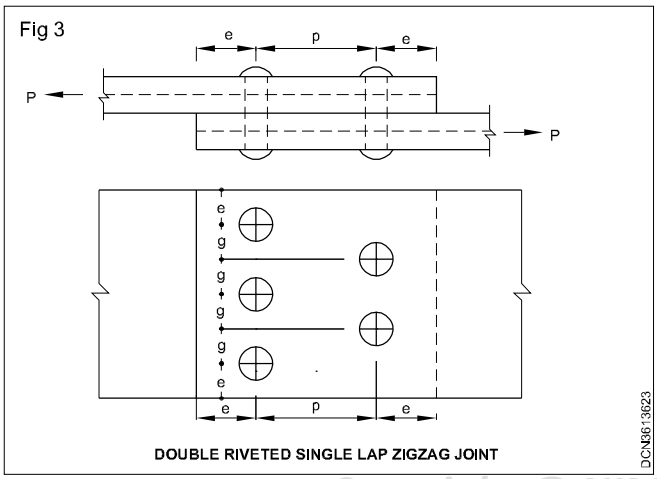


Double riveted single lap joint

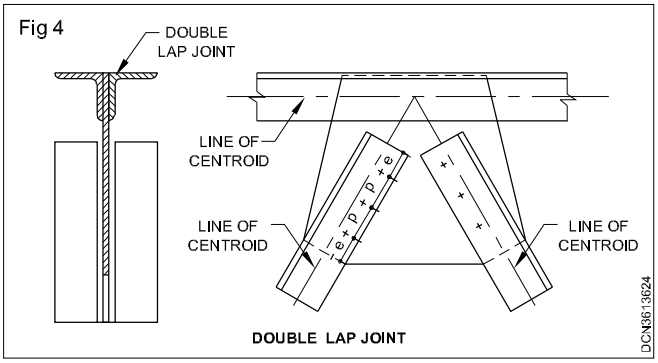
There are two parallel rows of rivets where rivets are just opposite each other (Fig 2)



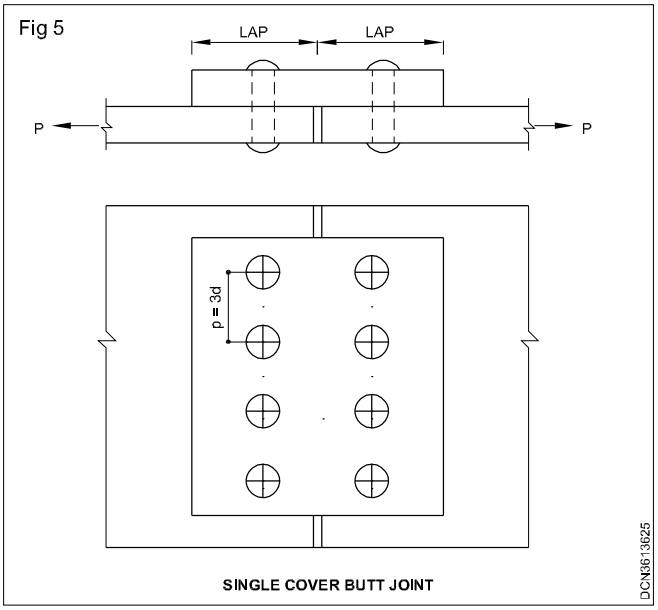
Double riveted single lap staggered or zigzag joint where the rivets are staggered. (Fig 3)



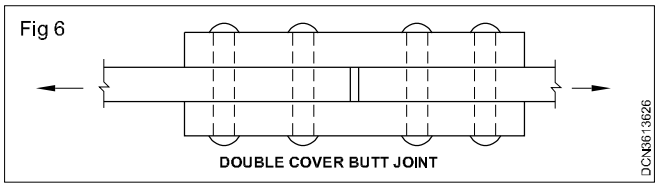
Double lap joint commonly used in trusses, where combined section consisting of two angles is connected to a gusset plate (Fig 4)



Single cover butt joints (Fig 5). The plates to be connected are kept butting against each other. They are connected through cover plates kept on one side only.



Double cover butt joint (Fig 6) This connection is similar to the single cover butt joint. The difference being that there are two cover plates, one on each side of the plates to be connected. Half the applied force is transmitted through each cover plate.



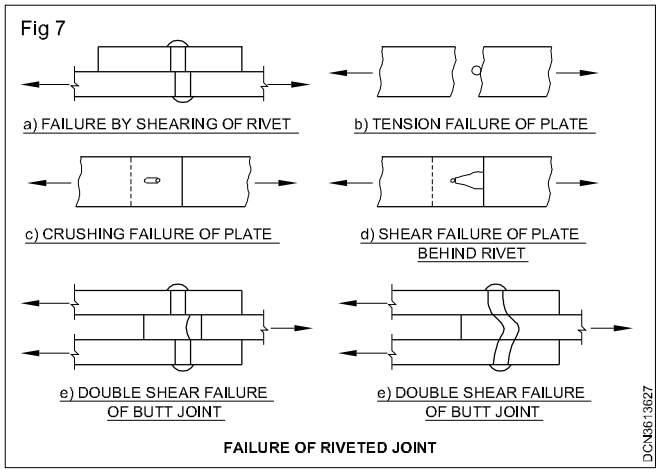
Failure of riveted joint

A riveted joint will fail when either the rivet or the plate fails. The failure of a rivet may be due to shearing of rivet or crushing of rivet.

The plate may fail by tearing of the plate or crushing of the plate (i.e.,) due to the bearing between the rivet and the plate.

If the rivet is quite long compared to its diameter, it may fail in bending, before it fails in shear or bearing.

Fig 7 shows the various ways of failure of riveted joints.



Welded joints

Objectives: At the end of this lesson you shall be able to
- **explain the term welding**
- **explain various types of welds**
- **explain various types of welded joints.**

Welded connection

The process of connecting metal parts by fusion is called welding. Welding can be done by two methods namely

i Arc welding and

ii Oxy - acetylene welding

Molten metal is deposited at the junction of metal parts to be connected. The metal parts are also fused to a specified depth. When the fused metal cools, the two metals part get joined. High temperature of about 3300°C occur during the process of welding. The heat for the process of welding is obtained in the oxy - acetylene method is by burning of oxygen and acetylene. During process of welding, a weld rod is used. The weld rod has a coating which melts and provides a shield preventing the combination of heated metal with freely available oxygen and nitrogen from the atmosphere.

Strength of weld

Strength of weld = permissible stress x throat area

Where the throat area = throat thickness x length of weld

Types of welds

Welds are classified as

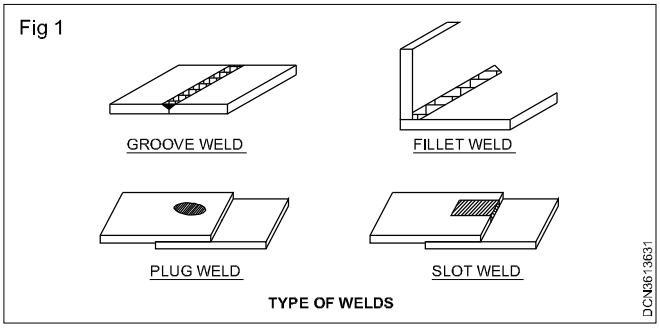
i Groove weld is made in the opening (called a groove) between the two parts being joined.

ii Fillet weld is triangular in shape and joints surfaces which are at an angle with one another.

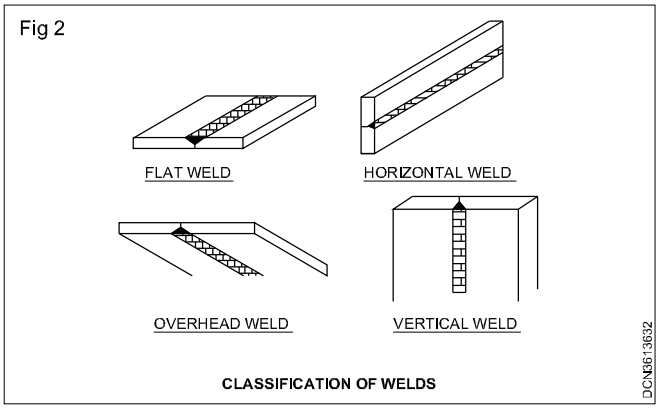
iii Plug weld is made by depositing weld metal in a circular hole in one of the two lapped pieces. The hole must be filled completely.

iv Slot weld is similar to a plug weld, the only difference being that the hole is elongated.

Types of weld Fig 1



Welds are also classified according to the position of the weld during welding as flat, horizontal, vertical and overhead. (Fig.2)



Types of welded joints

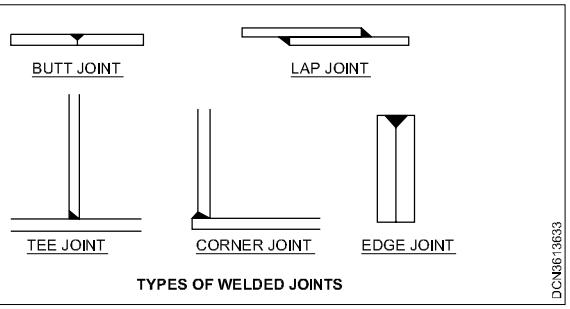
Welded joints are classified as

Butt joint which is groove welded

Lap joint which is fillet welded and

Tee joint which can be groove welded or can be fillet welded with one fillet on each side. (Fig 3)

Fig 3

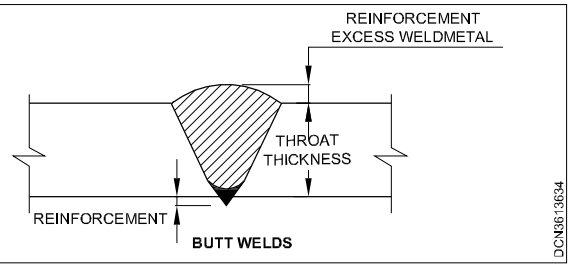


TYPES OF WELDED JOINTS

In structural steel work, fillet and butt welds are normally used.

Butt welds: The size of a butt weld is specified by its throat thickness, which is taken as the thickness of the thinner plate. (Fig 4)

Fig 4



BUTT WELDS

The excess weld metal is ignored in calculations. The strength of the weld is calculated as

Throat thickness x length of weld x permissible stress in the weld

Different types of butt welds: The different types of butt welds are shown in Fig 5

Single V- butt weld Permissible stress is taken as 150N/ mm^2 in axial tension and as well as compression.

Fillet welds Fig 6 shows a fillet weld. For design purposes, the effective section of the fillet weld is taken as an isosceles right angled triangle. The length of either of the equal sides of the triangle is called the size of the weld.

The perpendicular distance between the hypotenuse of the triangle and the opposite apex is called the throat thickness.

If t = throat thickness, and

S = size of the fillet weld

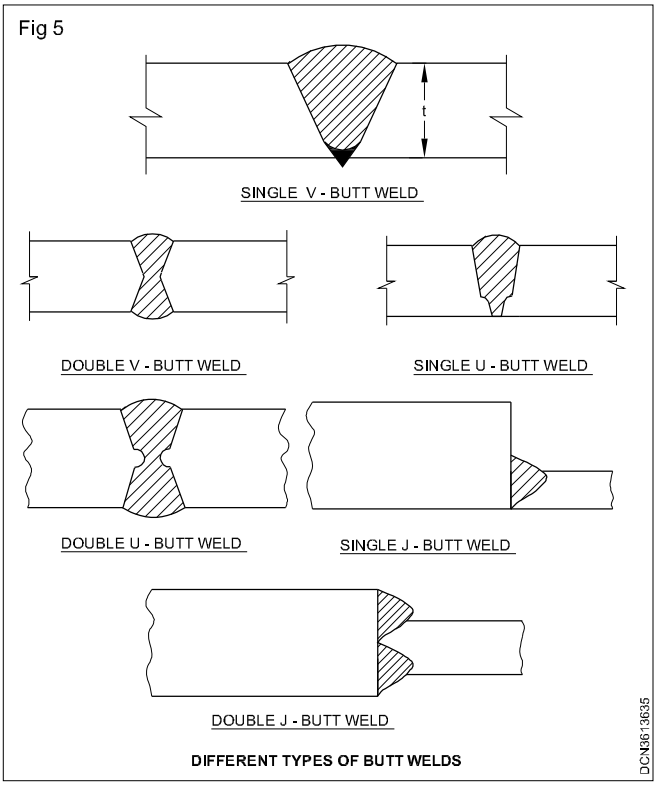
then, $t = s\cos 45^o = \frac{S}{\sqrt{2}} = 0.707S$

∴ Effective area of the weld = throat thickness x length of the weld

Safe load on a weld = throat thickness x length of the weld x permissible shear stress in weld.

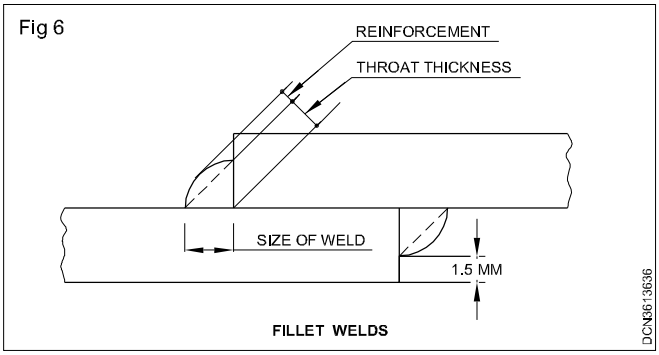
Permissible shear stress is taken as 110 N/mm^2.

Fig 5



DIFFERENT TYPES OF BUTT WELDS

Fig 6



FILLET WELDS

Symbols used in bolts & nuts

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

- **explain the various symbols used for welded structural connections**
- **explain the advantages and disadvantages of welded connections**
- **explain bolted and pinned connections**
- **explain the various symbols used in nuts and bolt connections.**

The figures below explain common welded symbols for structural connections (Fig 1)

Advantages of welded connections over riveted connections

1 Since welding does not involve driving holes, the gross sectional area of the welded members is effective.

2 Welded connections are comparatively lighter than riveted connections.

3 Welded joints often are as strong as the parent metal.

4 Making repairs and new connections are easier in welding than in riveted connections.

5 Welded connections are more rigid. Since the connections are more rigid, members are subject to smaller bending moments for same loading.

6 Welded joints are more economical, easier to maintain compared to riveted joints.

7 Under conditions where riveting is difficult, welding is often easier.

8 Better finish and appearance.

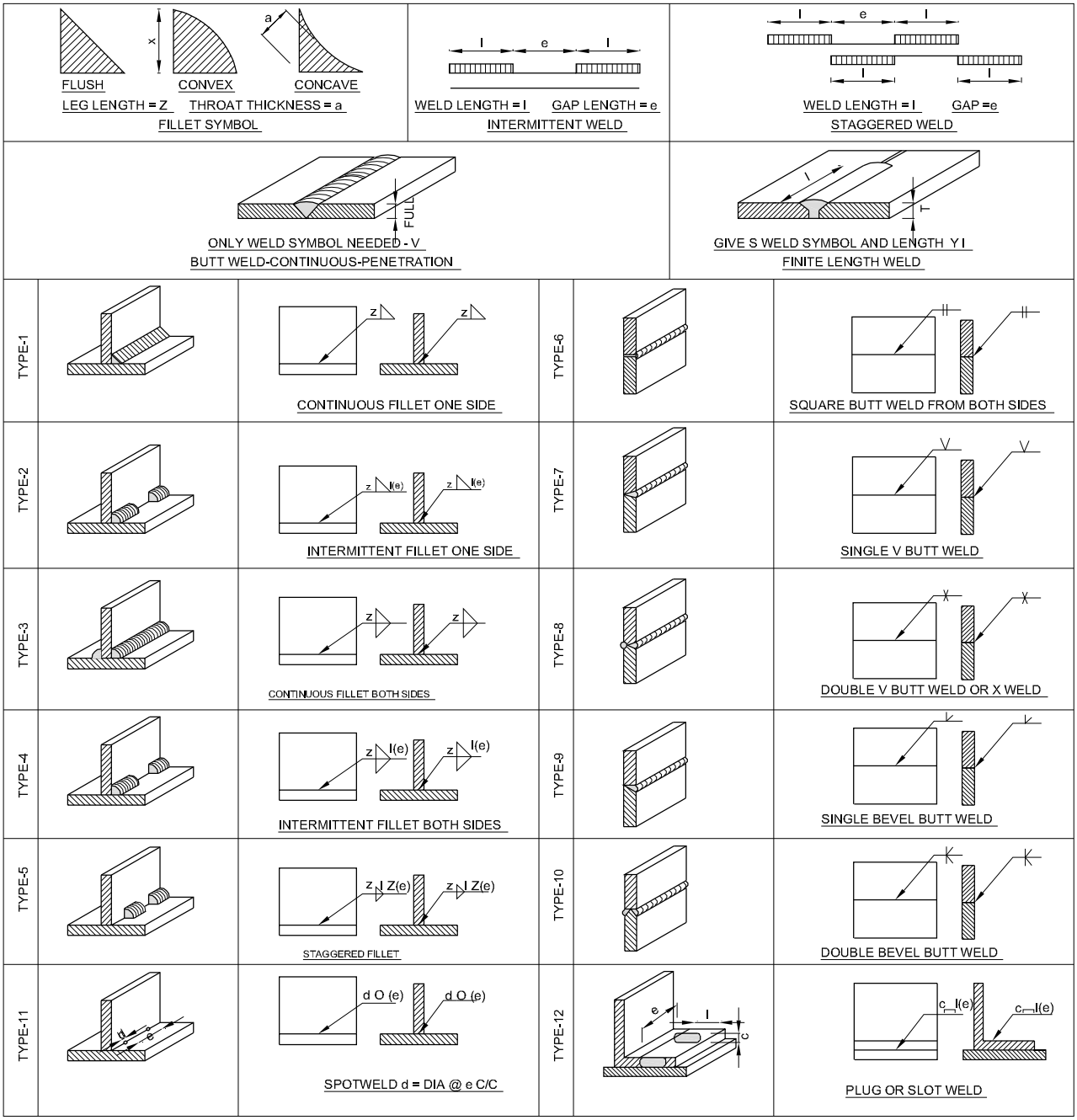
9 In welded connections, the accessories like connecting angles, splice plates etc. can be minimized or even avoided.

10 In RCC structures, lapping of reinforcing bars can be avoided.

11 Welding involves less noise.

12 Welding requires less clearance compared to riveting.

Fig 1



SYMBOLS OF SOME COMMON WELDS FOR STRUCTURAL CONNECTIONS

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Disadvantages of welded connections

1 Requires skilled labour and supervision

2 The quality of a welded connection can be studied only by an x - ray examination

3 Warping of welded members occur due to uneven heating and cooling

4 During welding, internal stresses built up in weld zones.

Bolted connections: These are connections made using bolts which is a steel pin with head at one end and threaded at the other. Square/hexagonal nut is used at the threaded end to make connection. Bolts also transmit loads from one component to the other. The specifications for pitch and minimum edge distance are the same as for rivets. (Fig 2)

Advantages of bolted connections are: (i) No need for hammering or heating, (ii) Very quick work and Most useful in temporary connections, to keep together components during fabrication.

Disadvantages are: (i) Liable to become loose causing reduction in strength, (ii) the diameter of a bolt is not uniform, (iii) the strength of a bolt in tension is less due to its reduced area at the root of the threads and (iv) since the bolt hole is made 1.5 mm greater than the bolt diameter, a clearance exists in bolted connections.

Pinned connections: A pin consists of a cylindrical rod meant for connecting two or more components. A pin has freedom to turn in the connections. Pins range from 8 mm diameter to 300 mm diameter.

Examples of use of pinned connections are

For connecting plates and

Bridge truss members.

Fig 2

NO.	TYPE	CONVENTIONAL SYMBOL	NO.	TYPE	CONVENTIONAL SYMBOL
1	HEXAGONAL BEADED BOLT		9	OVAL COUNTERSUNK HEADED SCREW CROSS SLOT	
2	HEXAGONAL SOCKET BOLT		10	SET SCREW SLOT	
3	SQUARE HEADED BOLT		11	WOOD AND SELT-TAPPING SCREW SLOT	
4	CYLINDER SCREW CROSS SLOT		12	WING SCREW	
5	CYLINDER SCREW PAN HEAD TYPE SLOT		13	WING NUT	
6	COUNTERSUNK HEADED SCREW SLOT		14	SQUARE NUT	
7	COUNTERSUNK HEADED SCREW CROSS SLOT		15	HEXAGONAL NUT	
8	OVAL COUNTERSUNK HEADED SCREW SLOT		16	CROWN NUT	

CONVENTIONAL SYMBOLS FOR NUTS AND BOLTS

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Public health and sanitation

Objectives: At the end of this lesson you shall be able to
- **define the term public health engineering, water supply engineering and sanitary engineering**
- **state the different technical terms in public health engineering.**

Introduction

The essential elements of the existence of living beings are air, water, food, shelter, clothing etc. Out of the above water is the second one. Water is required for satisfactory functioning of the physiological organisms, as a circulatory fluid to maintain temperature, to carry nourishing food, and to remove the waste products from the body. Now a days, water is required to perform many functions like supply of physical needs, preserve bodily cleanliness, ensure cleanliness of all personal and municipal environments, furnish a means of fire protection and meet the needs of the industry. The sewage and refuse of some of the cities are disposed off in water courses. Such disposal pollutes the water courses and render them unsafe for domestic use without treatment. Hence steps are taken to treat the sewage and dispose it suitably. The engineering which concerns to the water supply and sanitation of communities is called public health engineering. Water supply engineering comprises of storage of water, purification of water and its distribution for its proper use, while sanitary engineering starts where water supply engineering ends. Sanitary engineering concerns with the cleanliness of the cities such as collection, conveyance, treatment and disposal of refuses in a harmless manner.

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 objection able to human senses of sight, odour, taste,etc	Does not make apparently objection able.
4	Saline water,turbidwater, etc are examples for polluted water.	Water containing high concentration of pathogenes, etc, is an example for contami nated 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 syphonage: 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.

Antisyphonage: 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 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

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 syphonage 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 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

Importance of sanitary engineering: Sanitary engineering came into existence and it mainly concerns with the cleanliness of the cities. This project is divided into four stages namely collection, conveyance, treatment and disposal. The refuse from industrial and residential areas are collected and conveyed for disposal outside the city either by mechanical transport or with the help of water, depending upon the stage of waste. The wastes are made less harmful by treatment. The treated wastes are finally disposed by any suitable method.

Purpose of sanitation: The purpose of sanitation is to promote and preserve good health of the people by preventing the spread of communicable diseases. This is achieved by the scientific and methodical collection. Conveyance, treatment and disposal of the waste matter as detailed below.

Proper disposal of human excrete to a safe place before it starts decomposition causing insanitary conditions in the locality.

To take out all kinds of waste water from the locality immediately so that flies, mosquitoes, bacteria's etc. may not breed in it and cause nuisance.

Final disposal of sewage on land or in nearly water course after some treatment so that the receiving land sub - soil or water may not get polluted.

The fertilizing elements of sewage may be used to grow crops through sewage farming.

In unsewered areas, the treatment of sewage of individual houses should be done in septic tanks and the effluent should be disposed off.

Classification of dry refuse

The dry refuse includes house refuse, trade refuse and street refuse in dry state as far as possible. It is classified as.

i organic or combustible and

ii inorganic or mineral or non - combustible

i Organic or combustible

Organic dry refuse includes dry animal and vegetable refuse like cow dung. Excreta of birds, leaves of trees, papers, etc. It also includes condemned meat, spoiled food stuff, bad fish, slaughter house waste, market refuse etc. It is highly dangerous to public health but has great value as a fertilizer.

ii Inorganic or mineral or non - combustible

The inorganic refuse includes non - combustible material so like grit, dust, mud pieces of metals, glass, tiles, waste building materials, etc. This refuse is not liable to any decay and hence it is not harmful to the public health.

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 industrials 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

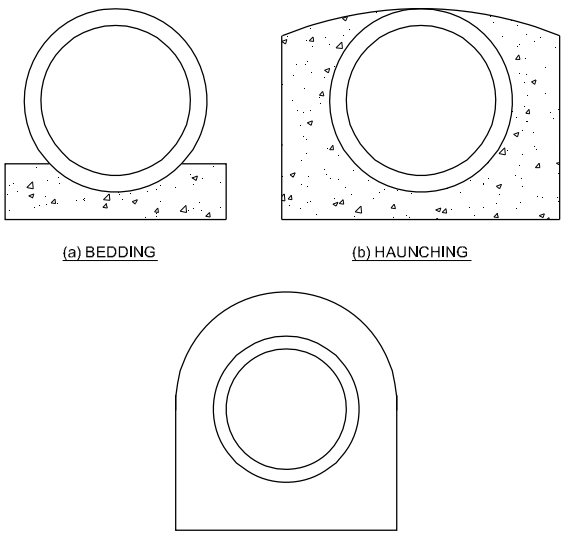
Shape of sewers

The sewer sections are broadly classified into, (1) circular sections and (2) non circular sections.

Circular sewer sections (Fig 1)

Mostly sewers of circular shape are used in all the sewerage systems, as they can be easily constructed and handled. They are best suitable for diameter upto 1.5m. Comparing to non - circular sewer sections, they give the least perimeter for a given area of flow and, therefore, have the maximum hydraulic mean depth for running full and half - full conditions. They are very much useful in a separate system. Where discharge is more or less constant.

Fig 1



CIRCULAR SEWER SECTIONS

Non - circular sewer sections (Figs 2-9)

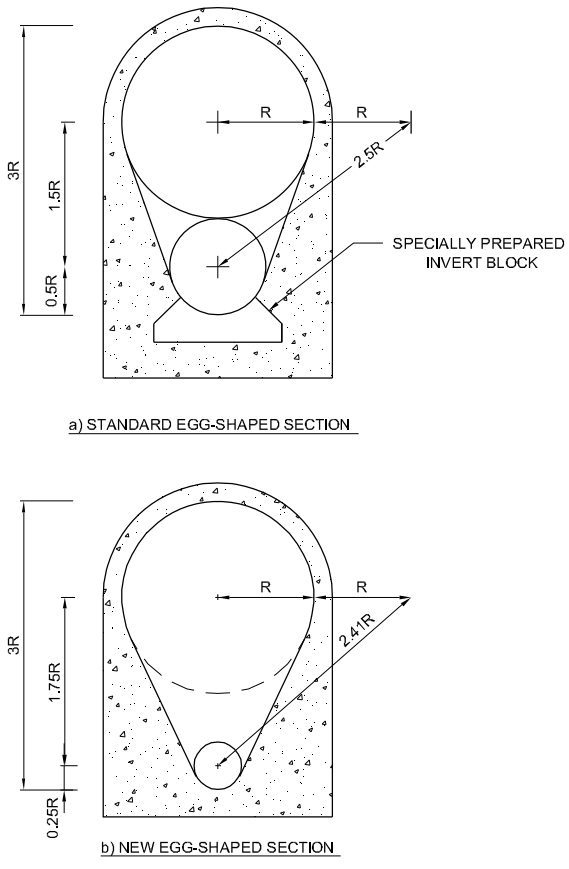
1 Egg - shaped or ovoid sewer section
2 Box or rectangular sewer section
3 Semi - elliptical sewer section
4 Semi - circular sewer section
5 Parabolic sewer section
6 Horse - shoe sewer section
7 Basket - handle sewer section
8 U - shaped sewer section

1 Egg - shaped or ovoid sewer section (Fig 2)

The egg - shaped or ovoid sewer section is available in two forms, namely (1) standard and (2) new egg - shaped.

The egg - shaped section has got better hydraulic properties, but costly. It is difficult and requires more materials for construction. It is less stable. Hence, it requires good foundation for its better stability. It is most suited in the case of combined sewers. Its main advantage is that it gives a slightly higher velocity during low flow than a circular sewer of the same capacity.

Fig 2

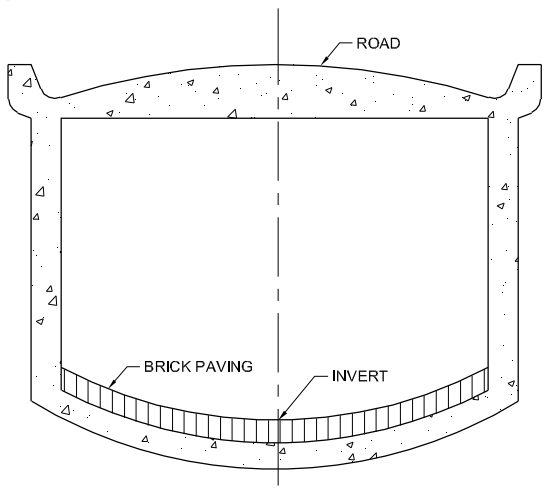


EGG-SHAPED OR OVOID SEWER SECTIONS

2 Box or rectangular sewer section (Fig 3)

This shape possesses very good hydraulic properties until it is filled. It is easier to construct and is economical. It is mainly used as out fall sewer. They are most suitable for large size storm sewers.

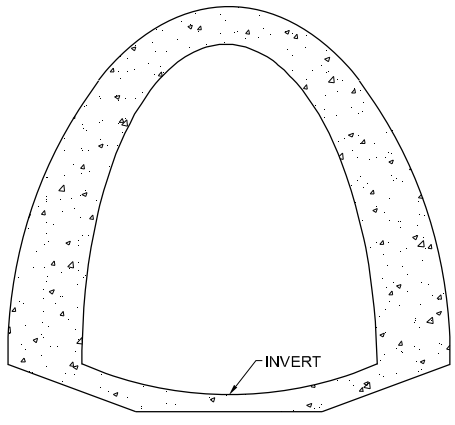
Fig 3



RECTANGULAR OR BOX SEWER SECTION

3 Semi - elliptical sewer section: As this shape of sewers are more stable, they are adopted for soft soils. This shape possesses good hydraulic properties except at low depths. It is normally adopted for sewers having diameters greater than 1.80 m or so. This section is not suitable for carrying small quantity of sewage. (Fig 4)

Fig 4



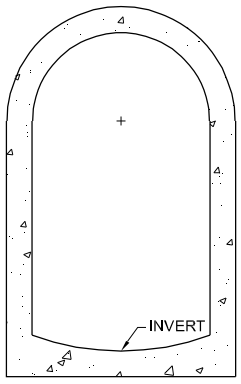
SEMI-ELLIPTICAL SEWER SECTION

4 Semi - circular sewer section This shape of sewer section gives a wider base at the bottom. Hence, suitable for constructing large sewers with less available head room. It possesses better hydraulic properties.(Fig 5)

5 Parabolic sewer section (Fig 6)

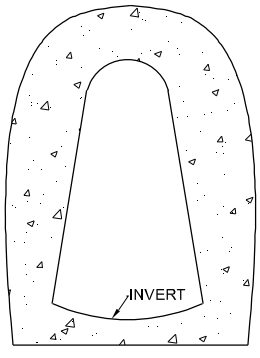
In this type of sewer sections, the upper arch takes the shape of a parabola. This shape is considered suitable for carrying small quantity of sewage and it is found to be economical in construction.

Fig 5



SEMI - CIRCULAR SEWER SECTION

Fig 6

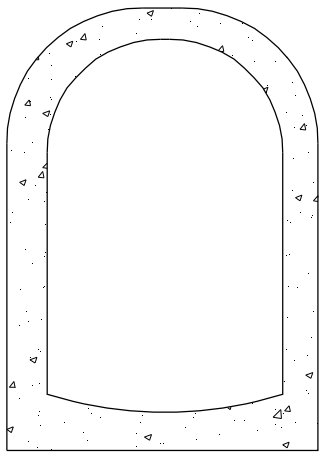


PARABOLIC SEWER SECTION

6 Horse shoe sewer section(Fig 7)

This type of sewer section is used for the construction of large sewers with heavy discharges such as outfall or trunk sewers. Its height is more than width. It is mostly used for sewers in tunnels. The top surface of the sewer is usually semi - circular with sides inclined or vertical. The bottom may be flat, circular or paraboloid.

Fig 7

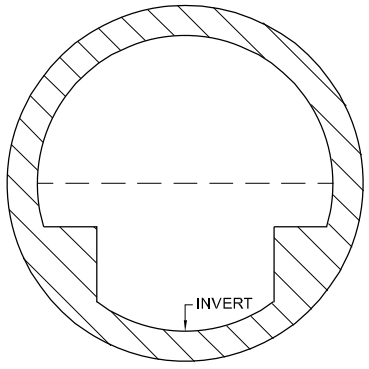


HORSE-SHOE SEWER SECTION

7 Basket - handle sewer section (Fig 8)

In this type of sewer section, the upper portion of sewer has got the shape of a basket - handle. Small discharges flow through the bottom narrower portion. During rainy seasons, the combined sewage flows in the full section. This shape of sewer is not generally used at present.

Fig 8



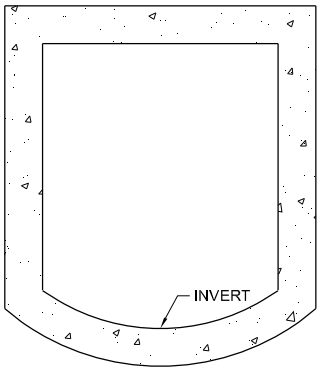
BASKET - HANDLE SEWER SECTION

DCN37:13718

8 U - shaped sewer section (Fig 9)

U - shaped sewers are easy to construct, especially in an open cut. The invert may be semi - circular or flat. The sides are vertical and the top is flat.

Fig 9



U-SHAPED SEWER SECTION

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Importance of water supply system: The water is a good solvent. If water contains impurities, excessive amount of minerals and poisonous substance etc., it will cause so many health hazards and difficulties to the public. Therefore water should be safe, whole some and free from disease producing bacteria, poisonous substances and excessive amount of minerals and organic matters.

Objectives of public water supply system

The broad objectives of a public water supply system are,

1 To ensure safe wholesome water to the public adequately.

2 To provide assured supply of water easily to the users.

3 To minimize the loss during transmission.

4 To eliminate the chances of water contamination.

5 To achieve the necessary flushing action in the sewerage system and

6 To provide adequate supply for fire - fighting.

The water should satisfy the criteria of being least harmful upon consumption and should be safe and wholesome. The source of water supply should be permanent and reliable with minimum impurities. The capacities of intakes and other water supply units should be properly designed, constructed and maintained. The intakes should be so located that the chances of contamination and bacterial infection are minimum. If necessary, water should be treated for its palatability. Water should be carried through pipes from source to treatment plant and to distribution system in order to avoid contamination and transmission loss considerably. By good planning, design and construction of a distribution system, the water should be made available to the consumers easily.

Pipes and pipe joints for underground drainage

Objectives: At the end of this lesson you shall be able to
- **list out the various factors considered for selection of pipe materials**
- **name the stresses in water pipes**
- **enumerate the types of pipes**
- **explain different types of pipe joints**
- **describe various operations involved in laying of pipes and pressure test.**

Pipes These are circular conduits in which water flows under pressure or under gravity. If the pipes do not run full, the flow will be under gravity, provided they are given a longitudinal slope. The pipes which run full are said to be flowing under pressure.

Selection of pipe materials

The selection of materials for the pipe is done on the following considerations.

Carrying capacity of the pipe.

Durability and life of the pipe.

Qualities of water to be conveyed.

Availability of funds.

Maintenance cost, repair, etc.

Resistance to corrosion.

Ease of transportation.

Stresses in water pipes

1 Stress due to change of direction.

2 Stress due to internal water pressure.

3 Stress due to the soil above the pipe.

4 Stress due to water hammer.

5 Stress due to yield of soil below the pipes.

6 Stress due to temperature changes.

Types of pipes

The following are the types of pipes based on the materials.

1 Asbestos cement pipes

2 Cast - iron pipes

3 Cement lined cast - iron pipes

4 Cement concrete pipes

5 Copper pipes

6 Galvanized iron pipes

7 Lead pipes

8 Plastic pipes

9 Steel pipes

10 Vitrified - clay pipes

11 Wooden pipes

12 Wrought - iron pipes

Pipe joints

Pipe joints are required to join together pipes of small lengths to make one continuous length of pipe line. The bell and spigot joint, using lead as filling material, is mostly used for C.I. pipes. Welded, riveted, flanged or screwed joints are used for steel pipes. Special types of joints are used for jointing R.C.C. and asbestos pipes. Flexible type of joints are used if the joint supports are likely to settle. Victaulic or dresser coupling joint should be used to bear shocks and vibrations.

Types of pipe joints

1 Collar joint

2 Expansion joint

3 Flanged joint

4 Flexible joint

5 Mechanical joint

6 Screwed joint

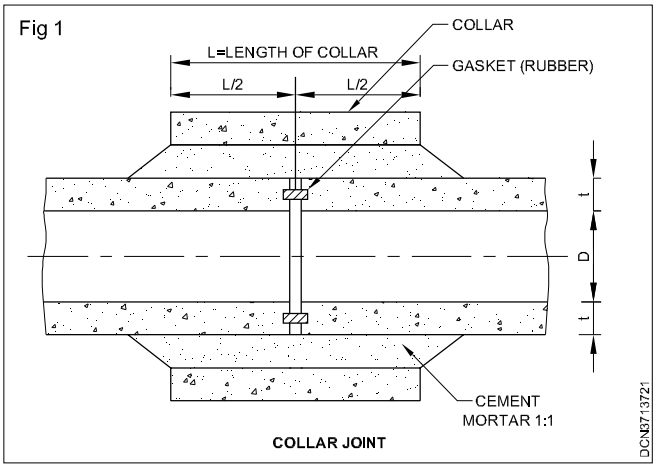
7 Simplex joint

8 Spigot and socket joint

1 Collar joint (Fig 1)

This type of joint is mostly used for jointing large diameter concrete and asbestos pipes. The, ends of the two pipes

Fig 1



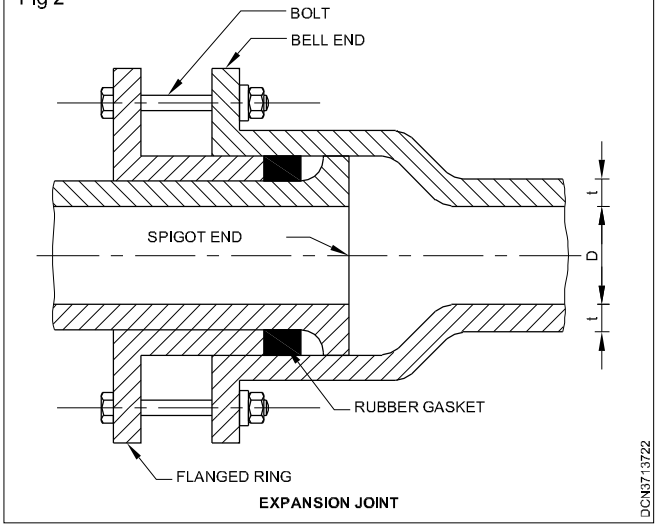
COLLAR JOINT

are brought in level. Then rubber gasket is placed between curves, as the pipes at rope soaked in cement is kept in the groove. Then the collar is placed at the joint so that it has equal laps over the joint. The space between the pipe and the collar is packed with cement mortar. 1:1 mix.

2 Expansion joint (Fig 2)

Expansion joint is used where the pipes expand or contract due to change in temperature. An elastic rubber gasket is tightly, pressed between the angular space of spigot and bell ends to make the joint water - tight. The flanged ring is bolted to bell end and it expands or contracts along with the bell end. The elastic rubber gasket in every position keeps the joint water tight.

Fig 2



EXPANSION JOINT

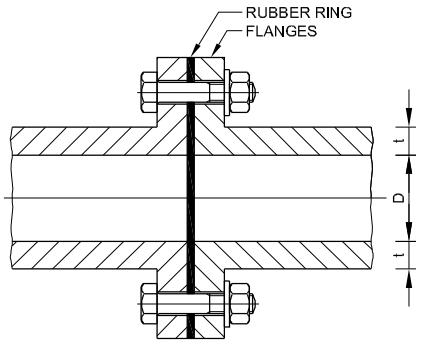
3 Flanged joint (Fig 3)

Flanged joint is used for connecting pipes carrying water under high pressure. The ends of pipes are provided with wide flanges which are bolted together. The two ends of the pipes to be jointed are brought together in level. Then a hard rubber gasket is inserted between the flanges to make the joint water - tight and the flanges are bolted together. Flanged joints are generally used in places where it is required to dismantle and reassemble the pipe lines.

4 Flexible joint (Fig 4)

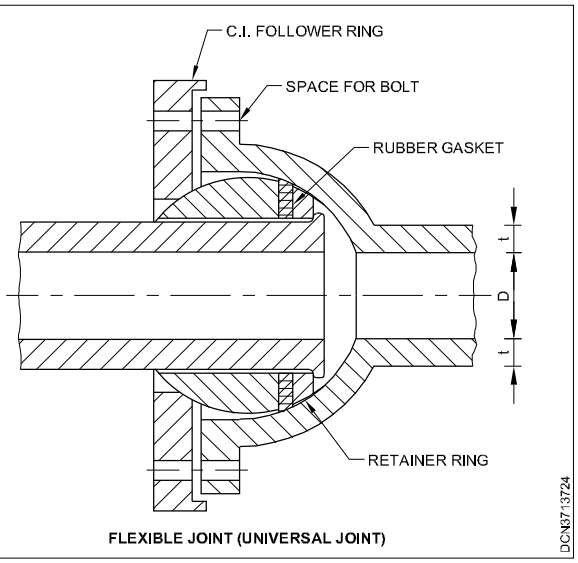
Flexible joint is used at such places where settlement is expected after laying and on curves, as the pipes at the joint can be laid at angle.The socket end is cast in a

Fig 3



FLANGED JOINT

Fig 4



FLEXIBLE JOINT (UNIVERSAL JOINT)

spherical shape. The spigot end is plain, but has a bead at the end. For assembling, the spigot end is placed in the spherical shaped socket end. After this, a retainer ring is slipped and stretched over the bead. A rubber gasket is placed against the retainer ring. Then a split cast iron gland ring is placed, the outer surface of which has the same shape as inner surface of socket end. Over this, cast iron follower ring is moved and is fixed to the socket end by means of bolt it is also known as universal joint.

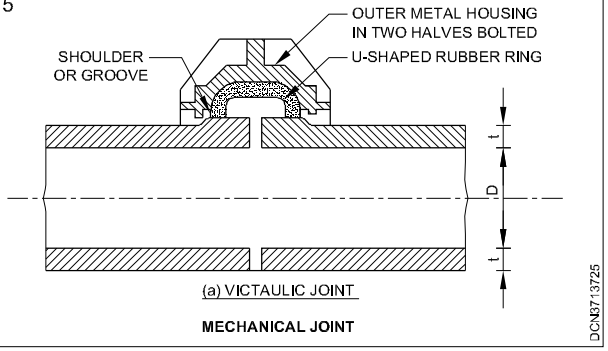
5 Mechanical joint (Fig 5 & 6)

Mechanical joint is used when both the ends of the pipes are plain or spigot. There are two types of mechanical joints.

a Victaulic joint

b Dresser coupling joint

Fig 5



MECHANICAL JOINT

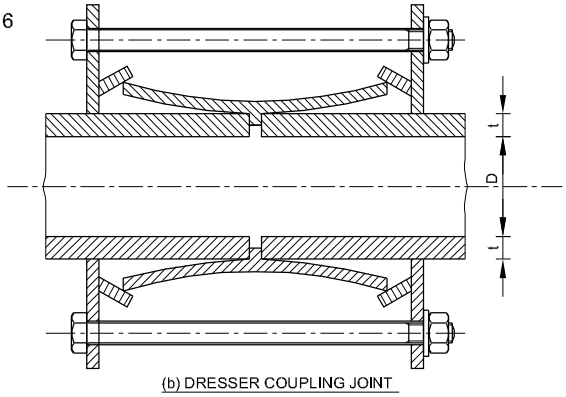
a Victaulic joint (Fig 5)

In this type of joint, a U - shaped rubber ring is slipped over both the ends of the pipes to make the joint water tight. Two half housings or couplings engage grooves near the pipe ends and enclose the rubber ring. The couplings are bolted around the pipe. The ends of the pipes are kept sufficiently apart to allow for free expansion, contraction and deflection. This joint can bear shocks, vibrations, etc.

b Dresser coupling joint (Fig 6)

This joint consists of a middle ring, two follower rings and two rubber gaskets. The two follower rings are connected together by bolts. When the bolts are tightened, they press both the gaskets tightly below the ends of the middle ring to make the joint water - tight.

Fig 6

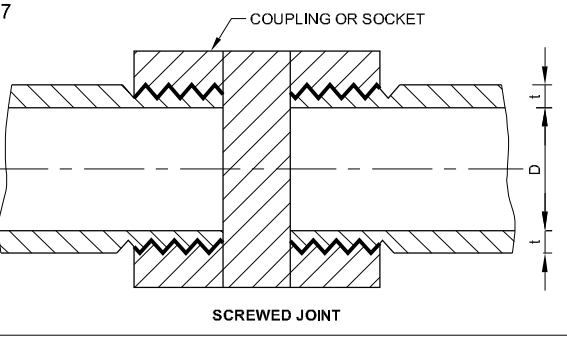


MECHANICAL JOINT

6 Screwed joint (Fig 7)

This joint is used for connecting small diameter cast iron. Wrought iron or galvanized iron pipes. The ends of the pipes to be jointed, have threads on outside. The socket or coupling has threads on the inner side. The same socket is screwed on both the ends of the pipes to be jointed. To ensure water tightness, jute soaked in white lead is placed in the threads before screwing the socket over the pipes.

Fig 7

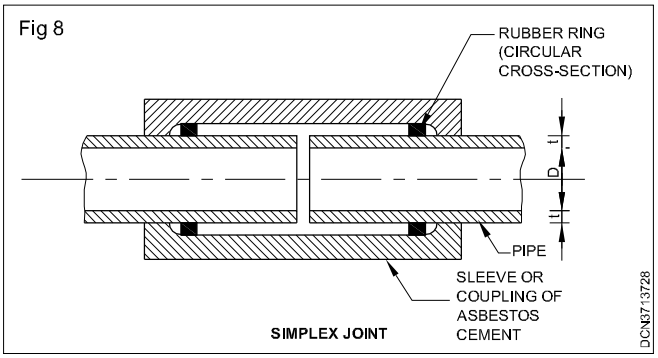


SCREWED JOINT

7 Simplex joint (Fig 8)

In this joint, the two plain ends of the pipes butt against each other. Then the rubber rings are slipped over the pipes. Next a coupling will be pushed over the rubber rings. This makes a water - tight and flexible joint which can be completed easily in a dry condition or under water.

Fig 8

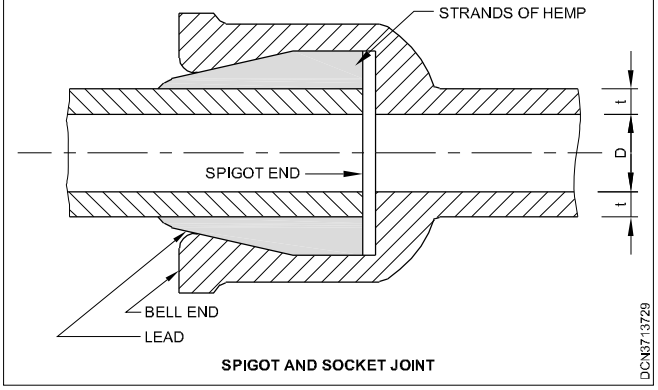


SIMPLEX JOINT

8 Spigot and socket joint (Fig 9)

This joint is otherwise known as bell and spigot joint and is mostly used for jointing cast iron pipes. The spigot of one pipe is slipped into the socket or bell of the proceeding pipe. Tarred gasket or hemp yarn is then wrapped around the spigot. It is then yarned tightly home with a yarning tool. A joint runner or a kneaded clay mould is then formed around the barrel and against the face of the socket.

Fig 9



SPIGOT AND SOCKET JOINT

The molten lead or its substitute is poured through the hole at top to fill the remaining annular space of the socket. When the lead has hardened, the runner of the clay mould is removed. The lead is caulked by caulking tool to make the joint water - tight. It should preferably be finished 3 mm beyond the socket face.

Laying of pipes

The various operations involved in the laying of pipes are as below

1 Preparation of detailed maps

2 Fixing the alignment

3 Excavation of trenches

4 Bottoming of trenches

5 Lowering of pipes

6 Laying of pipes

7 Jointing of pipes

8 Anchoring of pipes

9 Back - filling

1 Preparation of detailed maps

Detailed maps regarding roads and streets showing clearly the position of sewer lines, existing water mains, gas pipes, electrical cables, and curbs are to be prepared.

2 Fixing the alignment

The exact location of the proposed alignment is then marked on the ground. The trench line is marked by driving stakes and the centre line by driving pegs or stakes at intervals 30 m apart on straight reaches and at 7.5 to 15 m apart on curves.

3 Excavation of trenches

The trenches are then excavated to sufficient width so that the pipes can be properly laid and easily jointed. The width of the trench should be at least 0.3 to 0.5 m greater than the external diameter of the pipe. The trenches are excavated to the predetermined depth. The pipe should have a top cover of about 0.9 to 1 m to ground.

4 Bottoming of trenches

The bottom of the trenches should be prepared carefully so that the pipe can be laid in alignment and gradient to its entire length on a firm bed. To prevent any possible settlement and to provide a hard and even surface, a concrete bed of 150 mm thick is provided. Joint holes are left at suitable spacings in the bed for jointing the pipes latter.

5 Lowing of pipes

The pipes are lowered carefully into the trenches after they are cleaned internally and externally.

6 Laying of pipes

The pipes are laid in alignment along the ground profile to avoid troubles due to air - lock.

7 Jointing of pipes

The. joints are finished as per the description given under "pipe joints".

8 Anchoring of pipes

Concrete thrust blocks are constructed, at all bends, tee junctions, valves and at places where branch connections are to be provided, to distribute the hydraulic thrust over a larger area on the ground. For better anchorage, the pipes are rigidly secured with steel straps.

9 Back - filling

The sides and the upper portions of the trenches are refilled with excavated earth in layers of 150 mm thick, watered and rammed well. The top of refilling is finished slightly above the original level for future settlement.

Pressure test to water pipes

The sequence of operations involves in the pressure test to water pipes are as below.

1 A section of pipe line between two sluice valves is taken up for testing at a time.

2 Keeping one of the valves closed, water is filled, without any air lock, into the pipe through the second valve.

3 The pipe line is isolated from the rest, by closing the second valve.

4 Pressure recording devices are then fitted at intervals of 800 to 1000 m at the crown through holes left for the purpose.

5 The delivery side of a pump is connected to the test pipe through a small bypass valve.

6 The pump is worked till the inside pressure reaches the designed value (1.5N/mm^2 or the maximum working pressure plus 50% whichever is greater) which can be observed from the previously fixed pressure recording devices.

7 After attaining the desired pressure, the pump is disconnected and the pipe line is checked for 24 hours under this pressure for any defects or leakage. This can be read from the fall in pressure in the pressure recording devices.

8 Then the water is emptied through the scour valves. The defects, if any, are rectified.

During testing, the open end of the pipe line should be kept closed water - tight with a plug.

System of sanitation

Objectives: At the end of this lesson you shall be able to
- **explain the system of sanitation**
- **explain the system of sewerage.**

System of sanitation

Sanitation systems are a combination of functional units that together allow managing and reusing or disposing the different waste flows (i.e. waste, organic waste, excreta, etc.) from households, institutions, agriculture or industries in order to protect people and the environment. Sanitation systems are more than the toilets and have to do with management issues including treatment and reuse of waste and wastewaters, comfort, affordability, health aspects, gender aspects, etc.

Methods of collection

1 Conservancy system or dry system

2 Water carriage system or modern system or flush down system

Conservancy system (Dry system)

In conservancy system, garbage is collected, carried and disposed off by burning or burying. Sullage is collected in open drain and let off in natural water. Night soil is removed by labour and conveyed outside the town to form manure.

Merits

i It is cheap

ii It can be adopted for small towns and villages

iii It can be adopted where water is scarce

Demerits

i Unhygienic aspects are involved in the manual removal of human excreta.

ii Nuisance due to bad smell from the decomposed night soil.

iii Insanitation due to the transportation of night soil through streets.

iv Does not permit compact design and safety as the toilets are to be constructed away from the building.

v Risk of epidemics due to improper disposal of the night soil.

vi Misuse of sullage drains to dispose of garbage and other solid waste.

vii Considerably more land is required for disposal.

viii Contamination of underground water.

ix Though initial cost is less, maintenance cost is more.

2 Water carriage system: It is the most hygienic system. In this system sewage is collected in a system of pipes and transported for treatment and disposal in a harmless manner without causing any nuisance.

Merits

i It is hygienic, since the sewage is carried in covered conduits.

ii The effluent can be safely used to develop sewage farms.

iii The final solid matter obtained after treatment is a very good manure.

iv Less area is required for treatment and disposal.

v The risk off outbreak of epidemics is reduced as the sewage collected is properly treated and disposed off.

Demerits

i Needs large quantity of water

ii Costlier

iii Needs sophisticated and costly treatment methods

iv The effluent after treatment should be properly disposed off to prevent pollution of water resource of land.

Systems of sewerage

1 Separate system of sewerage

2 Combined system of sewerage

3 Partially combined or partially separate system of sewerage

1 Separate system of sewerage

In this system, two sets of sewers are laid. One sewer is meant for carrying sewage. While the other for carrying storm water.

Merits of separate system

i Sewer sizes are small.

ii Sewage load on treatment units is small.

iii River or stream waters are not polluted.

iv Without any treatment, rainwater or storm water can be discharged into streams or rivers.

v When sewage has to be pumped. This system proves to be economical.

Demerits

i It is costly, because it requires two set of sewers.

ii Sewers being small, it is difficult to clean them.

iii Sewers are likely to choke frequently.

iv Storm water sewers are used only during rains. Therefore during non - rainfall season they may become the dumping places for garbage and may get choked up.

2 Combined system of sewerage

In this system, only one set of sewer is laid to carry both sewage and storm water.

Merits of combined system

i Rain water keeps sewage fresh making it easier and more economical for treatment.

ii Dilution itself is a method of treatment.

iii Automatic flushing is provided by water.

iv Because of the bigger size of the sewer, cleaning is easier.

v This is a simple method of collection and house plumbing is economical.

vi Maintenance cost is reasonable.

vii Only one set of sewers is required in this system.

Demerits of combined system

i The bigger size of sewer would involve larger excavation.

ii The D.W.F. being a small amount of the total flow the larger size of the sewer would often result in causing silting up due to low velocity.

iii Cost of pumping and treatment is more, since large quantity of sewage is to be handled.

iv Over flowing under worst conditions may endanger public health.

v Load on treatment units increases.

vi Storm water is unnecessarily polluted.

3 Partially combined or partially separate system of sewerage

In this system also, only one set of sewer is laid. During small rain falls, the rain water is collected and conveyed along with sanitary sewage. If the amount of storm water exceeds certain limit, it is collected and conveyed in open drains. While sewage continues to flow through sewers.

Merits of partially combined system

i It simplifies the drainage of the house.

ii It provides reasonable sizes of sewers.

iii It is economical.

iv The rain water avoids silting in sewers.

v It has the advantages of both separate and combined systems.

Demerits of partially combined system

i Low velocity during dry period.

ii Storm - overflows may be found necessary.

iii Load on pumping and treatment unit is increased due to the admission of storm water.

iv Storm water is polluted unnecessarily.

System of house drainage

Objectives: At the end of this lesson you shall be able to
- **explain the aim of house plumbing**
- **explain the principles of house drainage**
- **define the terms related to house plumbing**
- **explain the types of traps.**

House plumbing

House plumbing is the collection and conveyance of liquid refuse upto the public drain adn sewers. Certain part of the building are set apart for this purpose. The positions of various sanitary conveyances and other conveniences are marked on the plan of the building. The drainage lines from the places of collection, leading to the sewer are also shown on the same plan with necessary appurtenances. Sanitary conveyances include lavatory blocks comprising of water closets and urinals, and bath rooms. Other conveniences comprise kitchen sinks and washing places.

Aim of building drainage

1 To dispose off liquid waste as early as possible

2 To prevent entry of foul gases from the sewer to the building

3 To dispose off the storm water into open surface drain

4 To facilitate quick removal of foul matter

5 To provided health condition in the building

Principles of house drainage

1 For proper design and construction of house drainage system, the following general principles are adopted.

2 The entrances to drains should be outside the building.

3 The drainage systems should have proper ventilation.

4 The drains should not pass through building, but should pass by the side of the building.

5 The drains should not be laid close to trees.

6 The drain should be laid at gradients for self cleansing.

7 The drain should be laid straight between points of access. All changes of direction or gradient should be open for inspection.

8 Branch drains should be as small as possible.

9 All the connections should be oblique, so that the incoming drain faces the direction of flow of the sewage.

10 The size of drains should be just sufficient to meet the requirements.

11 The pipe joints should be water tight and made from non - absorbent materials.

12 The house drain should be connected to public sewer only when the public sewer is deeper than the house drain.

13 The house drain should contain sufficient number of traps at suitable points.

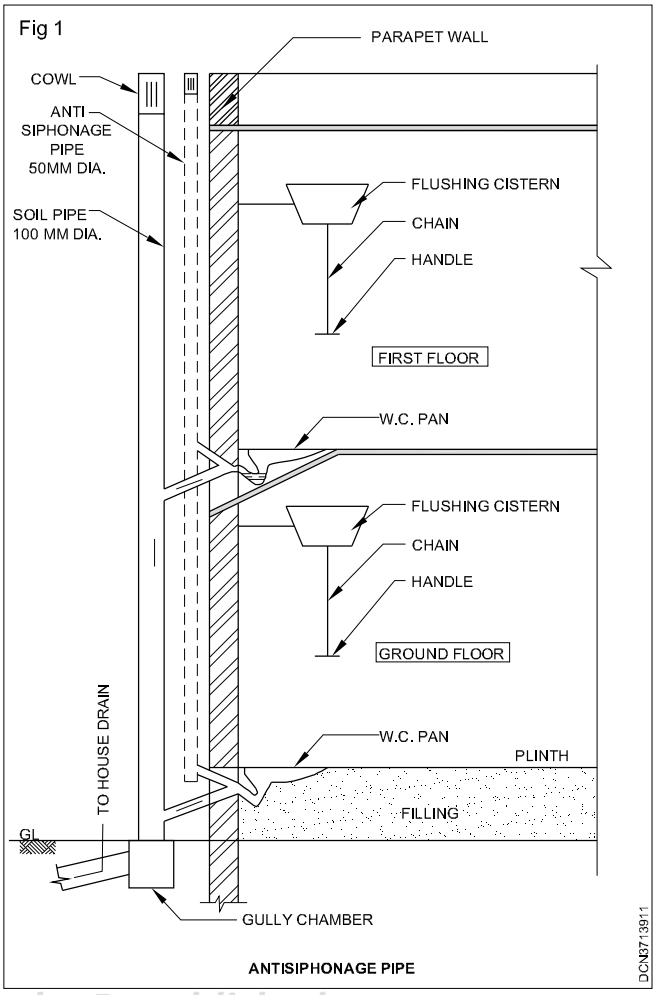
14 The house drain should be separated from the public sewer by a trap to prevent the entry of foul gas in to houses.

15 It is preferable to provide a separate system of drains to take the rain water.

Terms related to house drainage (Fig 1)

Anti - siphonage pipe - It is a pipe which is installed in the house drainage to preserve the water of traps. It maintains proper ventilation. It does not allow the siphonic action to take place.

Fig 1



Cowl - It is provided at the top of vent pipe. It prevents the birds from building the nests. It is provided with slits or narrow openings. It escapes the foul gas from septic tank or the drainage line.

Fixture drain - It is the outlet pipe from the trap of a fixture to make its connection any other drainage pipe.

Fresh air inlet - This is provided at the last manhole, which connects the house drain with the public sewer for admitting fresh air. This dilutes the sewage gases. It is kept at about 2 metres high above the ground level. It is provided with mica flap one way valve at its top. This valve opens inwards and admits fresh air.

Horizontal branch - It is a drain pipe extending laterally from a soil or waste stack or house drain. It receives the discharge from one or more fixture drains and conduct it to the soil or waste stack or house drain.

Horizontal pipe -It is any pipe or fitting which make an angle of less than 45° with the horizontal.

House drain or building drain- It is that part of the lowest horizontal piping of a plumbing drainage system. It receives discharge from soil, waste and other drainage pipes within the building and conveys it to the house sewer.

House sewer or building sewer - It is that part of the horizontal piping of a plumbing drainage system that extend from the end of the house drain or building drain to the public sewer or other outlet.

Siphonage - Due to siphonic action, water seal or traps may break. This is known as siphonage and it is induced when water is suddenly discharged from a fixture on the upper floor.

Soil pipe - It is any drainage pipe that carries liquid wastes containing human excreta.

Stack - A stack is any vertical line of drainage i.e., soil, waste or vent pipe.

Vent pipe - The pipe installed for ventilation of sewers is known as vent pipe. It is provided to protect the water seal of traps against siphonage and back flow.

Waste pipe - The waste pipe is any drainage pipe that carries liquid wastes that do not include human excreta.

System of plumbing - There are four system adopted in plumbing of drainage work in a building.

1 Single stack system

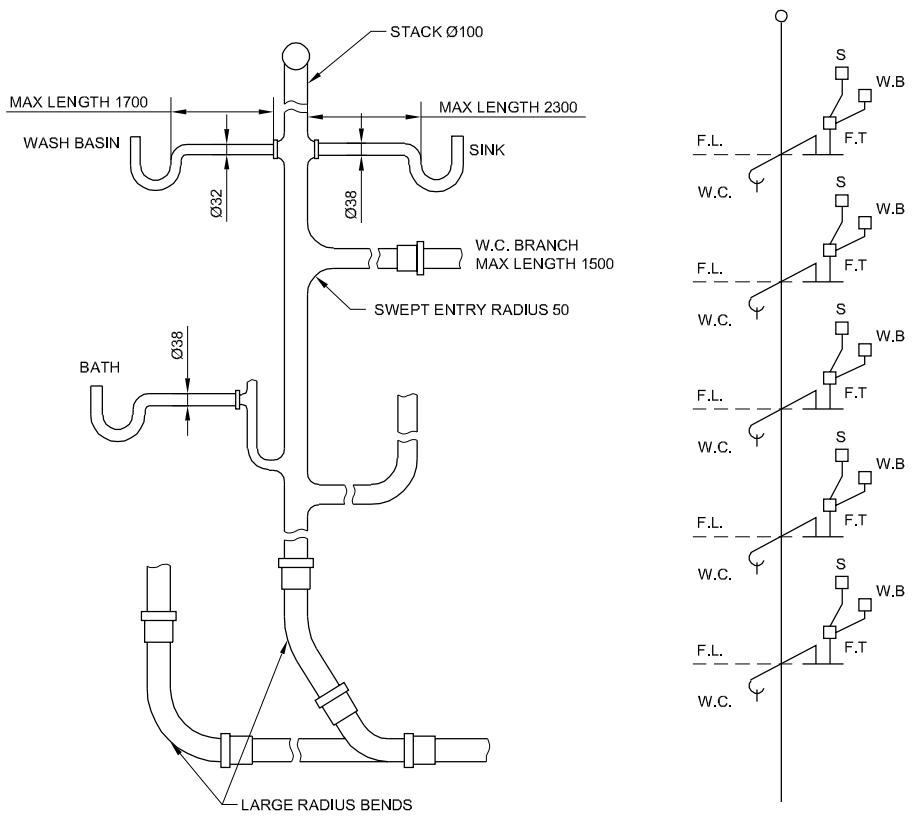
2 One pipe system

3 One pipe system partially ventilated

4 Two pipe system

1. The single stack system - This is the name given to a simplifide one - pipe system. All ventilating pipes are committed. The stack itself provides ventilation by restricting the flow into the stack upto certain limits.(Fig 2)

Fig 2



SINGLE STACK SYSTEM

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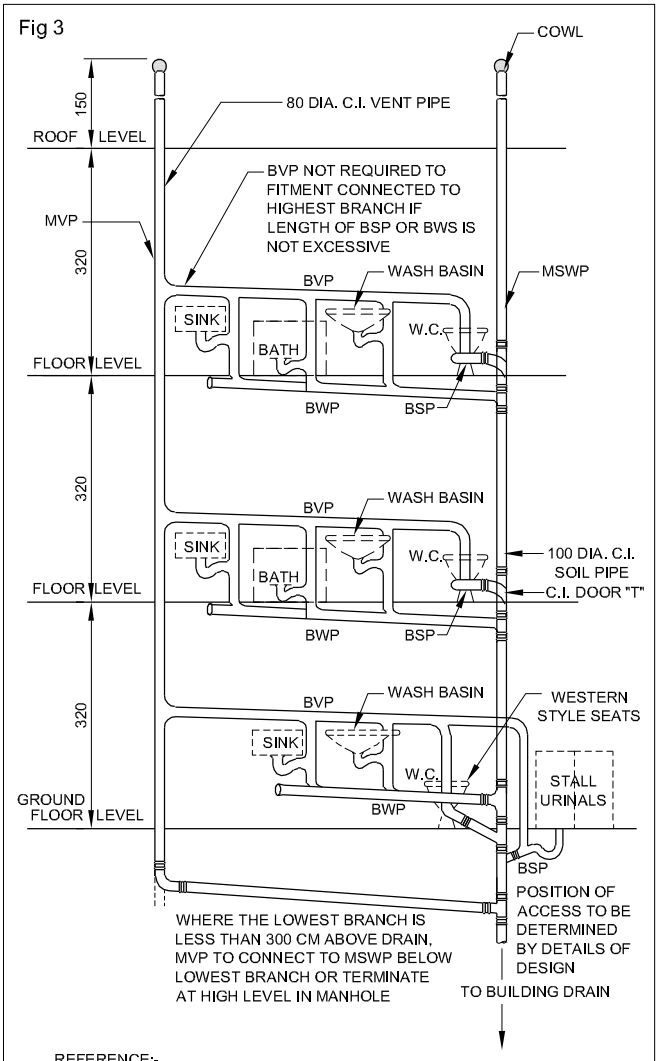
The single stack system is used only in buildings with a maximum ground floor and four upper floors having two bathroom units and two sinks at each floor.

2. The one - pipe system - In this system a single soil waste pipe conveys both soil and waste from all appliances directly into the building drain. It is an easy to install and economical system. Fig 3 shows a single pipe system.

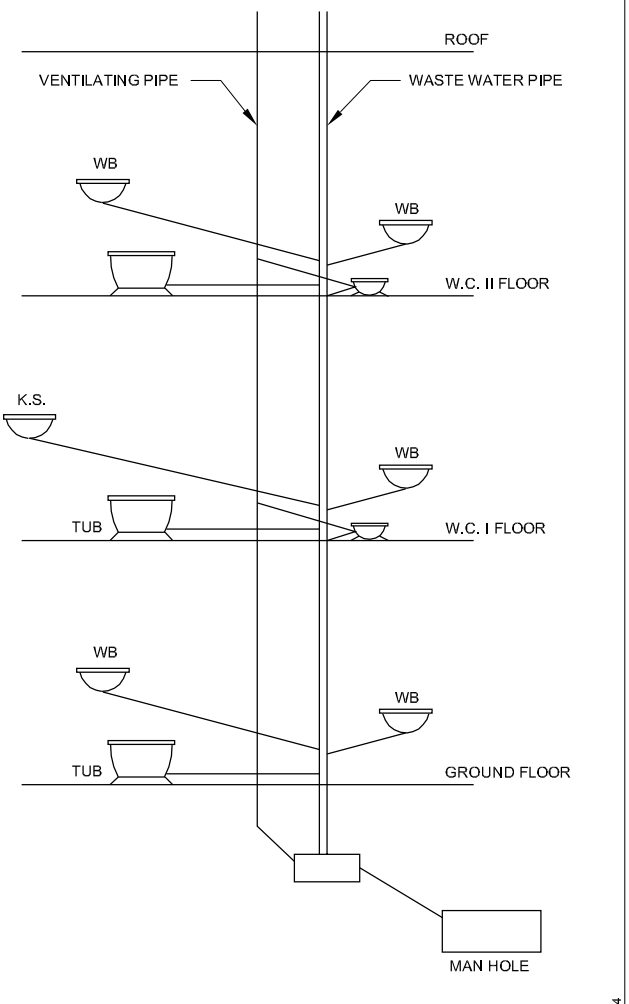
Fig 3



ONE PIPE SYSTEM

3. One pipe system partially ventilated - This system combines both the one - pipe and single stack system. In this system, only one soil waste pipe conveys both soil and waste. The separate vent pipe provides ventilation only to the traps of water closets.(Fig 4)

Fig 4

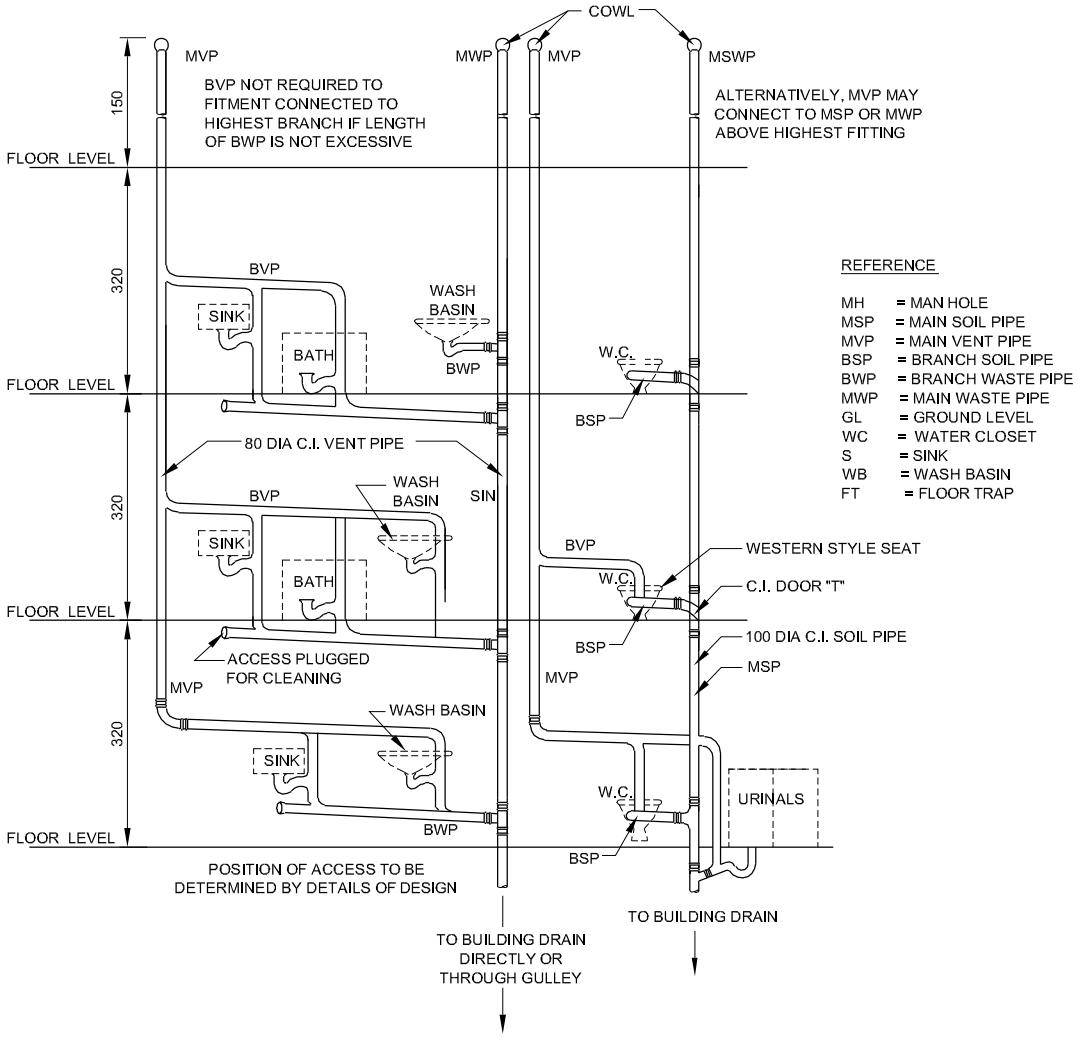


ONE PIPE SYSTEM (PARTIALLY VENTILATED

4 The two - pipe system (Fig 5) - Different waste pipes are used for drainage of waste from bath, kitchen and W.C's. The soil pipe conveys discharges from water closets, urinals, and similar soil appliances directly to the drainage system. The waste pipe conveys waste from ablutionary and culinary (sinks, wash basins, showers, bathrooms and kitchens) appliances to the drainage system directly or through a traped gully where desired.

This system is installed on the face of a side wall or a pipe duct in the case of multistoreyed buildings. In multistoreyed buildings where the number of floors exceeds four, this system is preferred.

Fig 5



TWO PIPE SYSTEM

Plumbing sanitary fittings

Objective: At the end of this lesson you shall be able to
- **explain different sanitary fittings.**

Sanitary fittings

The fittings required in a building for the efficient utility, collection and removal of water are called sanitary fittings.

These fittings are available in the market under many branded names and in variety of sizes, colours and designs. Only an outline is given here.

Traps

Fittings or sanitary appliances and accessories

Traps

The depression or bend provided in a drainage system which is always full of water and prevents the entry of foul gases into the atmosphere is termed as a trap. The water inside the trap is called seal. Traps are made of glazed earthen ware, vetereous, porceline, cast iron, and P.V.C. or hi - density polythelene. According to the shape the traps are classified as

P trap This trap has a shape of letter 'P'. The legs of trap are at right angles to each other(Fig 1)

Q trap This trap has the shape of letter 'Q'. Tthe legs of trap meet at an angle other than a right angle.(Fig 1)

S trap This trap has the shape of letter 'S'. The legs of trap are parallel. The two legs of traps are at right angles (Fig.1).

Classification according to use

According to use, traps are of the following types:

1 Floor trap (Fig 2c)

2 Gully trap (Fig 2a)

3 Intercepting trap (Fig 2b)

Requirements of good trap

1 It should be easily fixed and cleaned.

2 It should facilitate easy flow of sewage.

3 It should be simple in construction.

4 It should possess adequate water seal and self cleansing properties.

5 The internal and external surface should be finished smooth.

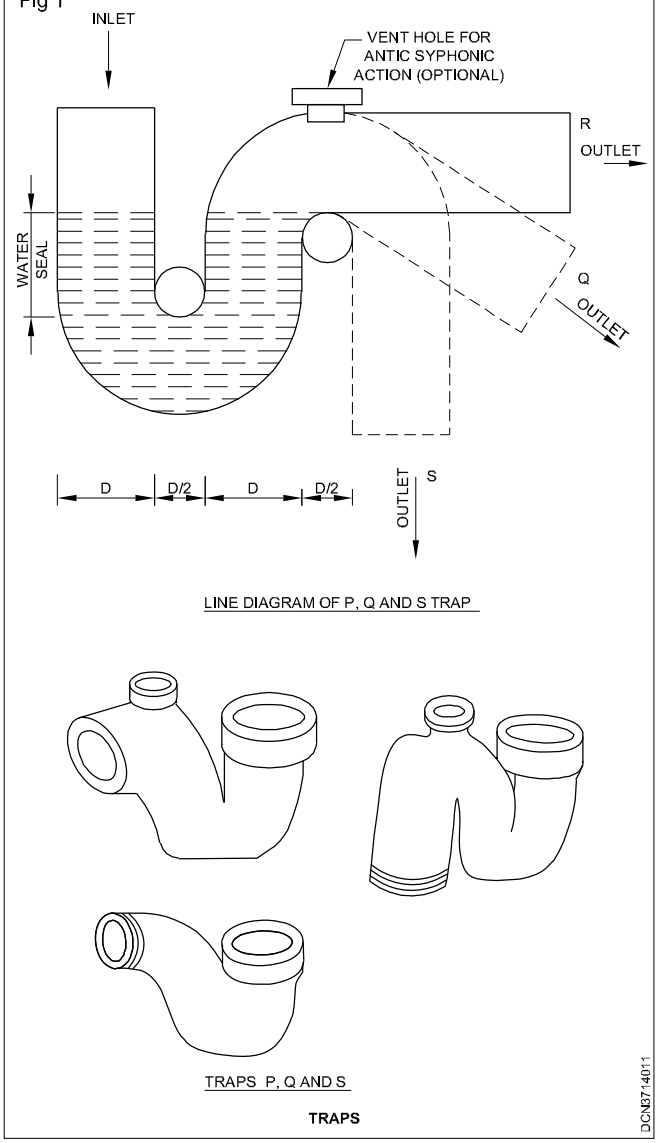
6 It should be easily fixed with the drain.

7 It should be free from any inside projections.

Fittings or sanitary appliances and accessories

Following are the common sanitary fittings which are provided in a building.

Fig 1



1 Wash basin.

2 Bath rub.

3 Sink

4 Bathroom fittings such as

- i Shower
- ii Shower stall
- iii Towel rail or ring
- iv Toilet roll stand or holder

5 Drinking fountain

6 W.C seats

- i Squatting type
- ii Chair - type or raised wash - down water closet.

7 W.C flushing cistern

i High level
ii Low level.

8 Automatic urinal flushing cistern.

9 Urinals

i Bowl pattern.

ii Urinal stalls.

10 Bidet.

All these appliances are manufactured in various sizes, elegant designs and attractive colours. The illustrations given here just give an idea about the space to be provided for installing different appliances.

Pictorial and three - dimensional views are given so that a layman can understand the shape of these fittings. Symbolic representation of each fitting is also given along the sketch.

1 Wash hand basin: Wash hand basins are available in various designs and sizes. These are mainly of two patterns. Fig 3 i.e. Flat back and angle back. Flat wash basins are mounted on walls while angle back

Fig 2

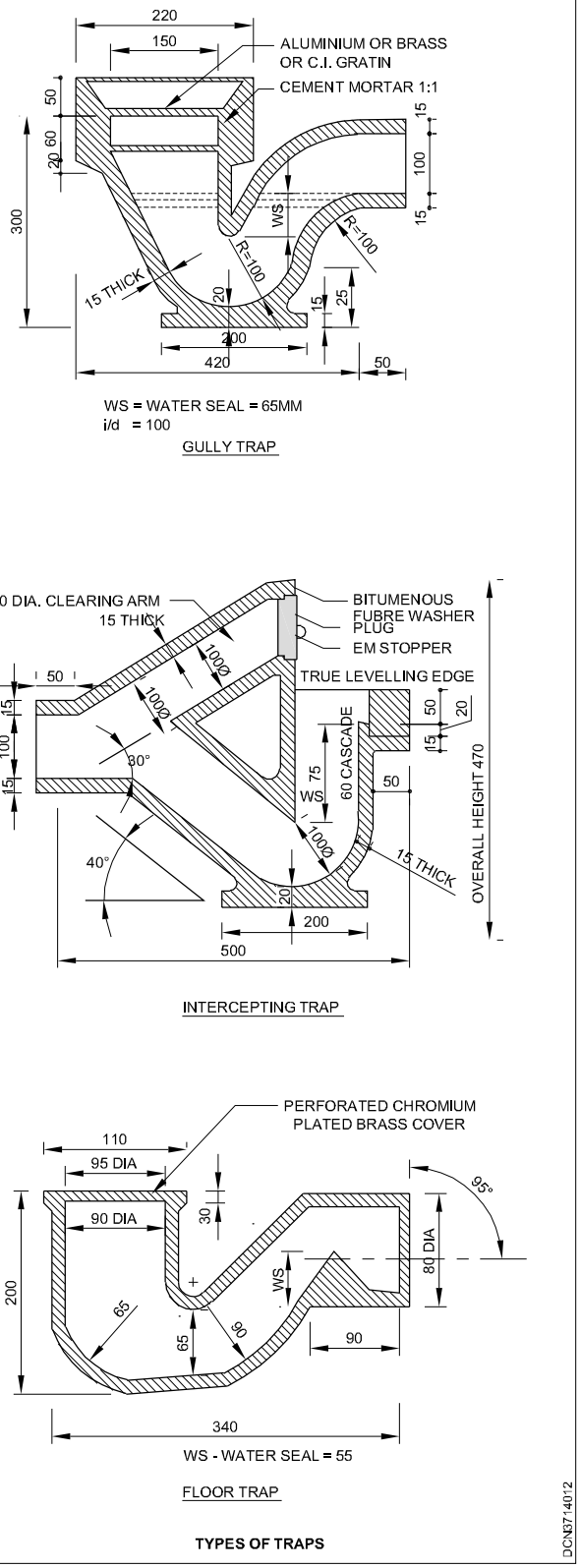
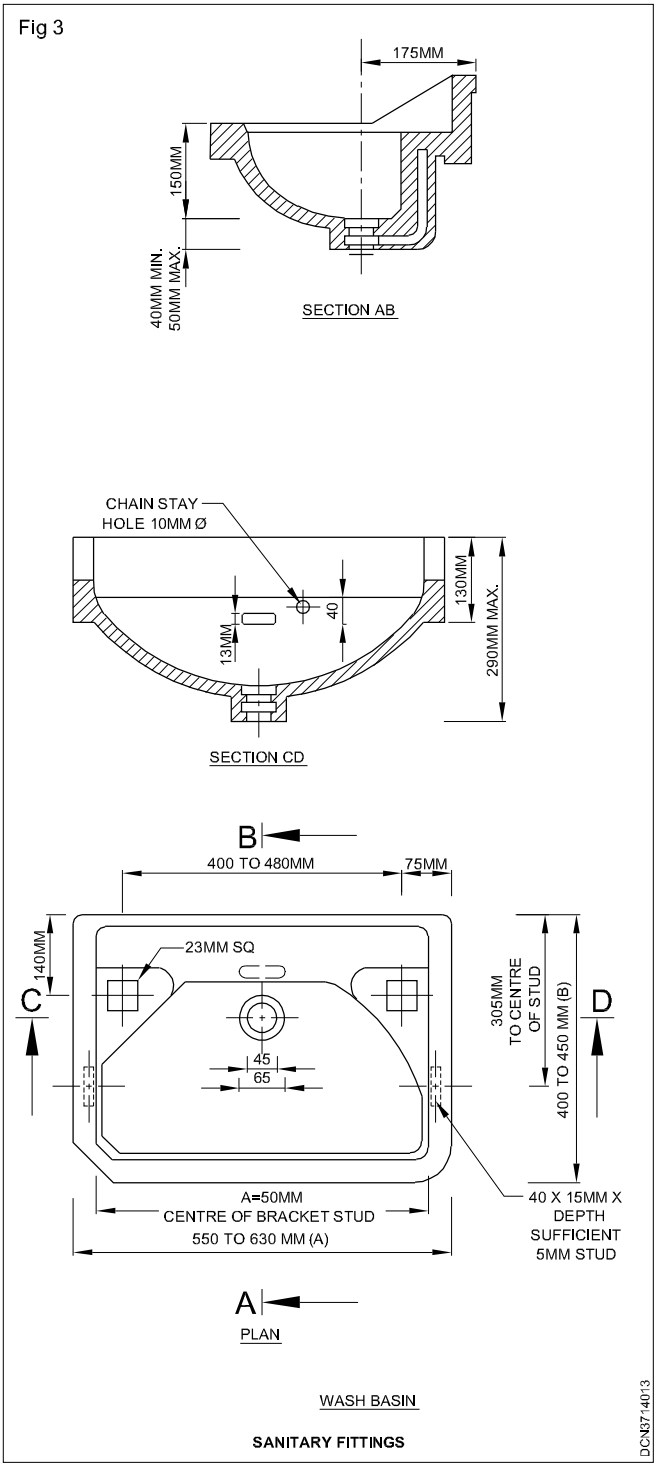


Fig 3



type are fixed at the junctions of two walls. Wash basins are made of fire clay, stoneware, earthen ware or vitreous china. Now a days steel and aluminium wash basins are also available in the market. A wash basin has syphonic trap underneath. A discharge pipe attached to it is left over floor trap. A wash hand basin with dimensions as per I.S. standard.

2 **Bath tub:** A bath tub is a luxurious item in the bath rooms which is used for taking bath. It is made of cast iron, enamelled iron, plastic marble, fire clay, steel or aluminium etc. It has a porcelain enamelled finishing inside. It is 170 to 185 cm long, 70 to 75 cm wide and inside depth at waste is 43 to 45 cm. Bath if fitted with over flow pipe and waste pipe of not less than 25 mm diameter and inside slope towards the outlet. Sometimes a bath is provided with hot and cold water taps. A bath tub is shown in Fig 4.

3 **Sink:** A sink is used in the kitchen for washing utensils. It is also used in laboratories. A sink may be of one piece constructed with or without rim, including a combined over flow of weir type and their inverts shall be 30 mm below the top edge. A circular waste hole is provided in the sink. A drain board is also provided with all the kitchen sinks. A sink with its sizes as per I.S standards is shown in Fig 5.

Fig 4

4 **Bath room fittings:** Inspite of usual bathroom fittings, some additional fittings are also provided in the bath room which are as given below.

i **Shower:** It is used for taking bath. A shower head 10 to 20 cm dia with 70 holes of 1 mm dia each is fixed at a height of 2.20 m from floor level to the water supply pipe as shown in Fig 6.

ii **Towel rail:** It is provided for keeping towel in the bath room. The size of towel rail is generally 75 cm x 18 mm or 60 cm x 18 mm. This is fixed by means of screws to wooden cleats firmly which are embedded in the wall. See Fig 7.

Fig 5

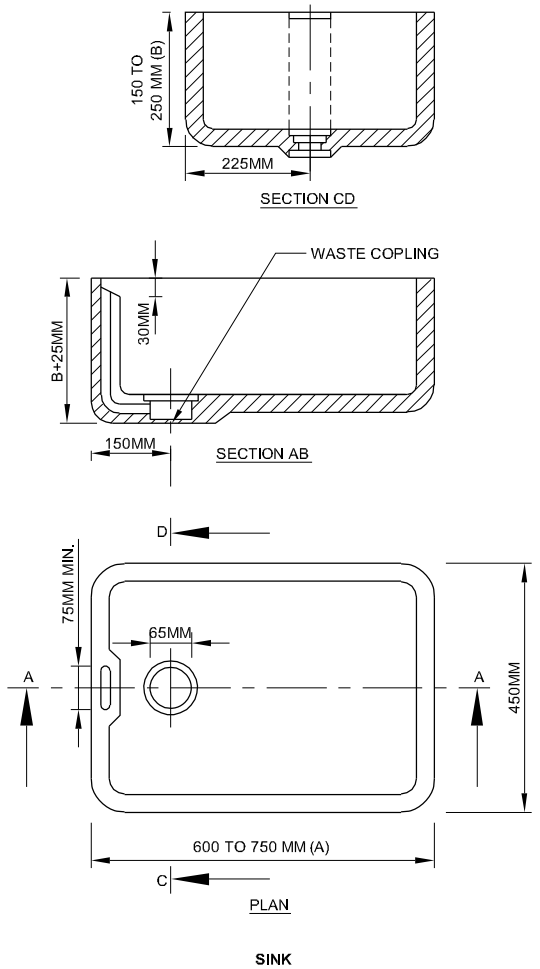


Fig 6

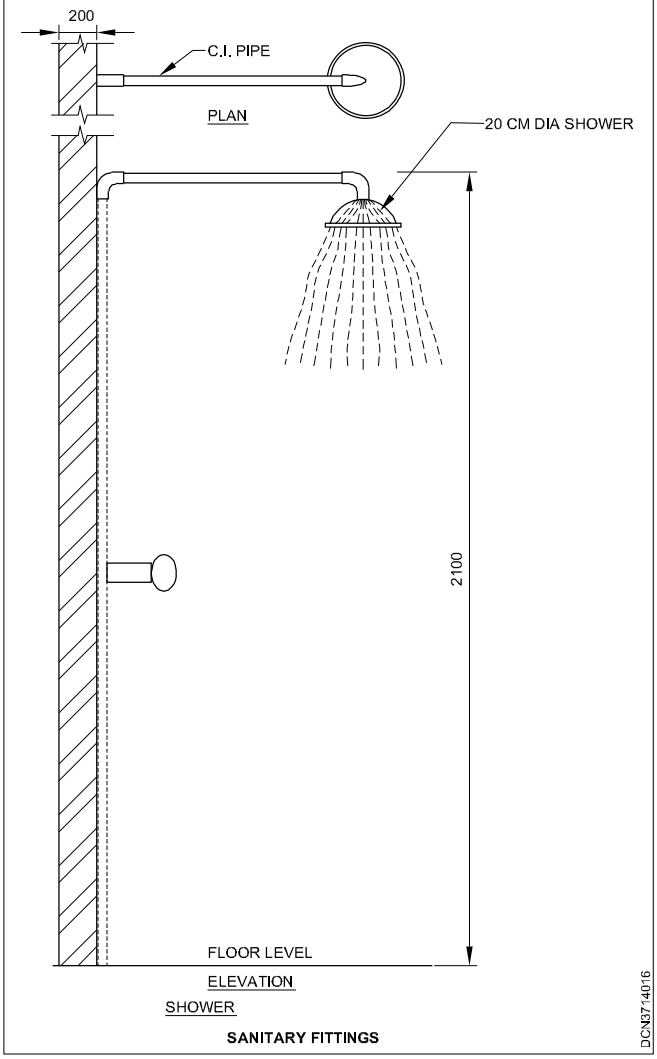
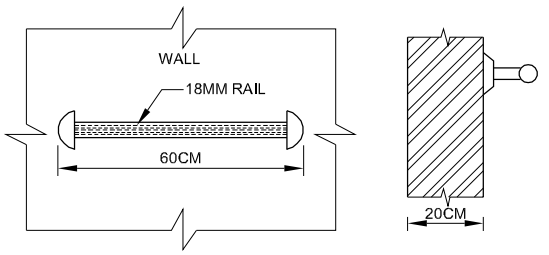


Fig 7



SANITARY FITTINGS

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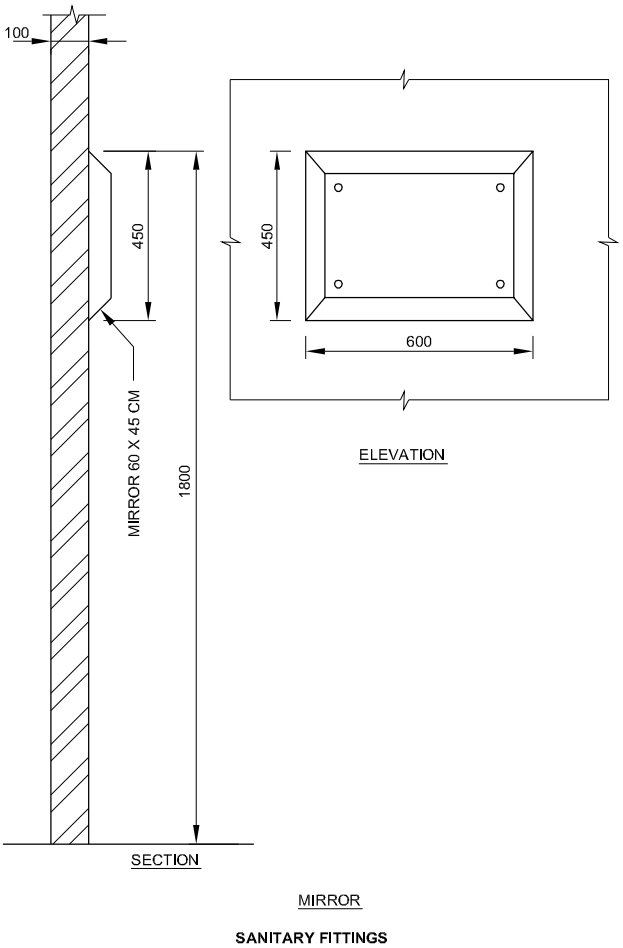
iii Mirrors: t is fixed at a suitable height having a size of about 60 x 45 cms. It is mounted on asbestos sheet ground and is fixed in position by means of 4 Nos.of brass screws and washers placed over rubber washers. Wooden pegs are firmly embedded in the wall to fix the mirror firmly. Fig 8

Fig 8



SANITARY FITTINGS

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Drinking fountain Fig 9

In schools, public buildings, factories, etc., drinking fountains are provided to supply drinking water. This is a simple arrangements and wastage of water is avoided. When the valve is pushed the water comes from the tap. After a part being consumed the remaining falls on the plat form. It is conveyed to the floor trap through the grating.

Fig 9

Water closet It is the sanitary engineering appliance which is used to receive human excreta directly and connected to a soil pipe by means of a trap. There are two main types of the water closet.Fig 10

i Indian type (long pattern squatting pan) Fig 10

ii European type Fig10a

Fig 10

Fig 10a

The Indian type consists of a pan or basin and a trap. The pan is of impervious and smooth material preferably white glazed. It should have a sufficient depth of water. The trap should have a minimum water seal of 45 mm. The pan should have also a sufficient slope towards the outlet for quick disposal during flushing. The top of the trap is attached to anti - syphonage pipe or vent pipe. An Indian type and European type water closets are shown in Fig 11.

Fig 11

Flushing cistern (Fig 12)

It is meant for flushing water closets and is made of cast iron of minimum thickness as 5 mm. The flushing capacity of the cistern is 10 to 15 litres. There are several varieties of flushing cisterns. They may be high level and low level cisterns. Plastic cisterns are also available now a days.

Fig 12

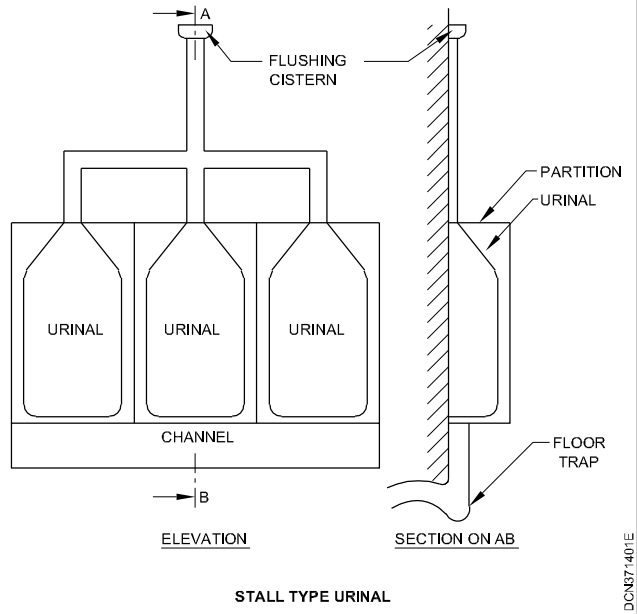
It is operated by pulling a chain by hand which due to lever action raises the ball inside the chamber. This causes partial vacuum inside the ball upto the top. As it happens water flows down into the flush pipe and thus the syphonage action starts. Water in the tank, goes on entering the ball through the bottom. The actual flush however will not take place unless the chain is released suddenly which forces down the water into the flush pipe with a splash. If the chain is not released, the partial vacuum created in the top of ball shall be destroyed by the entry of air from the flush pipe.

Urinals Urinals are constructed in various types. They may be bowl type, slab and stall type and squating plate type. Bowl type urinals are constructed as one piece construction. These are fixed against wall. It has a regular and smooth inside surface for efficient flushing. A slope is provided at the bottom towards outlet for efficient drainage of the urine. An automatic flushing cistern is provided at the top for flushing purposes Fig 13.

Fig 13

The slab and stall type urinals are provided in public places like, bus stands, railway stations, restaurants, offices and cinema houses etc Fig 14.

Fig 14



STALL TYPE URINAL

The squatting plate urinals are mostly used in ladies toilets. They are generally one piece construction.

Bidet (Fig 15)

The bidet is pronounced as "beday". The bidet is designed for cleanliness of localised parts of the body especially of genito urinary cleanliness. The bidet is equipped with valves for both hot and cold water and with popup waste plug, a flushing rim, an integral jet operated by menas of valve. When the jet is "ON" a stream of water flows upward from bottom section of bowl enabling cleaning.

Fig 15

New technologies in sewer appurtenances-system of plumbing

Objectives: At the end of this lesson you shall be able to
- **explain smart plumbing**
- **explain rain water harvesting**

The concept of smart plumbing or green plumbing is the reduction of use of water through resourceful landscaping, wastewater technology and high-efficiency plumbing design.

Water and energy conservation are the two conservation issues of a plumbing system in a green-built home. Changing climate and weather patterns have made water a precious commodity and are an incentive for efficient plumbing systems. The goal of water efficient plumbing is to reduce potable water use. For this

i Fit all sink and lavatory faucets and showers with water restricting aerators.

ii Install high - efficiency toilets Toilets consume more water than any other fixture in the house. Users will save money on their water bill. These toilets are installed in the same manner as any other toilet. Dual flush toilets are more expensive, but are available at home improvement stores.

iii Install flow reducers on faucets and shower heads.

iv Install on - demand circulation systems. So customers will get hot water without the wait. Saves energy by only heating the water as it is needed.

v Install drain water heat recovery systems Heat is recovered from waste water resulting in energy and water savings.

vi Pre - plumb for future grey water systems save money for the homeowner in the future (grey water systems mean less potable water used flushing toilets or for outdoor watering. Grey water is only legal in a few areas of the country as water shortages occur due to climate change, municipalities will be encouraged to legalize grey water).

Technology is playing an important role in the plumbing department whether in the form of products designed to make the kitchen and bath more comfortable, keep living spaces more sanitary. The cost of water is rising, increasing 6 to 7 percent a year, so it is necessary to finding ways to conserve and reuse water. One way to make this transition is through a grey water recycling system.

This system uses water from showers, sinks, washing machines and dishwashers that is relatively clean, containing very few pathogens. This water (unlike black water which comes from toilets) requires very little treatment before it can be reused for non-drinking purposes, such as for toilet flushing and lawn watering with sprinkler systems. Another eco-friendly product that continuous to gain popularity in the plumbing category is the tankless water heater.

In addition to some of the newer, technologically advanced green products mentioned above, green practices in plumbing have led to a new program, called water sense, from the united states Environment Protection Act (EPA). The water sense program was created to find ways to use water efficiency for consumers, communities and the environment, while helping conserve resources for the future.

In the bathroom, a touchless toilet allows the user to wave their hand above the toilet to flush it. After they're finished, the toilet lid will automatically close without slamming. Technological advancements also have had an impact on water filtration both for the whole house and at point of use.

Water collection

Storm water capture, storage and use systems collect rainwater and reuse it in the building's non-potable water fixtures, such as landscape, toilets and fire suppression storage. However, because the system requires two plumbing systems, it is best suited for new construction in areas where rainfall is substantial. For this, construct rain water harvesting tank.

Rain water harvesting tank

It is a water tank used to collect and store rain water runoff, typically from rooftops via rain gutters. A rainwater catchment or collection (also known as "rainwater harvesting") system can yield 2358 litres (623 gal) of water from 2.54 cm (1 in) of rain on a 93 m^2 (1,000 sq ft) roof. Rainwater harvesting tanks are devices for collecting and maintaining harvested rain.

Rainwater tanks are installed to make use of rainwater for later use, reduce mains water use for economic or environmental reasons, and aid self - sufficiency. Stored water may be used for water gardens, agriculture, flushing toilets, in washing machines, washing cars, and also for drinking, especially when other water supplies are unavailable, expensive, or of poor quality, and when adequate care is taken that the water is not contaminated and is adequately filtered.

Types of sewer appurtenances and manhole

Objectives: At the end of this lesson you shall be able to
- **explain the important sewer appurtenances**
- **drop/deep/shallow manhole**
- **explain various types of chambers in sewer line**
- **explain rainwater collection**
- **explain bio gas tank important construction and their functions.**

General

In order to make the construction process easy and to have efficient working and maintenances the sewer system requires various structures known as sewer appurtenances.

Following are the important sewer appurtenances

1 Manholes

2 Drop manholes

3 Lamp holes

4 Catch basins

5 Clean - outs

6 Flushing tanks

7 Grease and oil traps

8 Inlets

9 Storm regulators and weirs

10 Inverted siphons

11 Junction chambers

12 Outlets

1 Manholes

They are openings in the sewer line for a man to enter through its.

Purpose

The purpose of manholes is to inspect, clean and for other maintenance operations in connection with sewers.

Location

Man holes are located:

1 At every change in gradient, direction alignment or diameter.

2 At junctions of sewers.

3 At street intersections and

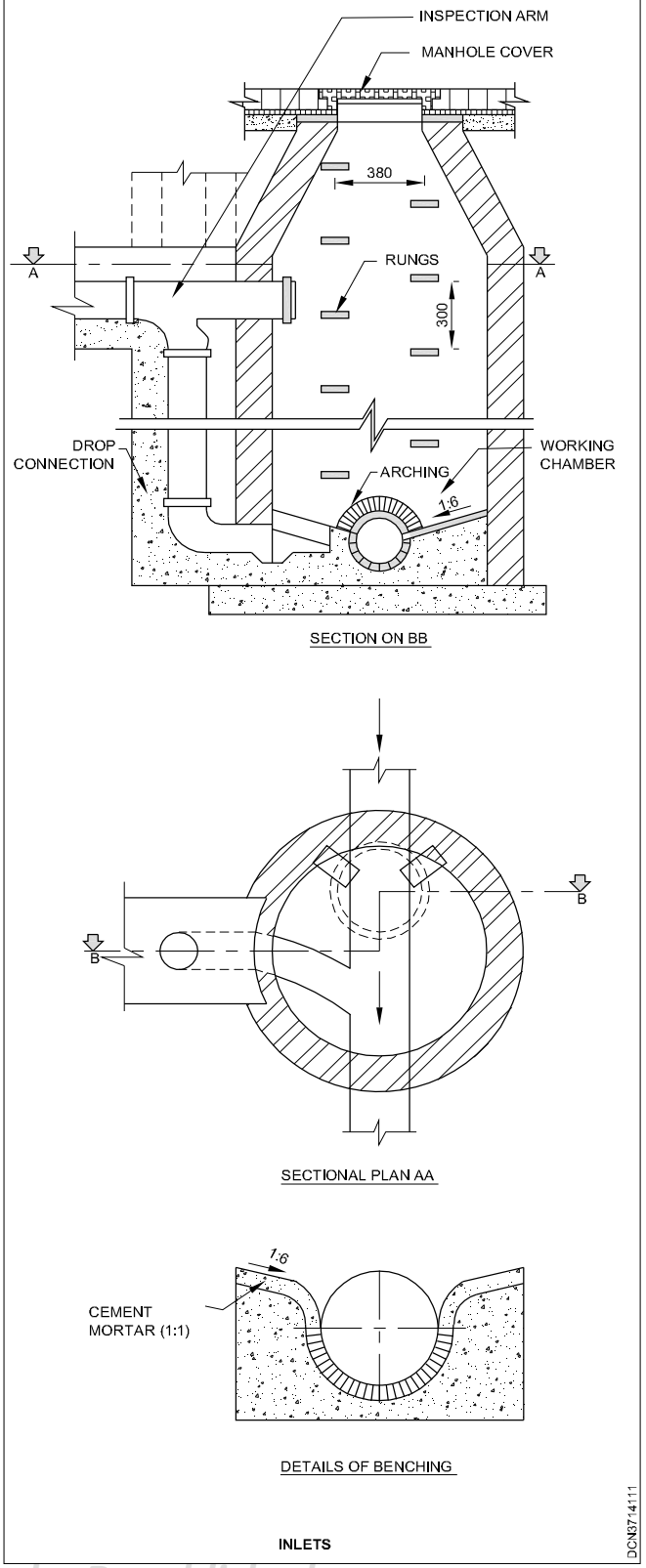
4 At intervals of 45 m to 90 m in straight reaches.

Component parts of manholes and their functions (Fig 1)

i Access shaft

It is the upper portion of a deep manhole. It provides an access to the working chamber below.

Fig 1



ii Bottom or invert

It is the bottom of the manhole. It is constructed of cement concrete or brick paving, over which the sewage flows.

iii Cover and frame

They are provided at the top of manholes. They provide an entry to the manhole whenever required. During other periods, these form the surface of the road. They prevent the accident of falling into the manholes.

iv Steps or ladder

They are provided to make the entry and exit of men easy. They are staggered two vertical runs, 200 mm apart horizontally and 300 mm vertically. They are also called rungs.

v Walls

They are constructed of brick work or stone work or cement concrete. They form the structure of the manhole. They support the components above, retain the soil from the sides and enclose the sewers.

vi Working chamber

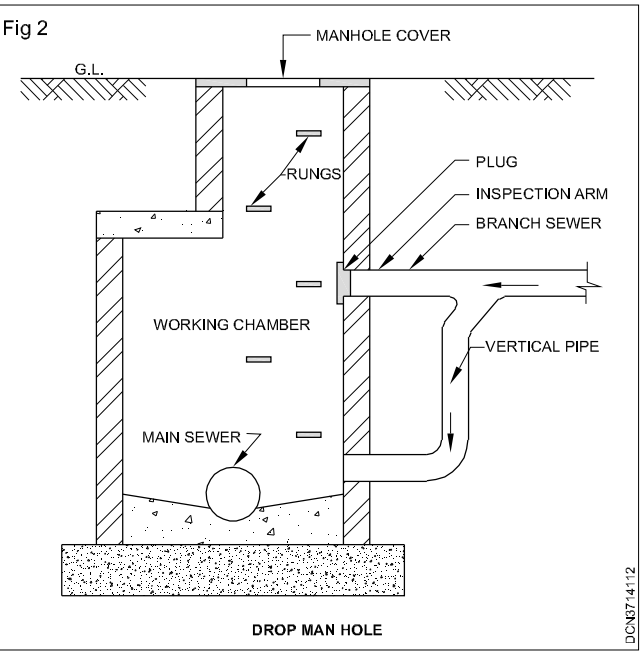
It is the lower portion of a deep manhole. It provides a working space for a man to stand inside and to carryout cleaning and inspection of sewer lines. It may be circular or rectangular in plan.

2 Drop manholes (Fig 2)

Purpose

The purpose of drop manholes is to avoid unnecessary steep gradient of branch sewer and thus reducing the quantity of earth work. Also, they avoid the splashing of sewage on the man working and on the masonry work.

Fig 2



DROP MAN HOLE

Location

Drop manholes are located,

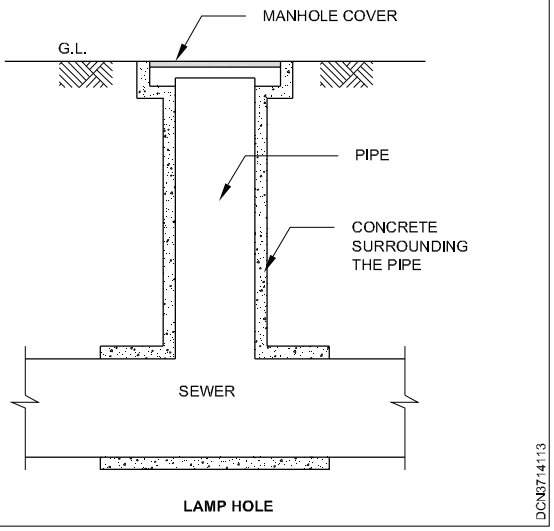
1 Where inlet and outlet pipe sewers have to be connected at different levels.

2 In places where it is desired to drop the level of invert of the incoming sewer.

The length of the pipe between the vertical shaft and the wall is called inspection arm. Opening the plug, it is used for inspecting and clearing of the vertical shaft, the vertical shaft is carried upto the ground level.

Lamp holes (Fig 3)

Fig 3



LAMP HOLE

Purpose

The lamphole is intended to detect the obstruction in the sewer. It is done by inserting a lamp in the lamphole and viewing it from the adjacent manholes. Also they incidentally serve as fresh - air inlets and for flushing.

Location

Suitable locations for lamp holes are,

i In places where a bend is necessarily to be inserted.

ii In places where construction of manhole is difficult.

iii When straight length between manholes is considerably more and,

iv For flushing the sewer line in the absence of any other flushing devices.

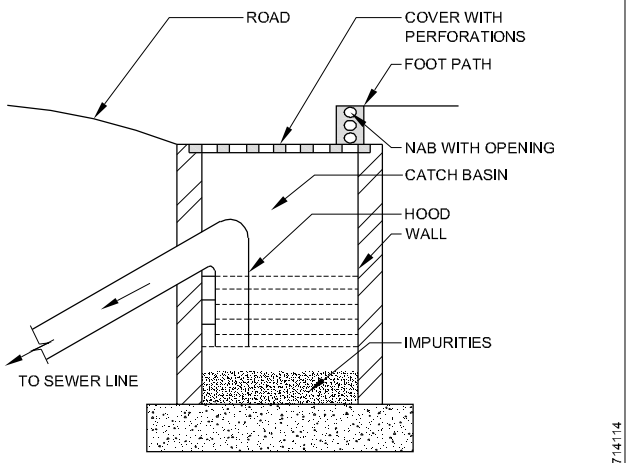
The use of lampholes should be recommended only under special circumstances.

There use should be as far as possible avoided.

4 Catch basins (Fig 4)

It is a structure constructed in the form of a chamber along the sewer line to admit clear rain water into the combined sewer. It also prevents the escape of sewer gases. It consists of a chamber constructed of walls. The silt, grit, etc, settles in the bottom and clear water alone flows into the sewer. At the top, a cover with perforations is fixed at the pavement, edge. A hood is provided which prevents the escape of sewer gases into the basin. It provides a temporary storage for impurities in rain water. Hence, it is cleaned after each storm.

Fig 4

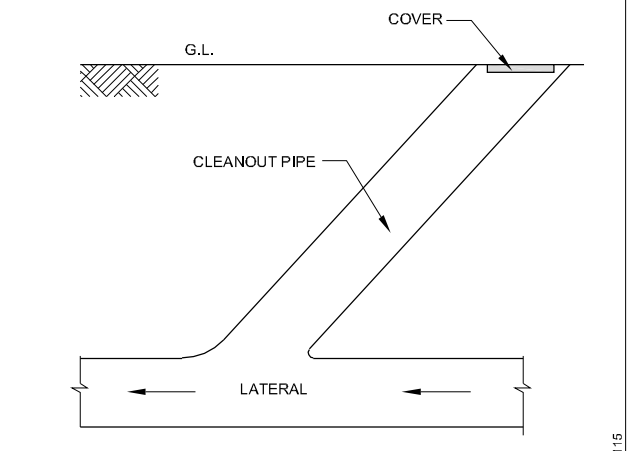


CATCH BASIN

5 Clean - outs (Fig 5)

It is a pipe, one end is connected to the underground sewer and the other end is brought upto ground level and is covered. It is generally provided at the upperends of lateral sewers in place of manholes.

Fig 5



CLEAN OUTS

For working, the cover is removed and water is forced through clean out pipe into lateral sewers to remove obstacles in the sewer line. Flexible rods may also be inserted through the cleanouts and moved back and forwarded to remove obstructions.

6 Flushing tanks

These are devices or arrangements used to store and then to throw water into the sewer to produce self cleansing velocity for flushing the sewer. Sometimes sewage is to be stored for a short period before allowed into the sewer line. Flushing tanks are used to store sewage temporarily and then discharge at intervals to flush the sewers. They are provided near the dead ends of sewers. Their capacity is about 10% of the cubical contents of the sewer line served by it.

The flushing tanks are of the following two types

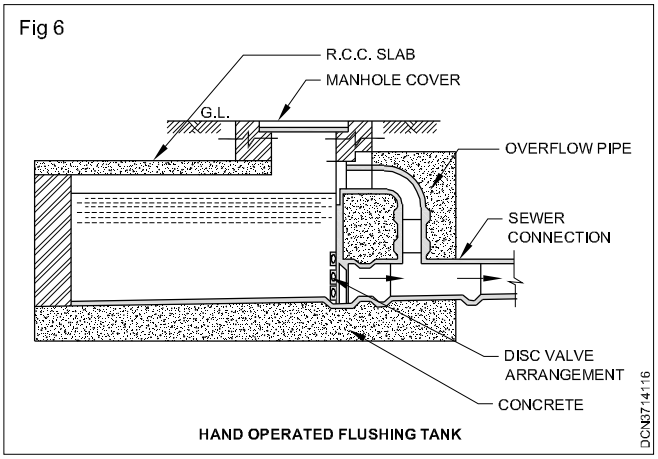
1 Hand operated flushing tanks

2 Automatic flushing tanks

Hand operated flushing tanks (Fig 6)

The flushing is done manually at intervals. Both the outlet and inlet ends of the manhole are closed. Then the manhole is filled with water completely. The lower end of the manhole is then opened and the water under pressure cleans of flushes the sewer line.

Fig 6

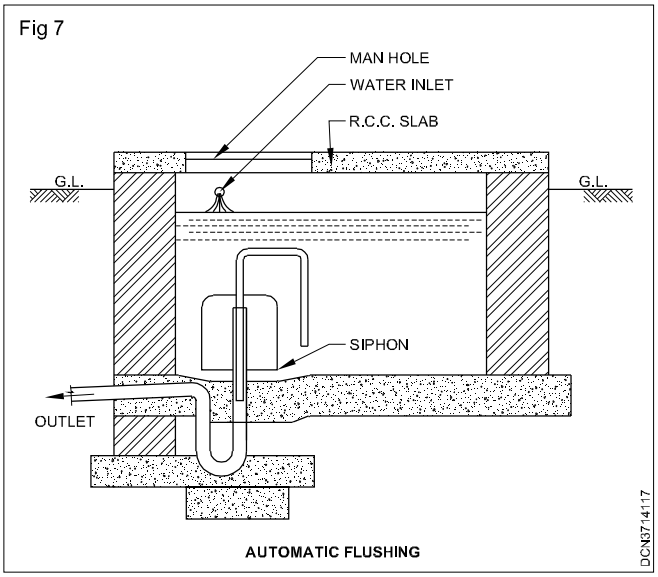


HAND OPERATED FLUSHING TANK

Automatic flushing tank (Fig 7)

The tank is like a manhole with a siphonic arrangement fixed at bottom. Water supply is regulated to flow at a constant rate through a connection made in the side wall. When the tank is full, the siphon goes into operation and quickly discharges the water into the sewer.

Fig 7



AUTOMATIC FLUSHING

Working

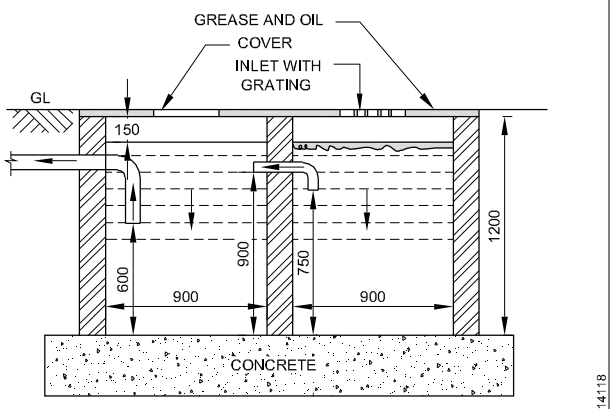
The water rising above the level of the sniff hole entraps and compresses air in the bell. The compressed air of the bell presses down water in the U - shaped trap. When the water level at the level of sniff hole goes down to the bottom of U - shaped trap, the air of the bell bubbles out with violence. Also, water tickles out through the outer limb of the U - tube into the sewer. More water now rushes into the bell. When the water level is above the lip of the trap pipe in the bell siphonic action begins.

This action continues till water level in the tank falls below the level of the swift hole. Air again enters the bell and the siphonic action is stopped. Thus, the cycle is repeated.

Grease and oil traps (Fig 8)

They are chambers on the sewer line to exclude grease and oil from sewage before it enters the sewer. These substances being light in weight, float on the surface of sewage. If the outlet draws sewage from lower level, grease and oil are excluded. Hence the outlet level is located near the bottom of chamber. Grease and oil traps are located near automobile workshops, grease and oil producing industries garages, etc.

Fig 8



GREASE AND OIL TRAPS

If grease and oil enter the sewers, they stick to the sides of sewer and may cause explosions. Also the suspended impurities stick to the grease. Consequent the capacity of the sewer reduces.

8 Inlets (Fig 9)

They are openings, through which storm water is admitted and conveyed to storm water sewer. They are located near the sides of the roads at 30 to 60 m centres. They are connected by pipes to the nearby manholes. They consist of concrete box with provision for admitting storm water.

They are of the following three types

1 Gutter inlet

In this type of inlet, a horizontal grating is provided at the top (Fig 9a).This type of inlets are suitable for roads having steep slope. This inlet is also known as horizontal inlet.

2 Curb inlet

In this type of inlet, a vertical grating is provided at curb (Fig 9b) It is also called vertical inlet.

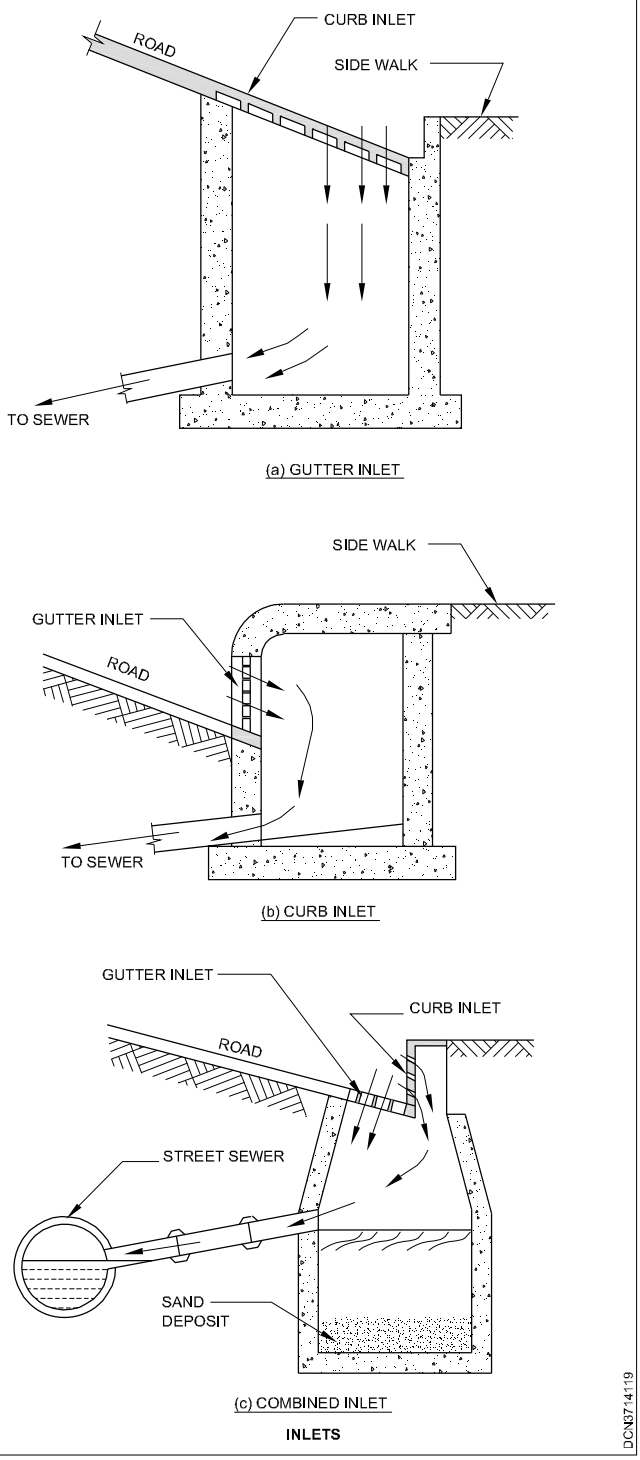
3 Combined inlet

In this type of inlet, storm water can enter from both gutter and curb (Fig 9c)

9 Storm regulators and weirs

The structure used to divert a portion of the flow of sewage from a combined or storm sewer are called storm regulators. Storm regulators come into operation when

Fig 9



INLETS

the discharge exceeds a certain limit. The excess storm water is diverted to natural streams. Thus, they reduce the load on the pumping stations.

Following are the three types of storm regulators

i Leaping weir

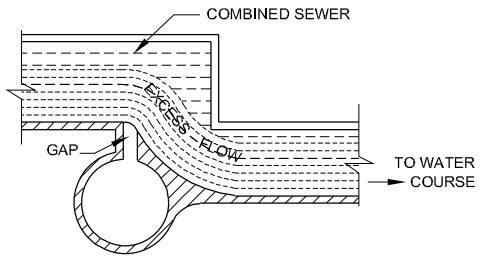
ii Overflow weir

iii Siphon spillway

Leaping weir (Fig 10)

Leaping weir is one, in which the normal dry weather flow falls into the sanitary sewer through an opening provided

Fig 10



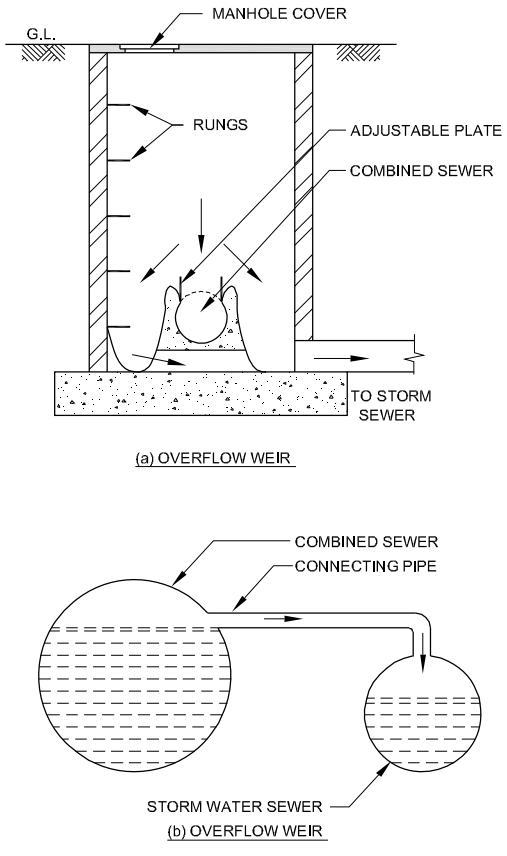
LEAPING WEIR

in its crown. The excess quantity of storm or sewage leap or jump over the opening on to the water course. The leaping weir does not have any moving parts. A grating may be provided on the gap to prevent stones, debris, etc. from entering into the intercepting sewer.

2 Overflow weir

Overflow weir is one, in which the extra quantity of sewage or storm water spills over the weir to pass off into another overflow sewer. The normal dry weather flow flows to the sewer outlet. Various types of overflow weirs are shown in (Fig 11a, b).

Fig 11

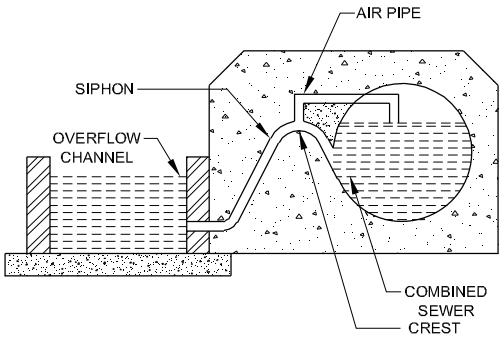


TYPES OF OVERFLOW WEIR

3 Siphon spillway (Fig 12)

It works on the principle of siphonic action and it works automatically. The rise of sewage is the combined sewer

Fig 12



SIPHON SPILLWAY

is thus controlled well. The overflow channel is connected to the combined sewer through the siphon. An air pipe is provided at the crest level of siphon.

Working

The level of crest of siphon is kept at the level reached by the flow in combined sewer during the period of maximum dry weather flow.

When the level is combined sewer goes beyond the crest level of siphon, the mouth of air pipe is closed and the air contained in the siphon is suddenly carried away and develops siphonic action. Water commences to flow into the overflow channel until the water level falls below the mouth of connecting pipe.

10 Inverted siphons (Fig 13)

Inverted siphons are ordinary pipes running under pressure. They are constructed for conveying the sewage under streams, railways, rivers, and such other obstructions. They are also called "depressed sewers".

Two manholes are built one at each end of the inverted siphon. These two structures are connected by the siphon pipe or pipes. An overflow pipe is provided to divert the sewage flow, when the inverted siphon is choked.

While designing the siphon, the following points should be considered.

1 The construction of the siphon should be simple.

2 Changes of direction should be easy and gradual.

3 The velocity of average flow should be atleast. 1 metre per second so that there will be no deposition of solids.

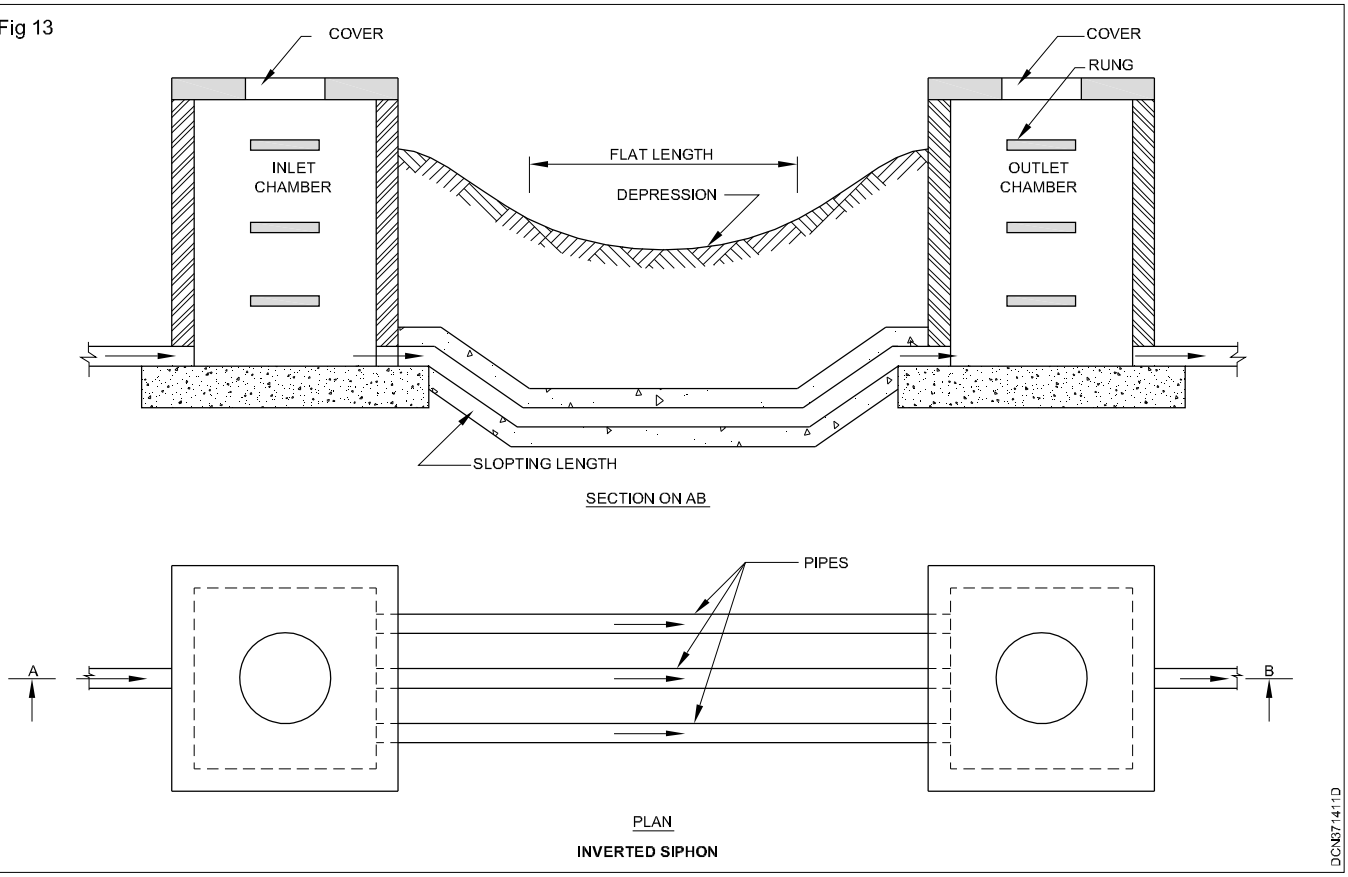
4 Siphons should be built with two or three pipes of different sizes. (These should be arranged in such a way that they come into servicingly and in proportion to the amount of flow.

5 The total length of the siphon is not the straight length from inlet to outlet, but includes the fall, bends and rise.

6 The siphon must be considered as a pipe running full under pressure. (For this, the maximum head available must be known).

7 Allowance should be made for losses of head due to bends and due to increased friction on account of roughness in the siphon caused by silting.

Fig 13



8 For the selection of the proper size of pipes for an inverted siphon, the minimum, average, and maximum flows in the sewer should be considered.

9 To avoid danger of silting, facilities should be provided for easy cleaning of the pipes. This can be achieved by.

- i providing screens and detritus pits above the siphon inlet.
- ii duplication of the pipe line for diversion of flows and
- iii laying the pipes in such a way that they could be drained to some lower point

10 overflow provision should be made to deal with the surcharge, in case the siphon is choked.

11 Junction chambers

They are chambers constructed to facilitate the junction of two or more sewers. They are large enough for a man to enter. They are provided where sewer intersect with horizontal angles between their axes to be less than 30°, so that ordinary type of junction is difficult to be constructed. They are classified based on the shape of the top surface.

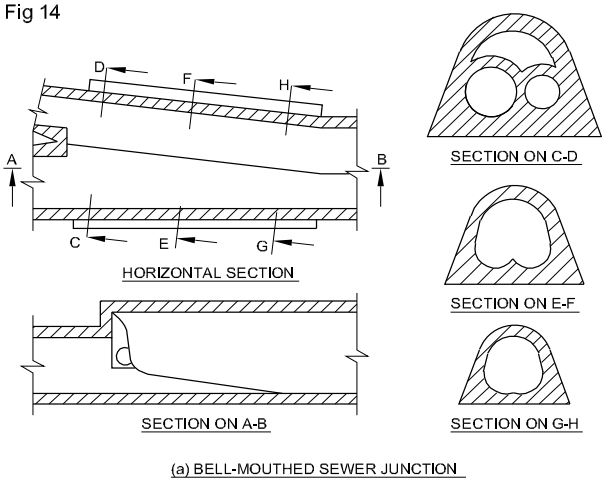
There are two types of junction chambers

i Bell - mouthed sewer junction.(Fig 14)

ii Flat - top sewer junction.(Fig 15)

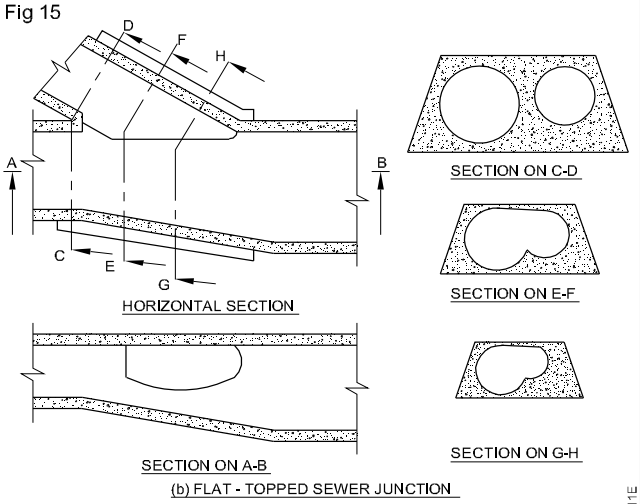
The former type is now obsolete because of the greater skill and cost involved. The latter type is commonly used.

Fig 14



(a) BELL-MOUTHED SEWER JUNCTION

Fig 15



(b) FLAT - TOPPED SEWER JUNCTION

JUNCTION CHAMBERS

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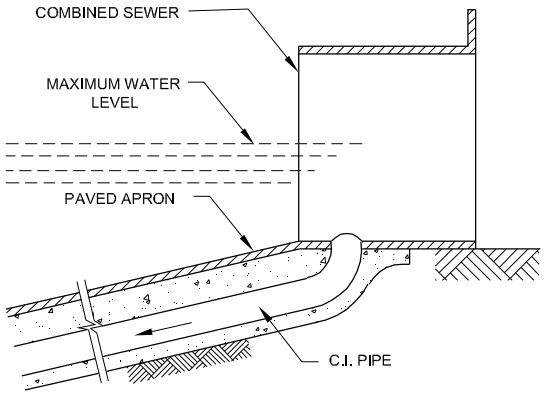
12 **Outlets** (Fig 16)

In a separate sewerage system, the storm water, discharges directly on the bank while the sewer outlet, which simply consists of cast iron pipe extending into the body of water from a manhole in the bank. In a combined system, it is considered more economical to separate out storm water overflow and discharge it into river bank or lake and the domestic sewage into the deep water.

Fig 16



OUTLETS

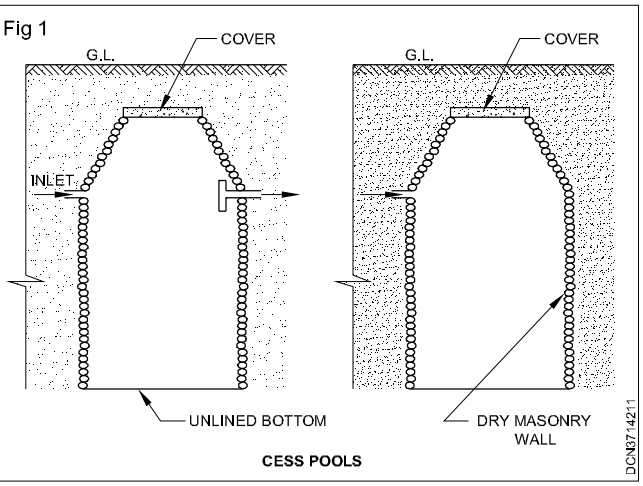
Septic tank

Objectives: At the end of this lesson you shall be able to
- **explain cess pool**
- **explain septic tank**
- **explain the principle of septic tank**
- **explain the disposal of septic tank effluent**
- **explain the construction details of septic tank**
- **design a septic tank.**

Cess pools

The water - carried wastes of small habitations may be disposed off by means of cess pools. These are masonry pits, usually not less than 1.5 m in diameter and 1.8 to 3m deep. Inner surfaces are plastered and covered by an air - tight cover at top. When the pool is filled up, it is emptied and cleaned. The contents obtained are conveyed in carts for further disposal. This is a tedious job and it results in extra cost. At the time of collection, it creates lot of nuisance due to bad smell and spillage (Fig.1).

Fig 1



CESS POOLS

Cess pools should be located on leaward side and away at least by 15 to 20m from residential buildings and wells of drinking water. They should also be properly ventilated.

Septic tank - The septic tank is a water tight underground tank. Sewage is admitted in to it for treatment. It is suitable for disposing excreta and liquid wastes from individual dwellings, small groups of houses and institutions.

Principle and working of a septic tank

Septic tank is just like a horizontal continuous flow plain sedimentation tank. The sewage moves very slowly. The flow is continuous from the inlet to the outlet. During the detention period, the solids settle down in the tank as sludge. The lighter solids rise to the surface as scum. The baffle wall prevents the scum from leaving the tank with the effluent. The solids get attacked by anaerobic bacteria and fungi. They are broken down into simpler chemical compound. This is the first stage of purification called anaerobic digestion. It renders sludge stable and inoffensive. The digested sludge from the tank is periodically removed and disposed off in a suitable manner.

A portion of the solids is converted into liquids and gases. The gases rise to the surface in the form of bubbles causing bad smell. Hence septic tanks are covered at top. They are provided with high vent shaft for the escape of gases.

The liquid which passes out of the outlet pipe is called the effluent. It is highly odours and rich in Biochemical Oxygen Demand (B.O.D). It has finely divided solid contents with numerous highly infectious pathogenic bacteria. For further treatment it is allowed to percolate into the subsoil through soak pit or dispersion trench. The aerobic bacteria in the upper layer of soil oxidize the organic matter into stable end products. This stage of purification is called aerobic oxidation.

Disposal of septic tank effluent

The effluent from septic tank contains a large amount of harmful organic matter and its B.O.D is high. Therefore the effluent should be disposed off carefully to cause minimum nuisance to public health.

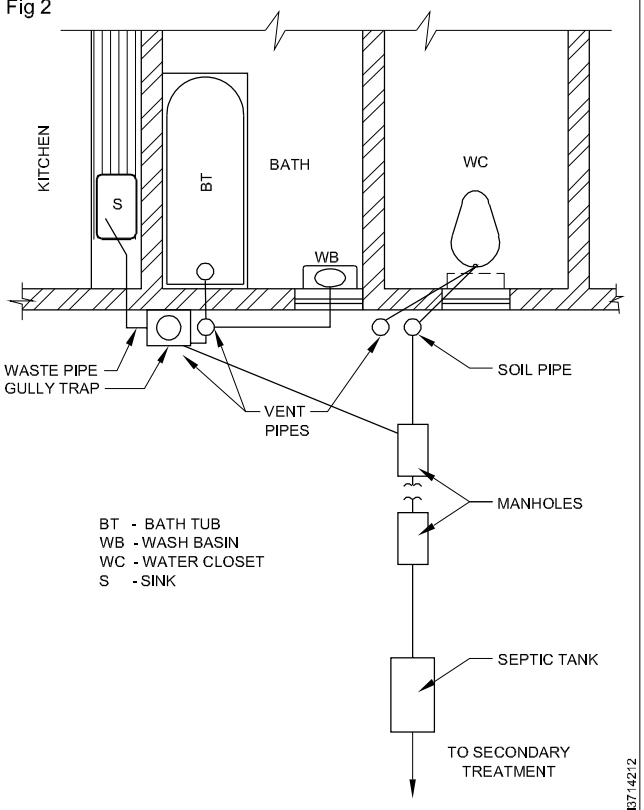
Septic tank effluent is more commonly disposed off on land by the following methods.

Disposal in absorption trenches In this method the effluent is allowed to percolate into the subsoil by means of perforated or open jointed pipes laid in trenches. The trenches are about 1 m deep and 1 m wide excavated with slight gradient. The trenches are filled with gravel, well graded aggregate and ordinary soil. The effluent percolates into the surrounding media. The organic matter present in the effluent is oxidised by the bacteria present in the upper layers of the soil. The clearer water get dispersed into the surrounding soil.

Disposal into soak pit

Soak pit is a covered circular pit. The effluent is allowed into it and gets soaked or absorbed into the surrounding soil. The pit may be kept either empty or filled up with brick bats or stone aggregates. When empty, the pit is lined with brick, stone or concrete blocks with dry open joints. It is provided with at least 75 mm backing of coarse aggregate below the inlet level to support the lining. When filled, no lining is required except for the top masonry ring.

Fig 2



LAYOUT OF A SEPTIC TANK SEWERAGE SYSTEM

Construction details of septic tank

i Dimensions of septic tank

Width = 750 mm. minimum

Length = 2 to 4 times width.

Depth = 1000 to 1300 mm. minimum below water level + 300 to 450 freeboard.

Total maximum depth = 1800 + 450 = 2250 mm.

Capacity = 1 cubic metre minimum.

ii Suitable sizes of septic tanks for use of 5,10,15,20 and 50 persons. See fig 2 which gives a typical layout of a septic tank sewerage system.

iii Detention period of 24 to 48 hours is usually available in a septic tank. The rate of flow of effluent must be equal to the rate of flow of influent.

iv The floor is of cement concrete 1:2:4 and laid with a slope of 5 to 10% towards sludge outlet or sludge collecting sump; if provided. Tank is cleaned of sludge every 6 to 12 months.

v **Inlet pipe** An elbow or T - pipe if 100 mm. diameter of stone ware or asbestos is used. It is laid at the time of construction of walls of the tank. The T - pipe is submerged to a depth of 250 to 600 mm below the liquid level.

vi **Outlet pipe** An elbow or T- pipe of 100 mm. diameter submerged to a depth of 200 to 500 mm below the liquid level is provided.

vii **Baffle walls** For small tanks, R.C.C hanging type of scum baffle walls are provided. Baffle walls are provided near the inlet as well as outlet. The inlet baffle is generally placed at a distance of L/5 from the end wall, where L is the length of the tank. The baffle wall is generally extended 150 mm above scum level and 400 to 700 mm. below it. Its thickness may vary from 40 to 80 mm. Flag stone slabs can also be used. For large tanks baffle walls are made of 100 thick brick walls with honey combed bottom courses to allow the flow of sludge.

viii **Roofing slab** The top of the tank is covered with an R.C.C slab of 80 mm. thickness. For the purpose of inspection and desludging, access openings are provided. Incase of circular openings the clear opening is kept 500 mm. in diameter and if rectangular, the opening is kept 600 x 450 mm.

ix **Ventilating pipe** A cast iron or asbestos pipe of 50 to 100 mm. diameter is used as a ventilating pipe. It is extended upto 2 m. minimum above G.L. Top of the ventilating pipe is provided with a mosquito proof wire mesh or cowl.

x The effluent from the septic tank is disposed off by seepage pit or dispersion channels.

xi The septic tank is exclusively used for residential buildings or such living units where there are no other sewerage disposal arrangements.

Design of septic tank (Fig.3)

Design of septic tank consists or providing chamber for

1 Settling of incoming sewage.

2 Digestion of settled sewage.

3 Storage of digested sludge.

4 Storage of scum.

1 Space for settling

This is calculated for the average flow and detention period. Smaller tanks are designed on the basis of average flow and 24 hours detention period and larger tanks, 12 hours detention period. If latrines are connected to septic tank, average flow per capita per day may be taken as 45 litres. On the other hand, if all the waste water of the houses is to be treated in septic tank, the average flow should be taken depending on the water supply. The volume of setting also depends on the clear space available. The clear space is the space between the upper level of the sludge and lower level of scum. The vertical height of the clear space may vary from 0.23 m to 0.30 m. The clear space multiplied by the plan area of the tank gives the minimum tank volume for settling.

2 Space for digestion

Sludge digestion capacity varies from $0.028m^3$ & $0.056m^3$/ capita.

Space for digested sludge

The space for digested sludge produced per capita in different periods are shown in table.

Period of cleaning	Storage capacity
6 months	0.0283 m^3
1 year	0.0490 m^3
2 years	0.0708 m^3
3 years	0.0850 m^3

The space for storage digested sludge designed on the basis of cleaning and number of persons using the tank.

Space of scum For scum storage 0.01 m^3 per capita is required.

Example No1

Design a septic tank for 50 users (Fig 3).

Assuming the usage of water 135 litre per/capita/day

No.of users = 50

Total quantity of sewage = 135 x 50 = 6750.00 litres = 6.75 m^3

Assuming a detention period = 24 hours (normal range 12.00 - to - 24.00 hours)

$$\text{Tank capacity} = 6.75 \times \frac{24}{24} = 6.75 m^3$$

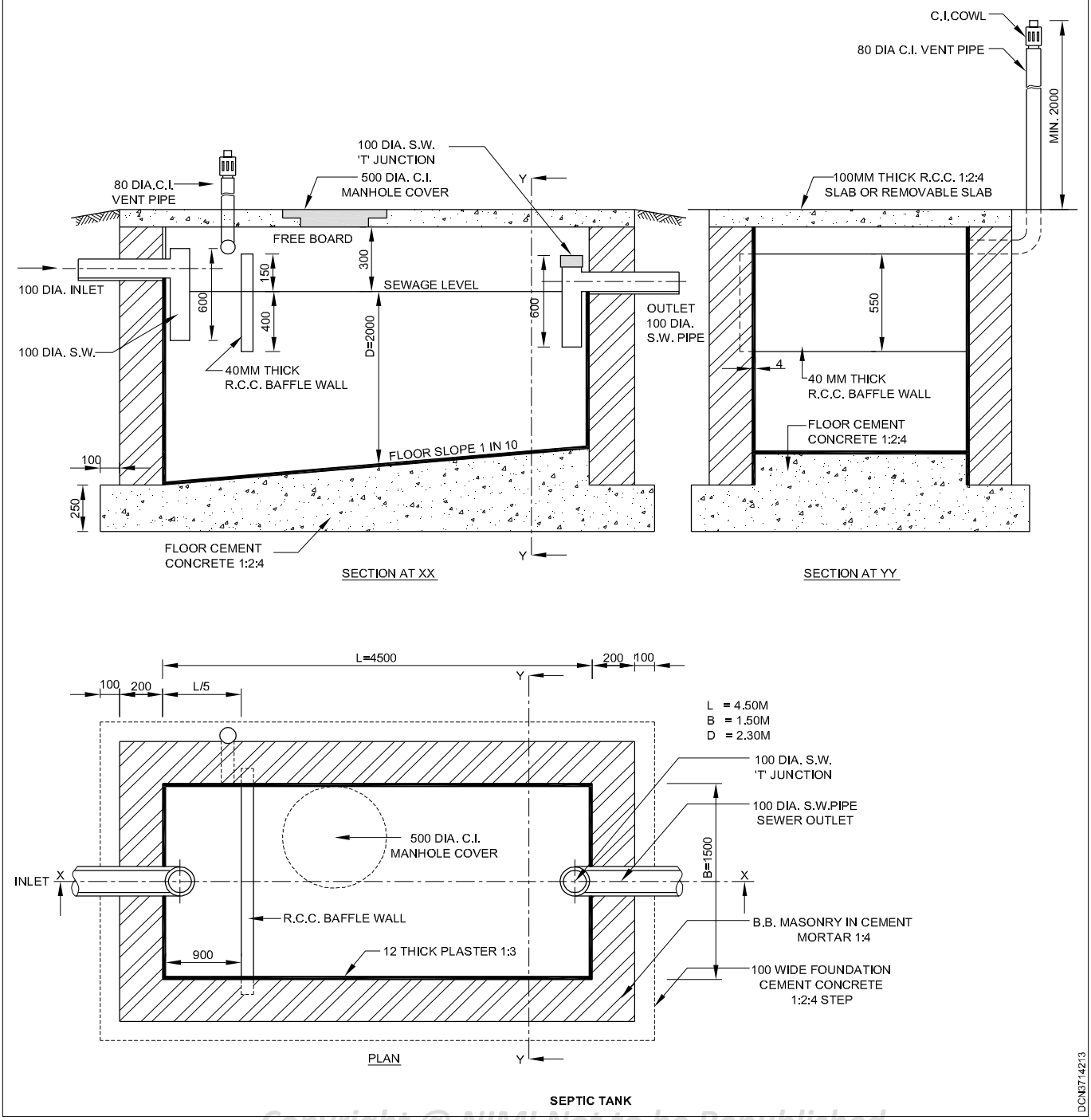
Assuming the tank is cleaning period = 2 years

The sludge storage per capita = 0.0708 m^3

Sludge storage required = 50 x 0.0708 = 3.54 m^3

Total capacity = 6.75 + 3.54 = 10.30m^3

Fig 3



Add 25% extra for future expansion

Then total design capacity

$$= \frac{10.30 \times 125}{100} = 12.88\,m^3 = 12.90\,m^3$$

Assuming the depth of septic tank.....say 2.00 metre

Then the area of septic tank = 12.9/2.00 = 6.45m^2

Length - width ratio..... = 3:1 (ratio may be in between 2.0 - to -4.00)

Length x breadth = 3 x breadth x breadth = 6.45m^2

$(Breadth)^2$ = 6.45/3 = 2.15

Breadth = 1.46 m say 1.50m

Length = 1.50 x 3 = 4.50m

Assuming free board of 30.00 cm (normal range 40.00 cm - to - 60.00 cm)

Total depth = 2.00 + 0.30 = 2.30 m

Hence provide septic tank of size (4.50 x 1.50 x 2.30) m

Check for spaces

Sedimentation volume for clear space of 0.30 m deep

= clear space x surface area = 0.30 x 6.45 = 1.935 m^3

Scum storage 0.01m^3/capita = 50 x 0.01 = 0.50 m^3

Sludge digestion at 0.028m^3/capita = 50 x 0.028 = 1.40m^3

Sludge storage at 0.0708m^3/capita for 2 years of cleaning interval = 50 x 0.0708

= 3.54 m^3

Total space = 1.935 + 0.5 + 1.40 + 3.54 = 7.38m^3 against tank capacity of 10.3m^3

Hence the design is correct.

Soak pit (Fig 4 & Fig.5)

Flow of sewage/day = 6.75 m^3

Add 25% for future expansion,

Then total flow of sewage/day

$$= \frac{6.75 \times 125}{100} = 8.44\,m^3 = 8.5\,m^3$$

Assume the percolating capacity of filter media of well as 1.25m^3/m^3/ per day

Volume required for soak pit = 8.5/1.25 = 6.8 m^3....say 7.00 m^3

If the depth of soak pit is 2.50 metre

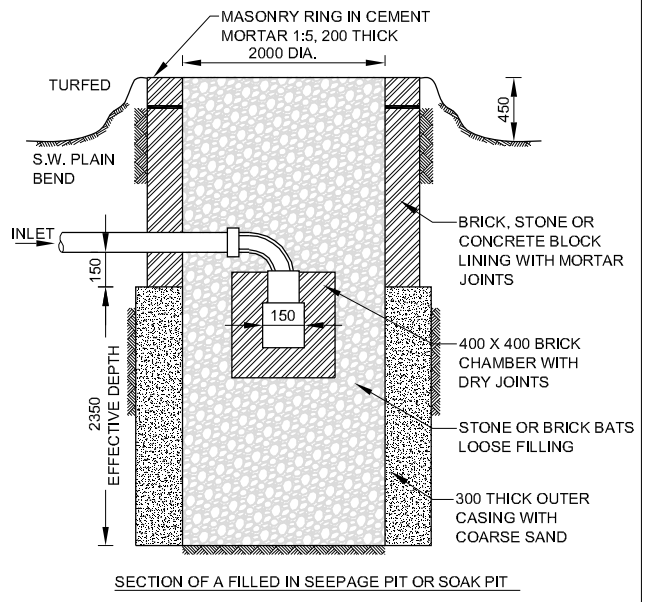
Area of soak pit = 7.00/2.50 = 2.80 m^2

$$\pi \frac{d^2}{4} = 2.80\,m^2$$

D = 1.90 m say 2.00 m diameter

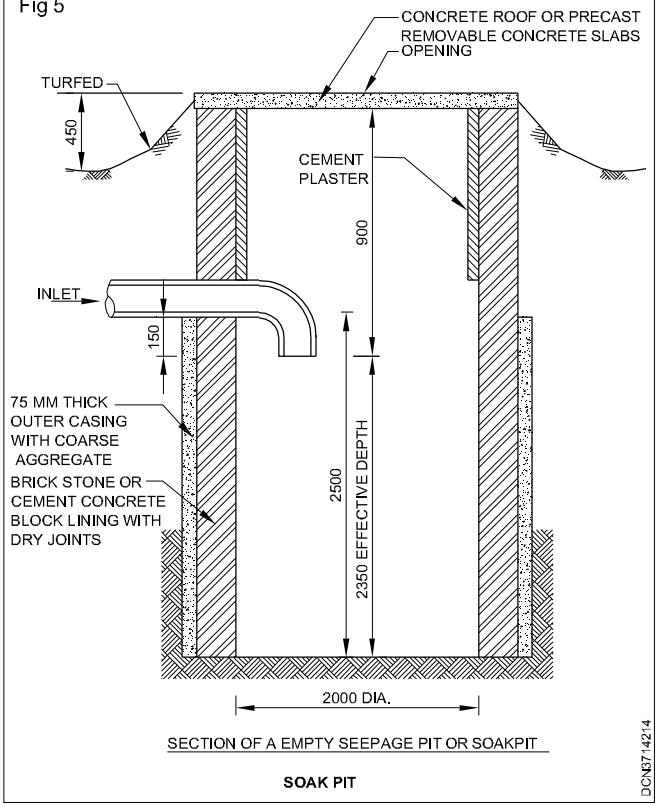
A soak pit of diameter 2 m and 2.5 m deep below the invert level of the inlet pipe may be provided.

Fig 4



SECTION OF A FILLED IN SEEPAGE PIT OR SOAK PIT

Fig 5



SECTION OF A EMPTY SEEPAGE PIT OR SOAKPIT

SOAK PIT

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Design of depression trench (Fig 6)

Flow of sewage in the trench per day = 8.5 m^3

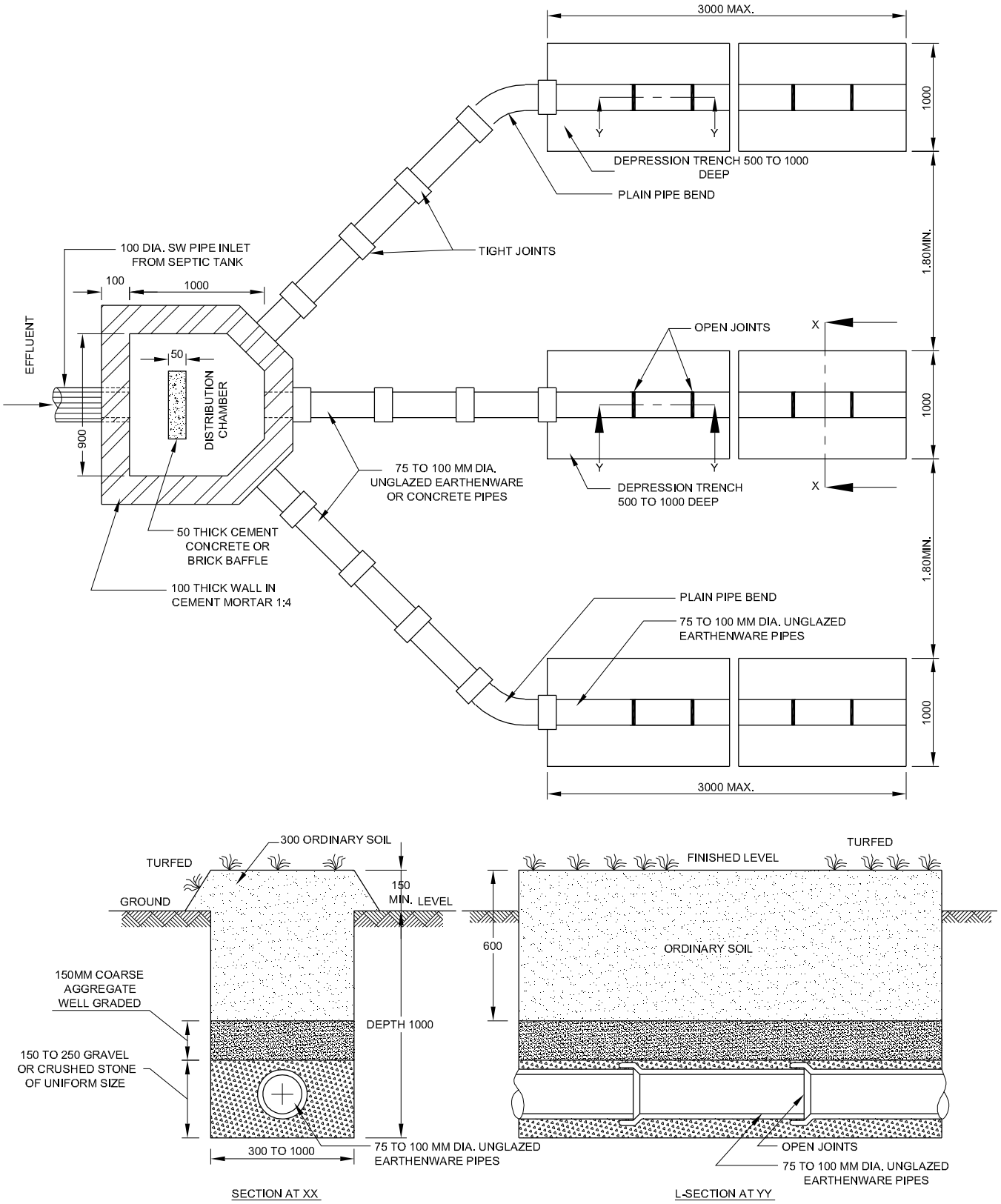
Assume width of depression trench = 1m

Percolation rate of sewage is 0.204 m^3/day (Assume)

$$\text{Length of trench required} = \frac{8.5}{0.204} \times 1 = 41.7\,m \text{ say } 42\,m$$

Provide 3 trenches of 14m in length

Fig 6



ENLARGED SECTION THROUGH FILLED IN DEPRESSION

LAYOUT PLAN OF DEPRESSION TRENCHES FOR THE DISPOSAL OF EFFLUENT FROM SEPTIC TANK

DC330416

DEPRESSION TRENCHES

Water and sewage treatment plant

Objective: At the end of this lesson you shall be able to
- **explain the water supply system.**

Water supply system

It is the infrastructure for the collection, transmission, treatment, storage, and distribution of water for homes, commercial establishments, industry, and irrigation, as well as for such public needs as fire fighting and street flushing.

The prime factor in the design of any water supply system is the estimation of the probable total quantity of water that will be required by the community after the completion of the works. The quantity can be estimated by studying the design period, rate of demand and population.

Sources of water

The success of water supply scheme depends upon the adequate sources of water supply. The chief source of all water supplies is precipitation. The sources of water supply may be classified as.

1 Surface sources

Rivers

Lakes and streams

Seas

Ponds

Waste water reclamation

Stored rainwater in cisterns.

2 Subsurface sources or ground sources

Springs

Infiltration galleries

Porous pipe galleries

Infiltration wells

Wells

Intakes and transmission of water

Intakes are structures used to collect water from the surface sources, which are relatively clean, free from pollution, sand and other objectionable floating materials. Transmission of water indicates the conveyance of water from the source to purification plants and from treatment plant to consumers.

Intakes are structures constructed with stone masonry or brick masonry or RCC blocks across the surface source of water. They essentially consist of a conduit with protective works, screens at open ends and gates and valves to regulate the flow. Transmission comprises of pipes, aqueducts, flumes and open channels, pipe joints, special pipes etc.

Quality of water

The water required for public water supplies should be potable. For domestic purpose, the water should be highly pure, free from bacteria, suspended impurities etc.

Impurities in water may be classified as physical impurities, chemical impurities and bacteriological impurities.

i **Physical impurities:** They are due to the presence of inorganic substances like clay, pebbles, sand, silt, etc in finely divided conditions. They imparts color, odour, and taste to water. They are not serious and can be easily detected and removed.

ii **Chemical impurities:** They may be either organic or inorganic. They may be present in either suspended or dissolved form. The chemical impurities are due to the presence of decayed or melting of vegetables or animals, or minerals in water.

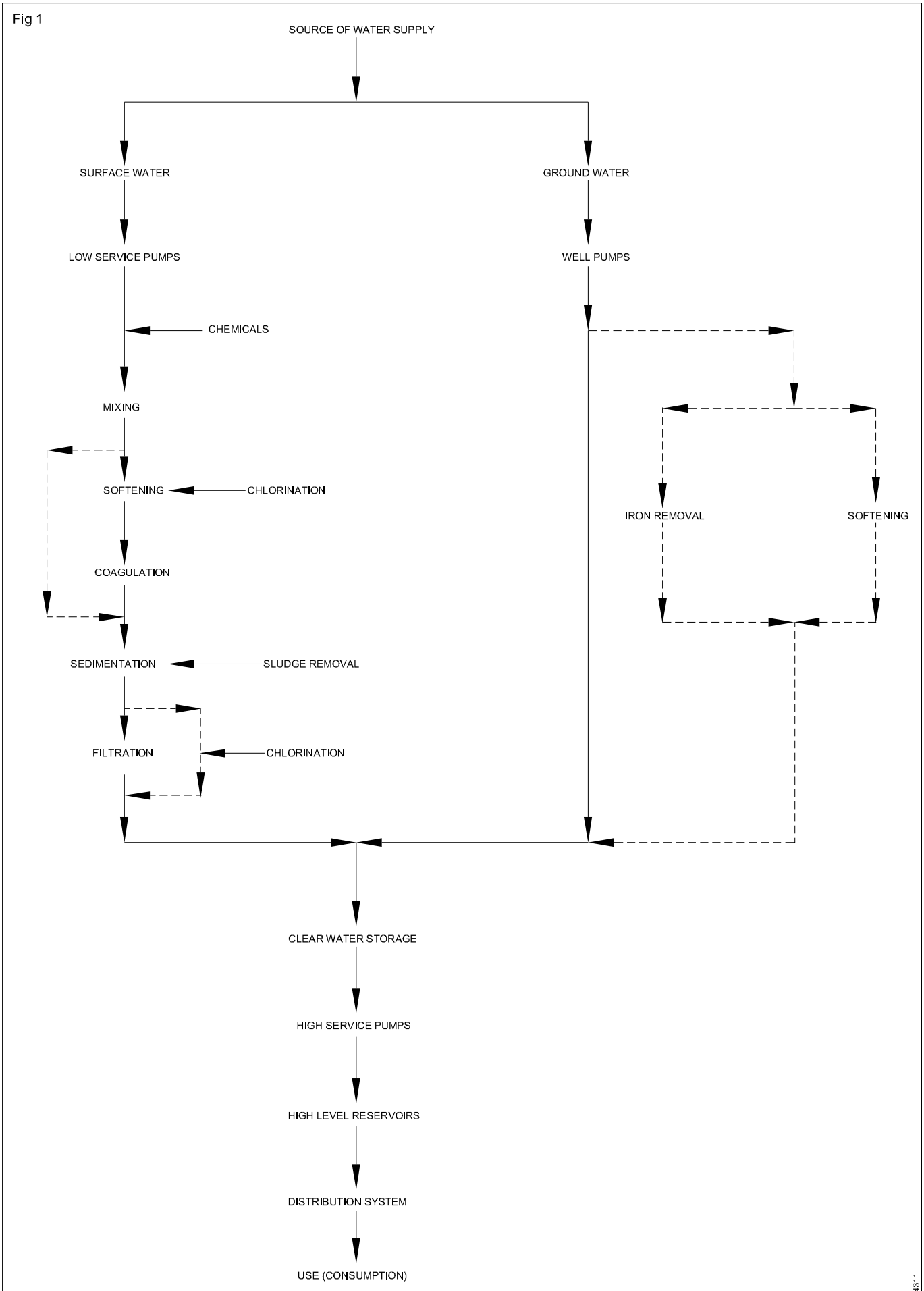
iii **Bacteriological impurities:** These are caused by the presence of bacteria. Bacterias may be harmful or harmless. Harmless bactrias are called non pathogens. Harmful bacterias are called pathogens. These are responsible for water - borne diseases and are also known as disease producing bacteria.

Analysis of water: The analysis of water carried out in order to establish its quality. The analysis of raw water is required to render the water fit and safe for use by suitable treatment and to design corresponding treatment works and water supply scheme as a whole. For analysis samples are collected and then subjected to tests for determining the physical, chemical or bacteriological impurities present in them.

Treatment of water: The raw water requires treatment to make it safe for use. The nature of treatment depends upon the initial quality of raw water and the purpose for which it is to be used.

Treatment process		
No	**Treatment**	**Impurities removed**
1	Screening	Floating matters such as leaves, trees, dead bodies of animals etc.
2	Plain sedimentation	Large suspended matters such as silt, clay, sand etc.
3	Sedimentation with coagulation	Fine suspended and electrically charged colloidal particles and some bacteria.
4	Filtration	Very fine colloidal and suspended particles and micro organisms
5	Chemical treatment followed by filtration	Dissolved matter
6	Aeriation and chemical treatment	Dissolved gases, taste and odour
7	Softening	Hardness
8	Disinfection	Living organisms including pathogens.

Fig 1



TREATMENT PROCESS - FLOW CHART

Sedimentation

It is the process of causing heavier particles in suspension, both organic and inorganic to settle by retaining water in a basin.

Theory of sedimentation

The particles heavier than water tend to settle down due to force of gravity. Impurities in water are held in suspension due to the turbulance of the moving water. When this turbulance is checked and the velocity of flow is reduced, the suspended particles tend to settle down at the bottom of the tank. This phenomenan of setting down of particles at the bottom of the tanks is known as hydraulic subsidence. At this stage, the particles travel with a constant vertical velocity called the setting velocity or velocity of subsidence.

The setting velocity depends upon

1 The horizontal velocity of flow

2 The shape and size of the particle

3 The specific gravity of the particle and

4 The temperature of water.

Types of sedimentation

Sedimentations are

1 Plain sedimentation and

2 Sedimentation with coagulation

Plain sedimentation The raw water is retained for some time quiescent in a basin for the suspended particles are settled by the action of gravity.

Sedimentation with coagulation Some chemical compounds called coagulants are added to water to assist sedimentation. Common coagulants are aluminium sulphate or alum called filter alum, sodium aluminates, ferric sulphate and lime, ferric chloride, magnesium carbonate, fullers earth etc.

Filtration Filtration is the process of passing the water through filter beds. Filtration removes colour, odour, turbidity and pathogenic bacteria from water. Filters are used for filtration.

Types of filters These are rapid sand filters, slow sand filters and pressure filters. Rapid sand filter and pressure filters are used for high rate filtration. But slow sand filter used for low rate filtration.

Slow sand filter (Fig 2)

A slow sand filter is a water - tight tank of 2.5 to 3.5 m in depth. It has a sand bed of 1 to 1.5 m thick, supported by a 0.3 to 0.75m thick layer of graded gravel or broken stone (25 to 50 mm size, of 0.30 to 0.60m thick) laid in layers. Beneath this, an under - drainage system consisting of open - jointed drains is laid over a concrete bed sloping towards a central longitudinal drain. The filtration is effected by gravity.

The rate of filtration is 100 to 200ℓ/m2/hour. Its bacterial efficiency is 98 to 99%. The filter bed is cleaned by scraping. Unsuitable for waters having turbidity more than 50 ppm.

Construction

A typical longitudinal section of a slow sand filter is shown in Fig 2. It consists of the following essential parts.

1 Enclosure tank.

2 Filter media.

3 Base material.

4 Under - drainage system.

5 Inlet and outlet arrangement.

6 Other appurtenances.

1 Enclosure tank

It consists of an open watertight rectangular tank, built of masonry or concrete. The sides and floor are coated with waterproof material. The bed slope is about 1 in 200 to 1 in 100 towards the central main drain. The depth may be 2.5 to 3.5m. The surface area may be 100 to 2000 m^2 or more.

2 Filter media

It consists of sand layers of 0.6 to 1 m thick, laid over gravel support. The effective size of sand is 0.25 to 0.35 mm and uniformity coefficient is 2 to 3. The top 150 mm layer of this sand is generally finer. The finer the sand used, the purer the water will be obtained.

3 Base material

It consists of 150 mm layers of graded gravel of 0.30 to 0.75 m thick layer or 25 to 50 mm size broken stone, 0.3 to 0.6m thick layer. It supports the sand bed. The coarsest gravel is used in the bottom most layer and the finest in the top most layer.

Top most layer - 150 mm thick - 3 mm to 6 mm size

Intermediate layers - 150 mm thick - 6 mm to 20 mm size

- 150 mm thick - 20 mm to 40 mm size

Bottom most layer - 150 mm thick - 40 mm to 65 mm size

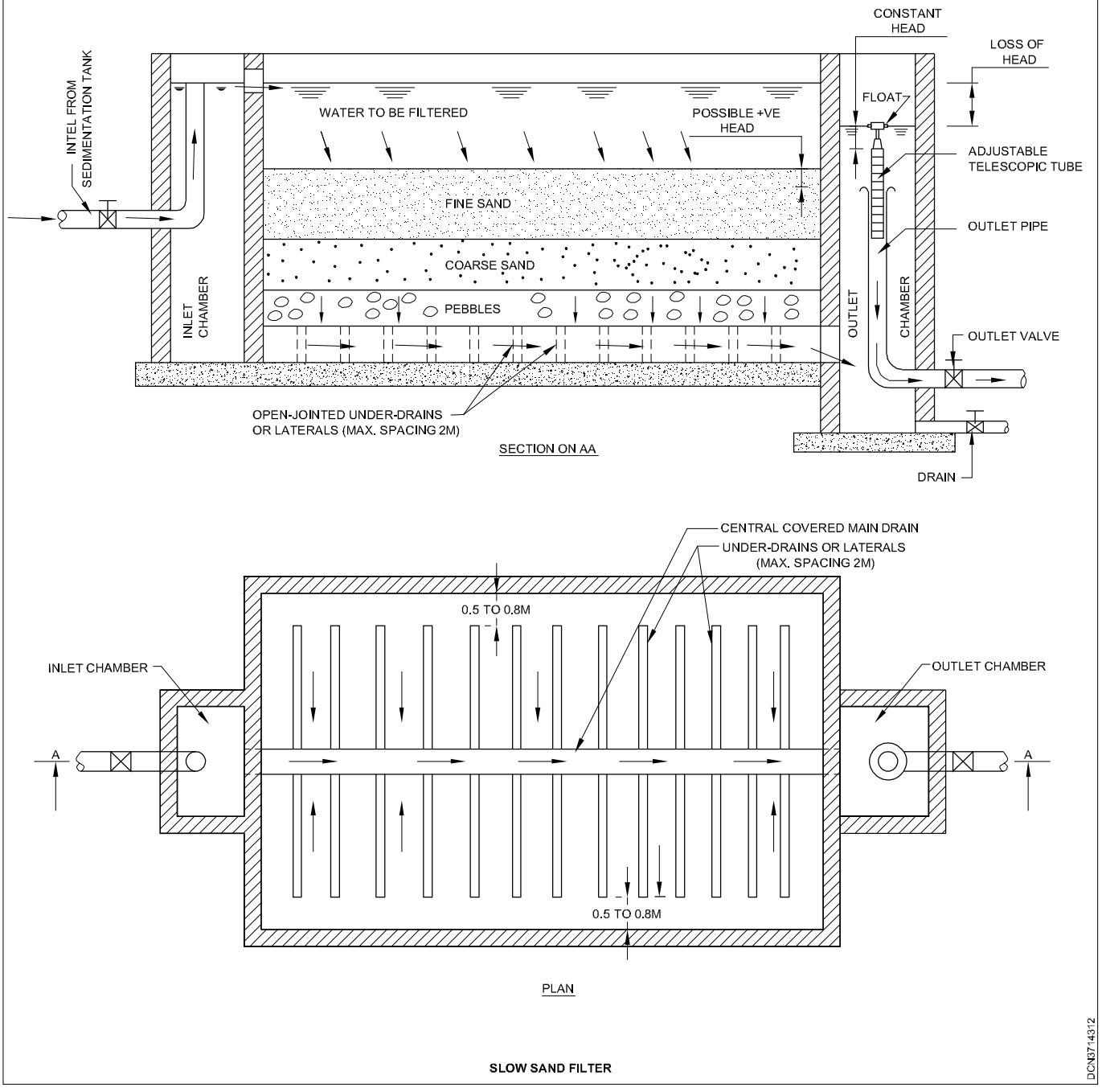
4 Under - drainage system

The gravel support is laid on the top of an under - drainage system Fig.2 The under - drainage system is laid on a concrete floor sloping towards the central covered main drain. The lateral drains are open - jointed pipes or porous pipes placed at a maximum spacing of 2m. Their ends are stopped at a distance of 0.5 to 0.8 m from the walls.

5 Inlet and outlet arrangements

An inlet chamber is constructed to receive the discharge from the plain sedimentation tank and to distribute it uniformly over the sand bed. Mostly, the inlet pipe is carried vertically in the body of the filter with the mouth of the inlet pipe flush with the water level.

Fig 2



SLOW SAND FILTER

A filtered water outlet well is also constructed on the outlet side to collect the filtered water coming out from the central covered main drain. To maintain a constant discharge through the filter, an adjustable telescopic pipe is used. Generally, both inlets and outlets are governed by automatic valves.

6 Other appurtenances

In addition to the above arrangements, certain other appurtenances are provided for the efficient working of the filter. Vertical air pipes passing through the layers of sand may be provided to help in proper functioning of filter media. Similarly, arrangements are made to control the depth of water above the sand layer (1 to 1.5 m). Besides these, a meter to measure the flow and a gauge to measure loss of head are also to be provided. When the loss of head becomes high (0.7 to 1.2 m), the filter is to be put out of service and be cleaned.

Working

The treated water from the sedimentation tank is allowed into the inlet chamber. It is uniformly distributed over the sand bed to a depth of 1 to 1.5m. without any disturbance. The water percolates through the filter media and gets filtered. Now, the water enters the base material and comes out as filtered water. It gets collected in the laterals and discharged into the central main covered drain. From where it is finally discharged into the filtered water well. The standard rate of filtration (100 to 200l/m2/hour) is continued until the difference between the water levels in the filter and the outlet chamber is slightly less than the depth of water above the sand or the loss of head reaches 0.7 to 1.2 m.

Cleaning

During working of the filter, if the loss of head reaches the permissible limit, the working is stopped. About 20 to 30 mm sand is scraped from the top of the filter bed. The top surface is finally raked, roughened, cleaned and washed with pure water till the sand depth reduces to 0.4 m or so. Then more clean sand is added to have a minimum sand depth of about 0.45 m. The interval of cleaning may vary from 1 to 3 months.

After every cleaning, the initial filling is done by admitting filtered water from the bottom till it rises about 0.8 m above the sand. Then the fresh water is allowed to enter from the top. The amount of filtered water required is about 0.2 to 0.6% of the total water filtered.

Rapid sand filters (Fig 3)

In rapid sand filters, the yield is about 30 times the yield given by slow sand filters for the same filter area. This is achieved by increasing the size of sand. They are also known as mechanical sand filters.

A rapid sand filter is an open watertight chamber, 3 to 3.5 m deep. It has coarse sand filter media, 0.6 to 0.75 m thick, laid on 0.45 m thick graded gravel. The under drainage system is supported by concrete floor. The under drainage system consists manifold with strainers mounted on top and laterals. Laterals have perforations on sides. The filtration is effected by gravity.

The rate of filtration is about 3000 to 6000ℓ/m2/hour. Its bacterial efficiency is 80 to 90%. Removes turbidity upto 30 to 40 ppm.

Construction

A typical longitudinal section of a rapid sand gravity filter is shown in fig 3. The following are its essential parts.

1 Enclosure tank.

2 Filter media.

3 Base material.

4 Under - drainage system.

5 Appurtenances.

1 Enclosure tank

It is an open watertight tank built either of masonry or concrete. The sides and floor are coated with water proof material. It is about 2.5 to 3.5 m deep 3.5 to 6 m wide and 6 to 9m long. The usual plan size is12 m x 9 m. The units are arranged in series. The surface area may be 10 to 80 m2.

2 Filter media

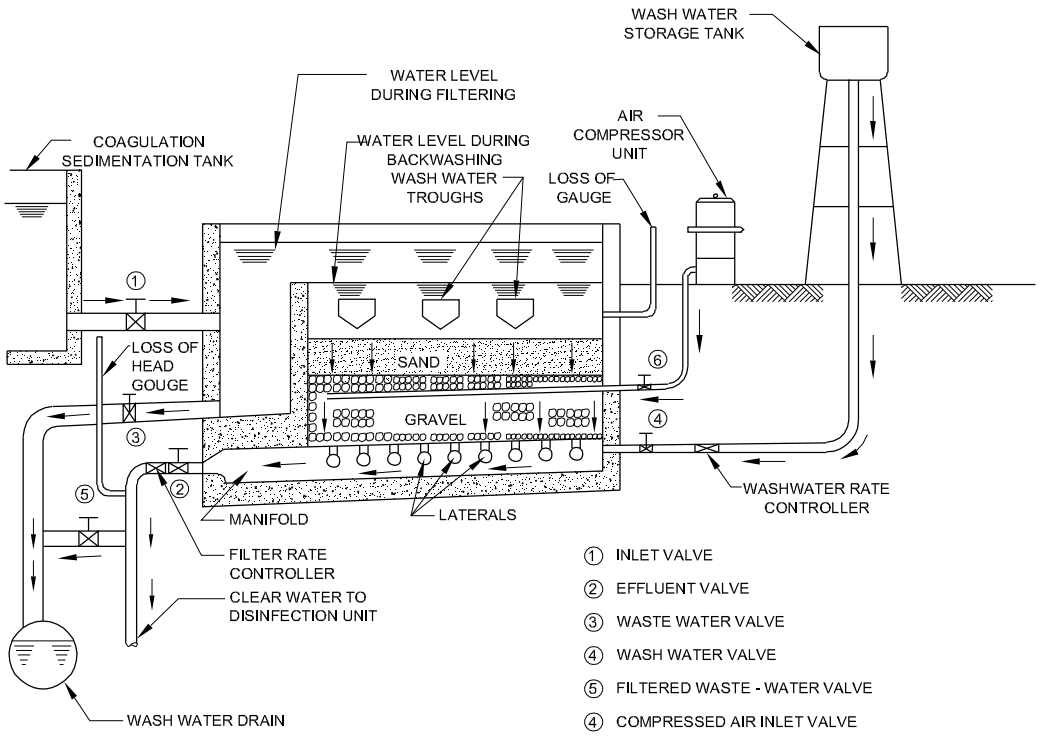
It consists of sand layers of 0.6 to 0.9 m thick, supported over graded gravel layer. The effective size is 0.35

35 to 0.6 mm and uniformity coefficient is 1.2. to 1.7. The finer sand is placed at top and coarser variety at bottom.

3 Base material

Durable, hard, round, strong and clean graded gravel free of clay, dust, silt and vegetable matter is used as base material. It is placed on the top of an under - drainage system to a thickness of 0.45 to 0.9 m.

Fig 3



RAPID SAND FILTER

Top most layer - 150 mm thick - 3 mm to 6 mm size

Intermediate layers- 150 mm thick - 6 mm to 12 mm size

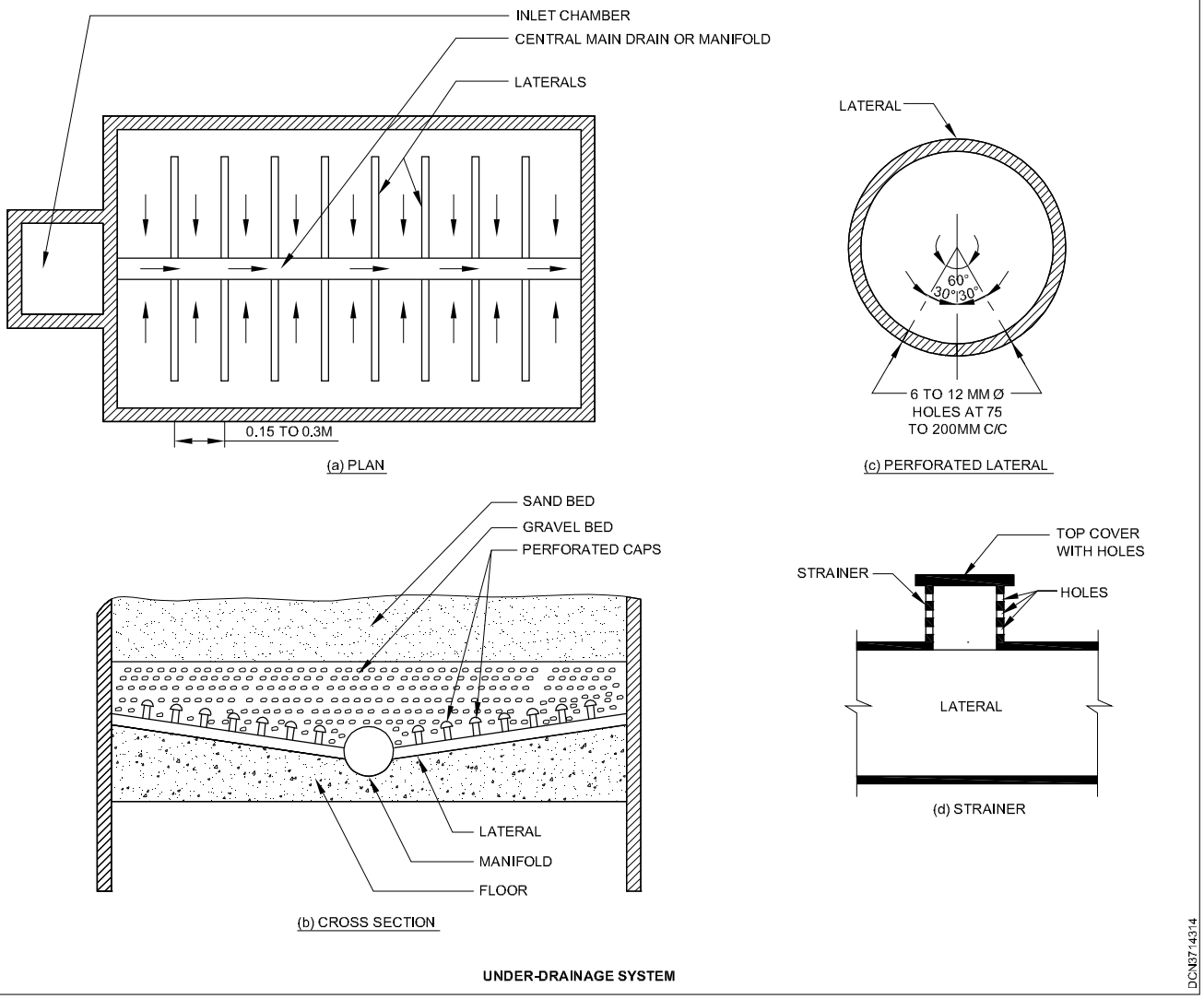
- 150 mm thick - 12 mm to 20 mm size

Bottom most layer - 150 mm thick - 20 mm to 40 mm size

4 Under - drainage system (Fig 4)

It consists of a cast iron central longitudinal conduit or manifold with laterals branching off at right angles to it. Laterals are smaller diameter pipes fixed at 150 to 300 mm centres. They are provided with 6 to 12 mm diameter holes at an angle of 30° to the vertical at 75 to 200 mm centres. In another system, strainers are placed on laterals. Strainer is a small brass pipe, closed at top. It has holes on its top and sides.

Fig 4



UNDER-DRAINAGE SYSTEM

5 Appurtenances

The following are the most important appurtenances of a rapid sand gravity filter.

1 Air compressor

2 Rate controller

3 Wash water troughs

4 Miscellaneous accessories

Air compressors

These are employed to agitate the sand grains of the filter during backwashing. The compressed air is supplied either through laterals or through a separate pipe system. Generally, they should supply compressed air at the rate of 0.6 to 0.8 m3/m2/minute for about 5 minutes.

The agitation of sand grains may also be carried out by water jet or by mechanical rakes.

Rate controller

It is used to control the rate of flow. Most popular device is a "venturi rate controller". It works on the principle of venturimeter.

Wash water troughs

They collect the dirty water after washing of filter. They are placed with their bottom at 0.45 to 0.75 m above sand bed level. They are placed at 1.3 to 1.8 m apart. For efficient

functioning, they should be large and should be laid at suitable slopes.

Miscellaneous accessories

Additional devices such as head loss indicators, flow rate meters, etc. are to be installed.

Working

The working of a rapid sand filter is explained with reference to the fig.3.

Action during filtration

Inlet valve (1) is opened and water from coagulated sedimentation tank is allowed to enter the filter. Effluent valve (2) is opened to carry filtered water to clear water reservoir. During this, all other valves remain closed. Only, inlet and effluent valves are open.

Action during backwashing

Backwashing is done when the loss of head reaches the maximum permissible limit (2.5 to 3.5m). The filter is drained out, leaving a very small depth of water standing above the filter bed. Now, compressed air is sent under pressure through the under - drainage system for about 2 to 3 minutes. This agitates the mass of water. The agitated water loosens the dirt from the surface of sand grains. Now, an upward flow of water from a high level tank is sent through the bed. This causes the sand bed to expand, agitate the sand grains and wash off the surface deposits. The deposits are carried by wash water troughs and disposed through wash water drains. During backwashing, valve positions are as below

1 Inlet valve (1) and effluent valve (2) are closed.

2 Waste water valve (3) and wash water valve (4) are opened.

3 Filtered waste water valve (5) is kept closed till the wash water is fairly clear.

4 Waste water valve (3) and wash water valve (4) are closed.

5 Inlet valve (1) and filtered waste water valve (5) are opened for rewash.

6 Filtered waste water valve (5) is closed and the effluent valve (2) is opened for the operation of the filter.

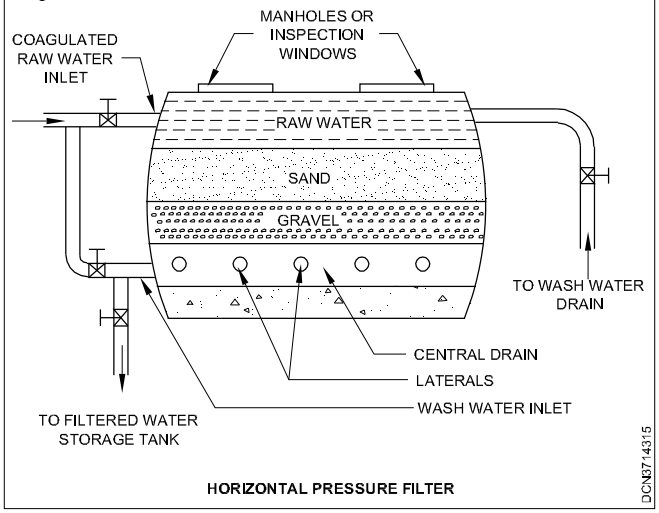
The amount of water required for washing a rapid sand gravity filter is 1 to 5% of the total amount of water filtered. It is to be cleaned every 1 to 3 days.

Pressure filters

They consist of closed water - tight cylindrical metal tanks of 1.5 to 3m diameter and length or height 3.5 to 8 m, containing filter media as for a rapid sand gravity filter. The raw water mixed with a dose or coagulant is pumped into the filter under a pressure of 300 to 700 KN/m

. After filtration, water comes out under high pressure. The rate of filtration is 6000 to 15000 l/m^2/hour. They are of horizontal or vertical type. They are more suitable for small installations like industries, private estates, etc. They are less efficient than slow and rapid sand gravity filters. Inspection windows are provided at top. A horizontal type of filter is shown in fig 5.

Fig 5



HORIZONTAL PRESSURE FILTER

Working

The coagulated water under pressure is directly admitted to the pressure filter through inlet valve (1). The filtered water comes out through the outlet valve (2). It is collected in the central drain and conveyed to filtered water storage tank. During normal working, only the valves for raw water and filtered water are kept open.

The cleaning of the filter may be carried out by backwashing as for the rapid sand filter. The compressed air may be used to agitate sand grains. For cleaning, inlet and outlet valves (1) and (2) are closed. The wash water valve (3) and wash water gutter valve (4) are opened. The cleaning is done more frequently.

Compact automatic pressure filters are also available. The cleaning is done automatically at a predetermined interval of time or loss of head.

Disinfection of water

Disinfection is the process of removal of pathogenic bacteria from water by chemicals or other means. The chemicals used for killing disease producing bacteria's are called disinfectants. Sterilization is the process of killing all bacteria's by boiling.

Necessity of disinfection

Even the filtered water may contain some harmful impurities such as disease producing bacterias, dissolved inorganic salts, colour, odour, taste, iron and manganese.

The bacterially contaminated waters will spread various diseases and their epidemics causing disaster to public life. Hence, disinfection is most essential. Further, disinfection not only kills the existing bacterias from water, but also prevents its contamination during its transit from the treatment plant to place of its consumption.

The disinfection should be able to retain a residual sterilizing effect for a long period to prevent recontamination. Also, it should be harmless, unobjectionable, economical and measurable by simple tests.

Methods of disinfection

a Chlorination

Chlorination is the treatment of water with chlorine or chlorine compounds. Chlorine is a powerful disinfectant and also it removes colour, odour, unpleasant taste and prevents the growth of weeds in water. This treatment is cheap and reliable. It produces desired effects and last long. It is also easy to measure and handle.

Disinfecting action of chlorine

On reaction with water, chlorine produces hypochlorous acid (HOCI) and hypochlorite ion (OCI). Together, they are known as free available chlorine. The actions that take place are

$Cl_2 + H_2O$ $HOCl + H^+ + Cl^-$ - Hydrolysis
(Hypochlorous acid)

HOCl $H^+ + OCl^-$ - Ionization
(Hydrogen ions) (Hypochlorous ions)

When ammonia is also present, monochloramine (NH2CI) and dichlramine (NHCI2) compounds are formed. These are together known as combined available chlorine. The above resulting chlorine compounds interfere with certain enzymes in the bacterial cell - wall. This forms into a toxic chloro compound destroying the bacterias completely.

Forms of chlorination

Chlorine is generally applied to water in one of the following forms.

1 As bleaching powder or hypochlorites.

2 As chloramines.

3 As chlorine - di - oxide.

4 As free chlorine gas.

5 As liquid chlorine.

b Excess lime treatment

Addition of excess lime to water removes salts and also kills the bacterias. After disinfection, this method requires some suitable method to remove the excess lime from water. This method cannot protect water from recontamination.

c Iodine and bromine treatment

Iodine and bromine used as water disinfectant. These are unsuitable for large scale pubic supplies. These are suitable for small water supplies like swimming pools, private plants etc.

d Ozone treatment

Ozone gas is passed through water removes the organic matter and the bacterias from water. This method is costlier and not adopted for treating water on large scale.

e Potassium permanganate treatment

Potassium permanganate kills bacterias and oxidizing the taste producing organisms. It also remove colour and iron from water. In due course, it produces dark precipitate.

f Silver treatment

Metallic silver ions are introduced in water. It is a strong germicide. It is safe against future contamination. It do not produce any harmful effect on human body. This method is very costly. This method is not adopted for public water supplies.

g Ultra - violet ray treatment

This is an effective method of disinfecting clear water. This treatment impart any colour or taste in water. Also, there is no danger of overdose. It is costly.

h Boiling

Continued boiling of water for a long time above certain temperature kills the bacteria. It is the most effective method of disinfection. It is not suitable for public water supplies.

Softening of water

Water softening is the process of reduction or removal of hardness from water.

Hardness of potable water is 5 to 8 degrees. Hardness is the characteristic which prevents the lathering of soap. It is caused by the presence of certain salts of calcium and magnesium dissolved in water.

Purpose of water softening

Water softening is done to achieve the following objectives.

1 To reduce soap consumption.

2 To reduce corrosion and incrustation of pipes and fittings.

3 To improve the taste of food preparations.

4 To reduce scaling in boilers.

5 To minimize its interference in dying systems.

Hardness of potable water is 5 to 8 degrees. Hardness less than 5 degrees is tasteless and above 8 degrees produces undesirable effects. One degree of hardness = 14.25 ppm.

Types of hardness

a Temporary hardness or carbonate hardness

It is due to the presence of carbonates and bicarbonates of calcium and magnesium. Temporary hardness can be removed by boiling or by adding lime called lime process.

b Permanent hardness or non - carbonate hardness

It is caused by the presence of sulphates, chlorides and nitrates of calcium and magnesium. It can be removed by special methods of water softening such as lime soda process, zeolite process, or demineralization.

Removal of - temporary hardness

The temporary hardness can be removed by boiling or by adding lime called lime process. Lime process is otherwise known as clark process.

The principle involved in this process is the neutralization of carbon - di - oxide with milk of lime. This forms normal

carbonates which precipitate out when present in excess. These precipitates are insoluble in water. They are removed by sedimentation and filtration. Boiling of water on large scales is highly impracticable. Hence, lime process is preferred.

Removal of hardness - permanent hardness

The permanent hardness can be removed by special methods of water softening. Any of the following methods can be adopted.

1 Lime - soda process.

2 Zeolite process or base exchange process.

3 Demineralisation.

1 **Lime - soda process**

In this process, lime (Ca (OH)2) and soda ash (Na2CO3) are used to remove permanent hardness from water. They react with calcium and magnesium salts and form insoluble precipitates of calcium carbonate and magnesium hydroxide. The precipitates can be removed by sedimentation. The reactions are

$$MgCl_2 + Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow CaCl_2$$

$$MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow CaSO_4$$

$$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 \downarrow + Na_2SO_4$$

$$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 \downarrow + 2NaCl$$

Advantages

1 The pH value of treated water increases which decreases corrosion of distribution system.

2 Minimizes coagulant dosage.

3 Removes iron and manganese to some extent.

4 Reduces total mineral content of water.

5 Removes pathogenic bacteria by some amount.

6 The process is economical.

Disadvantages

1 Disposal of the sludge formed is very difficult.

2 Requires skilled supervision.

3 Requires recarbonation.

4 Cannot produce zero hardness.

Zeolite process

The process is also known as base - exchange or ion - exchange process. The zeolites are compounds of aluminium, silica and soda. They have excellent property of interchanging base.

In this process, hard water is passed through a zeolite sand bed. There exchanges its Ca and Mg for Na in the zeolite until Na is exhausted. Na is then restored by regenerating zeolite with a solution a common salt (NaCl). This results in the reversal of ionic reactions.

The reactions are

For softening

$$CaMg\begin{bmatrix} SO_4 \\ CO_3 \\ Cl_2 \end{bmatrix} + Na_2Z = \begin{bmatrix} Ca \\ Mg \end{bmatrix} Z + \begin{bmatrix} Na_2Co_3 \\ Na_2SO_4 \\ 2NaCl \end{bmatrix}$$

(Hard water) (Sodium zeolite)

(2) For regeneration

$$\begin{bmatrix} Ca \\ Mg \end{bmatrix} Z + 2NaCl = Na_2 Z + \begin{bmatrix} CaCl_2 \\ MgCl_2 \end{bmatrix}$$

(Sodium zeolite)

The zeolite softeners are very much similar to the rapid sand gravity filters. The zeolite bed is 1.2 to 1.8 m in thickness. This process is applicable to clear waters only.

Advantages

1 No sludge formation.

2 The zeolite unit is very compact.

3 Requires no skilled supervision.

4 No deposition of layer of calcium carbonate in the distribution system.

5 Zero hundred is achieved.

6 Water of any hardness can be prepared.

7 Completely automatic.

Disadvantages

1 Unsuitable for turbid water.

2 Unsuitable for water containing iron and manganese.

3 Requires careful operation to avoid damage of unit.

Demineralization

This process is otherwise known as de - ionisation process. In this process, hydrogen is exchanged for metallic ions. The hard water is passed through a bed of resin or carbonaceous material in the hydrogen form.

After the reactions, the effluent from the equipment contains diluted carbonic acid, sulphuric acid or hydrochloric acid. These acids can be removed by mixing the treated water in the required proportion of alkaline water.

The water produced is completely free from mineral salts. It is like distilled water. When the hydrogen content of the material is exhausted, it is regenerated by passing a solution of suitable strength of sulphuric acid or hydrochloric acid. This process is too costly. It is used for preparing water for industrial purpose.

Miscellaneous methods of treatment

Besides the normal treatments, sometimes water requires certain other special treatments to remove minerals,

tastes, odours, colours etc. from water. For this purpose the methods adopted are aeration, activate carbon treatment, copper sulphate treatment, oxidation of organic matter etc.

Distribution of water

Distribution of water is the supply of safe and whole some water to all parts of the area served at adequate pressure and quantity. Hence the distribution system may consist the following

a **Pipe lines** of different sizes to convey water.

b **Valves** for controlling the flow in the pipe lines.

c **Meters** for measuring the consumption.

d **Hydrants** for providing connections with water mains for releasing water during fires.

e **Service** connections to the individual houses.

f **Pumps** for lifting and forcing the water into the distribution pipes.

g **Service reservoirs** for storing the treated water and feeding to the distribution pipes. These are surface reservoirs and overhead reservoirs.

General requirement of a distribution system

A Distribution system should satisfy the following general requirements:

1 It should be capable supplying water in adequate quantities and pressure at all points of the area served.

2 It should meet the demands of water supply for fire - fighting purposes.

3 It should be thoroughly reliable.

4 It should be economical in its design, lay - out and construction.

5 It should be easy and simple to operate and repair.

6 It should be safe against any future pollution of water.

7 It should be water - tight.

8 It should be safe as not to cause the failure of the pipe lines.

9 It should provide free circulation of water and the number of dead ends should be very few.

10 The pipe lines should be laid away from sewers at least by 2 m vertically and 3 m horizontally.

11 It should not have any unsafe cross connections.

12 The sanitation of the water distribution area should be good so that the possibilities of pollution are remote during repairs or replacements of pipes.

House service connection (Fig 6)

This is also called service pipe or house connection. This connects the street main with the interior pipe line of the consumers. This consists of

1 Furrule

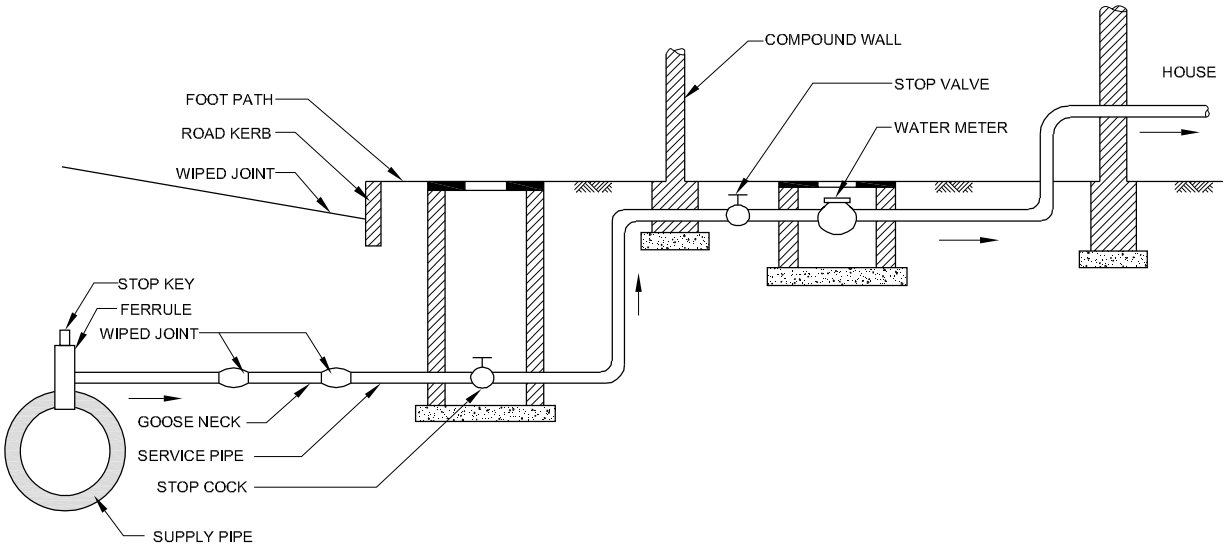
2 Goose neck

3 Service pipe

4 Stop cock

5 Water meter

Fig 6



SERVICE CONNECTION

1 Ferrule

It is a right - angled sleeve of brass or gun metal jointed to an opening drilled in the water main. It is screwed down with a plug. It size is 10 to 50 mm bore. For all other connections of more than 50 mm bore, a tee branch connection of the water main is used instead of a ferrule.

2 Goose neck

It is a small sized curved pipe of flexible material like lead. It is about 750 mm in length. It forms a flexible connection between the water main and the service pipe.

3 Service pipe

It is a galvanised iron pipe of 50 mm or less in diameter. It is laid underground in a trench in which no sewer or drainage pipe is laid. It is connected to the main through the goose neck and furrule. It supplies water from the municipal street main to the building.

4 Stop cock

It is fixed in an accessible position just outside the compound. It is housed in a chamber provided with a removable cover. Its size is according to the size of the service pipe. It is used to stop the water supply of defaulters. Sometimes, it is also called crub valve.

5 Water meter

It is used to measure the water consumption. It is housed in a chamber provided with a removable iron cover.It is fixed inside the compound.

Sometimes, a stop valve may be provided by the owner just before the water meter.It is used to close down the water supply to the buildings when repairs are going on in the house fittings.

Pipe appurtenances

These accessories or devices are provided in the distribution system for its efficient control and easy and effective functioning.Following are some of such appurtenances.

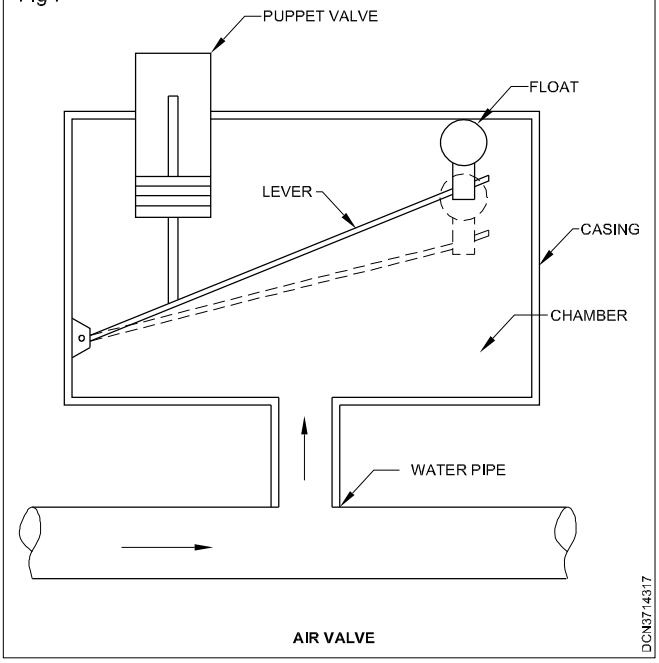
1 Air valves
2 Bib cocks
3 Fire hydrants
4 Reflux valves
5 Relief valves
6 Scour valves
7 Sluice valves
8 Stop cocks

1 Air valves (Fig 7)

These are also known as air relief valves. They are provided at all summits along the water pipe. If they are not provided, pipes may be air - locked. The air - locking will reduce the effective area of flow.

Air can automatically escape under pressure from the pipe due to this valve. Similarly, air is sucked in when there is vacuum in the pipe. They prevent the collapse of pipes due to vacuum on sudden stoppage of water supply.

Fig 7



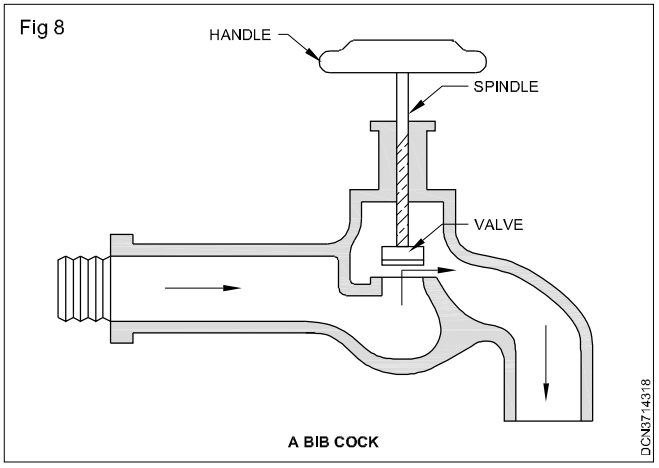
AIR VALVE

An air valve consists of a cast iron chamber, float, lever and a puppet valve. Air from the pipe line accumulates above the water surface in the chamber. The coming down of the float causes the puppet valve open and air escapes. Water rises again in the chamber. Float also rises closing the puppet valve before water escapes through it.

2 Bib cocks (Fig 8)

These are the water taps. They are fixed at the end of water pipes. Water is obtained from them. They have regulating arrangements. A typical bib cock is shown fig.8.

Fig 8



A BIB COCK

It is operated using a handle. It is a screwing type. Push types are also available. They are also known as waste - not taps.

3 Fire hydrants

These are the protected mountings or outlets provided in water mains for tapping water mainly for fire - extinguishing. Generally, they are located at all street junctions so that they can command 60 to 90 m radius.

Types

The fire hydrants are of two types.

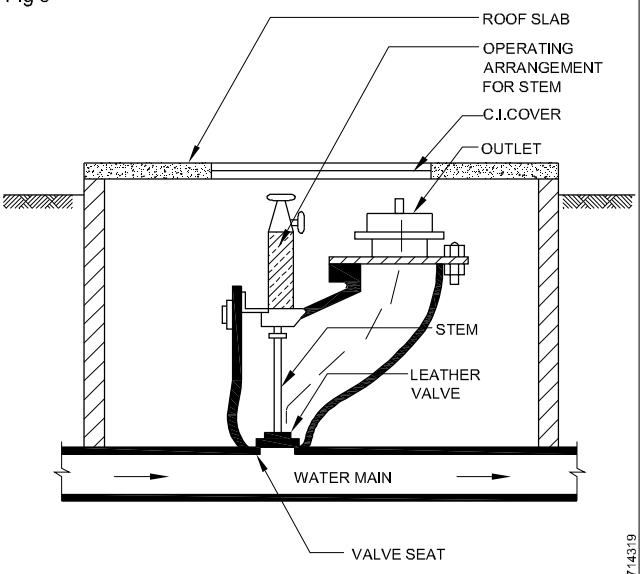
i Flush hydrants.

ii Post hydrants.

Flush hydrant

It is provided below the foot path or street level. It is covered by a cast iron box or brick masonry chamber, constructed flush with the ground surface. It is more secure though less prominent. For easy location, a plate with letters. F.H. (Fire hydrant) may be fixed to any nearby permanent structure. Fig 9 shows a flush hydrant.

Fig 9

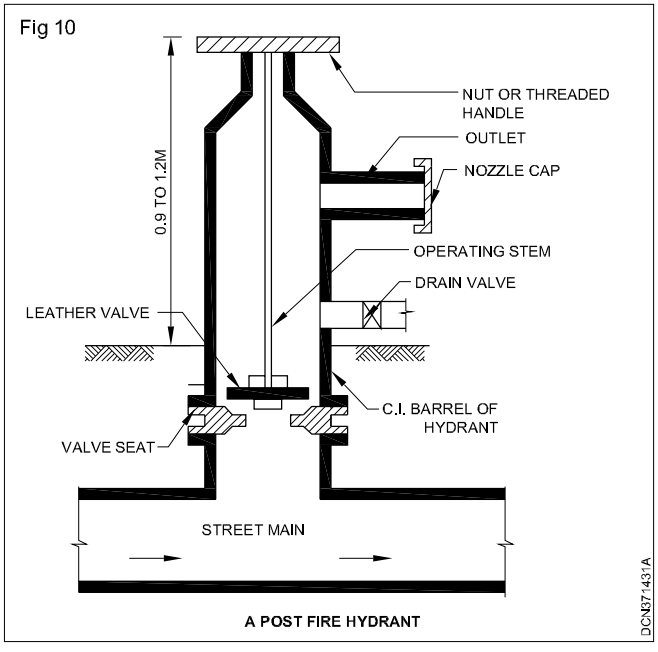


A FLUSH FIRE HYDRANT

Post hydrant

It is set at the back of the kerb line. Its barrel projects above the ground surface by 0.9 to 1.2 m. The nut at its top is opened and the fire hose is attached to it. On opening the nut, the stem is lifted. This opens the valve. It is very prominent and is very easy to locate. But, it is likely to be damaged or misused. A typical post hydrant is shown in fig 10.

Fig 10



A POST FIRE HYDRANT

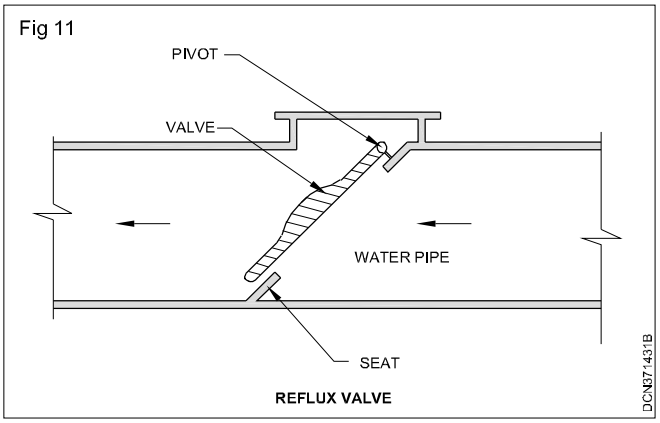
Working

The nut is operated by a key. The valve lowers down. Water enters fills up the barrel. Then water is delivered from the outlet. A fire - hose of the same diameter as the outlet is attached to it. After use, the nut is closed by the key. The valve rises up and prevents the entry of water from the pipe to barrel. The water remaining in the barrel is drained.

4 Reflux valves

These are also known as check valves or non - return valves. They are automatic valves. They allow the flow in one direction only. They are installed on the delivery side of pumps. They prevent the damage to the pumps from the water hammer due to sudden stoppage of pumps. A typical reflux valve is shown in fig 11.

Fig 11



REFLUX VALVE

Working

When the water flows in the direction of arrows, the valve swings around the pivot and remains open due to water pressure. When the flow stops, the valve comes back to its seat due its self weight and backward water pressure. Thus, it prevents the reverse flow of water.

5 Relief valves (Fig 12)

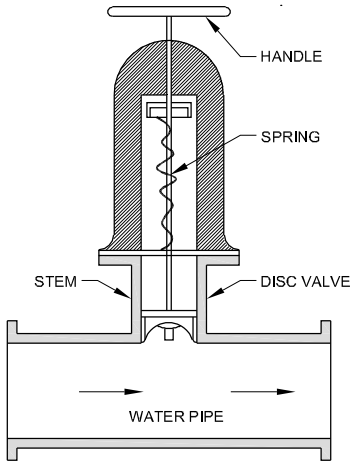
These are also called safety valves, pressure reducing valves or automatic cutoff valves. They are located at points of maximum pressure. They are mostly loaded by springs. When the pressure exceeds a predetermined limit, they open automatically. Thus, they save the pipes from bursting. Fig shows a relief valve. They are also located at entry points to low - lying areas.

6 Scour vales

These are also known as mud valves, blow - off valves or wash - out valves.

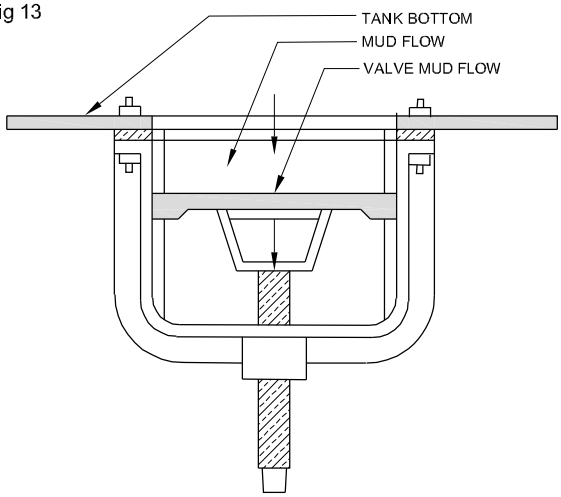
They are sluice valves. They are provided at all dead ends, and all depressions or lowest points in the mains. They are operated to remove the accumulated silt by allowing water under pressure until it becomes clear. Fig 13 shows a scour valve.

Fig 12



A RELIEF VALVE

Fig 13

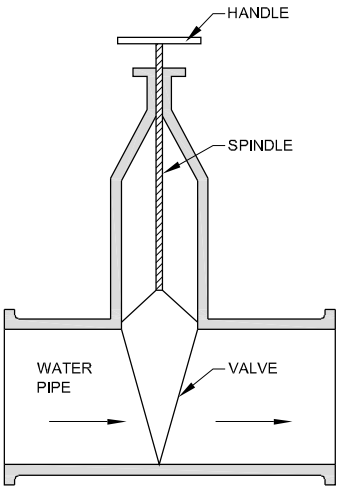


SCOUR VALVE

7 Sluice valves

These are also known as gate valves, shut off valves or stop valves. They are used to control the flow of water. They divide the mains into several sections. They help in carrying out repairs in one section without affecting the other sections. They are also very useful in intermittent system of supply of water. Fig 14 shows a typical sluice valve. The rising and lowering of the valve is carried out by rotating the handle from top.

Fig 14

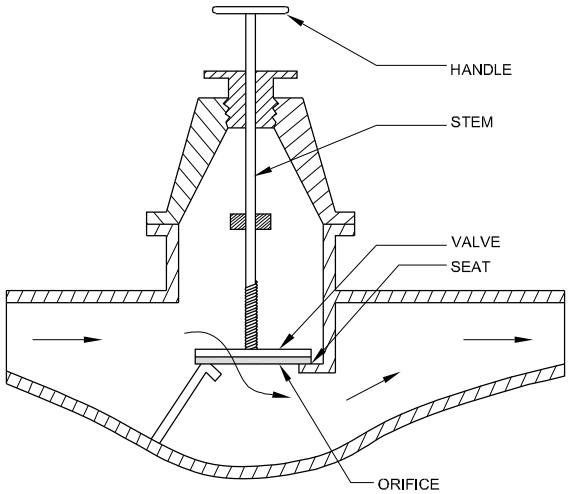


SLUICE VALVE

8 Stop cocks

These are small sized screw down type of sluice valves. They are installed in service connections. A typical stop cock is shown in fig 15.

Fig 15



STOP COCK

The water passes through an orifice when the valve is raised. When it is lowered to stop the supply, it rests on the seat closing the orifice. They are also installed on pipes leading to flushing tanks, wash - basins, water tanks, etc.