BASIC OF CIVIL ENGINEERING

Module 1

- **General Introduction to Civil Engineering:** Relevance of Civil Engineering in the overall infrastructural development of the country. Responsibility of an engineer in ensuring the safety of built environment. Brief introduction to major disciplines of Civil Engineering like Transportation Engineering, Structural Engineering, Geo-technical Engineering, Water Resources Engineering and Environmental Engineering.
- **Introduction to buildings:** Types of buildings, selection of site for buildings, components of a residential building and their functions.
- **Building rules and regulations:** Relevance of NBC, KBR & CRZ norms (brief discussion only).
- **Building area:** Plinth area, built up area, floor area, carpet area and floor area ratio for a building as per KBR.

Introduction

- Civil engineering is one of the oldest engineering disciplines
- Includes planning, designing, and construction and maintenance of building structures, and facilities, such as roads, railroads, airports, bridges, harbours, channels, dams, irrigation projects, and water and sewage systems.

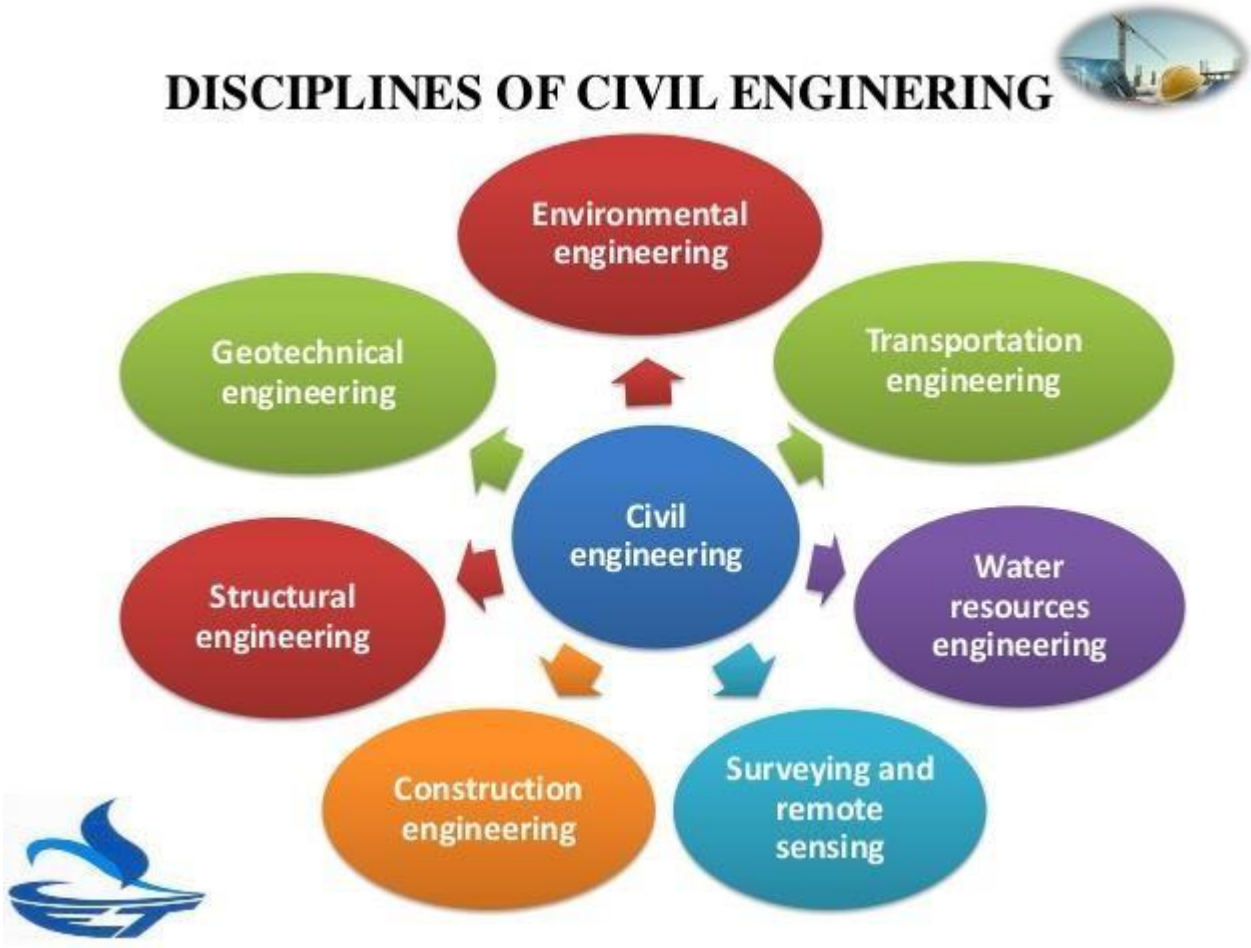
Role of Civil Engineers in Infrastructural Development

- ✓ Construction of residential , commercial and industrial buildings
- ✓ Town and city planning
- ✓ Construction of roads , railway, harbours and airports
- ✓ Construction of dams , water and sewage treatment plants
- ✓ Providing safe domestic ,agricultural and industrial water supply
- ✓ Secure and scientific waste disposal
- ✓ Monitoring pollution and adopting preventive measures
- ✓ Rehabilitation and rebuilding of structures

Impacts of Infrastructural Development

- Healthy and comfortable living condition
- Improvement in communication and transportation
- Protection from flood and drought
- Safe domestic and industrial water supply
- Generation of electricity
- Increase in food production
- Safe and scientific disposal of waste
- Improved wealth , prosperity and standard of living

Various Disciplines of Civil Engineering



Various disciplines of Civil Engineering

- Structural Engineering
- Construction Engineering
- Geotechnical Engineering
- Transportation Engineering
- Environmental Engineering
- Water resource Engineering
- Surveying and Remote Sensing

Structural Engineering

- ✓ Deals with design of RCC structures like water tank , retaining wall , bridges, residential buildings etc
- ✓ Design of steel structures like railway platform, steel bridges etc
- ✓ Design of earthquake resistant structures

Structural Engineering

- ✓ Analysis and design of structures subjected to self weight , external loads acting on it and resist forces due to wind ,earthquake ,temperature etc
- ✓ Structural engineers develops proper combinations of steel , timber, concrete, plastic etc
- ✓ Ensure aesthetically pleasing , safe and durable structures

Construction Engineering

- ✓ Turn designs into reality on time and within budget
- ✓ Management of resources - money, materials, labours , time , equipment's
- ✓ Construction management involves planning , scheduling and execution of project from its beginning to its completion
- ✓ Application of knowledge , skills ,tools and techniques to project activities in order to meet project requirements for the successful completion of project .

Geotechnical Engineering

- ✓ Deals with projects below ground (eg: tunnels , foundations)
- ✓ Analyse soil properties and rock that support and affect the behaviour of structures.
- ✓ Evaluate stability of slopes and fill, seepage of ground water
- ✓ Helps on design and construction of dams, embankments and retaining walls

Geotechnical Engineering

Soil Mechanics

- branch of science concerned with the properties and behaviour of soil and its application as engineering material in construction

Foundation Engineering

- application of soil mechanics and rock mechanics (Geotechnical engineering) in the design of foundation elements of structures

Transportation Engineering

- ✓ Focuses on planning, design , construction and management of transportation facilities
- ✓ Upgrading our transportation capability by improving traffic control

1. Airport engineering
2. Highway engineering
3. Railway engineering
4. Tunnel engineering
5. Traffic engineering
6. Harbour and dock engineering

Environmental Engineering

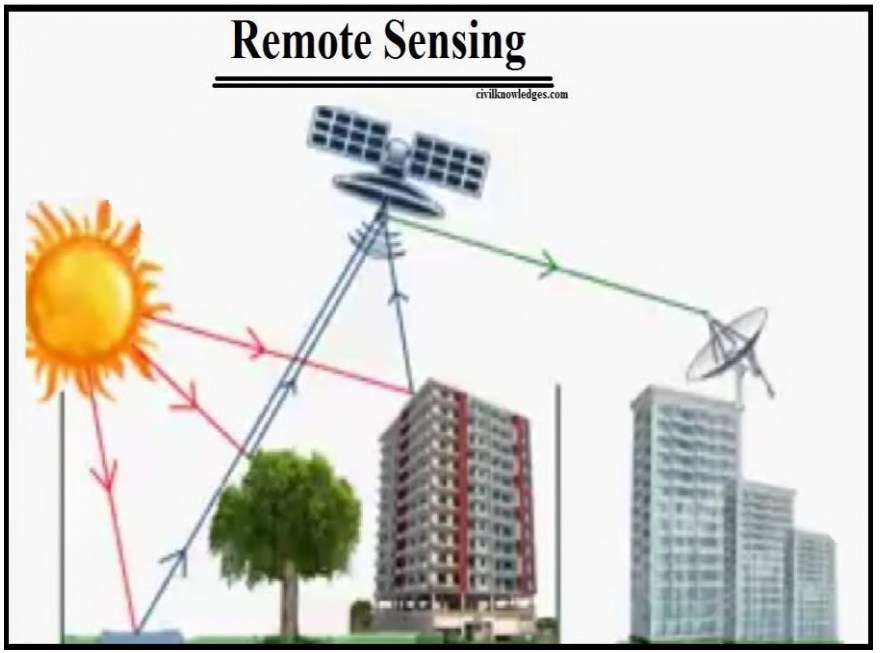
- ✓ Deals with purification of air and water , sewage treatment , hazardous waste management , pollution reduction ,water supply etc
- ✓ Environmental engineers translate physical , chemical and biological processes into systems to destroy toxic substances, remove pollutants from water, reduce non hazardous solid waste volumes, and eliminate contaminants from air .

Water Resource Engineering

- ✓ Deals with physical control of water
- ✓ Works related to Prevents floods, supply of water , protect beaches or to manage and redirect rivers
- ✓ Design , construct and maintain hydro electric power plant facilities, canal, dams and pipelines, pumping stations etc

Surveying and Remote Sensing

- Art of determining the relative positions of points on, above or beneath the surface of the earth by means of direct or indirect measurements of distance, direction and elevation.
- Objective of surveying is to prepare plan or map
- Remote sensing is the science of acquiring information about the Earth's surface without actually being in contact with it.



Surveying and Remote Sensing

Site selection for Residential Buildings

- ✓ Site should be fairly level with good quality soil
- ✓ It should be calm but reasonably developed
- ✓ It should be well connected by roads and other modes of transport
- ✓ Should have good communication facilities
- ✓ Electricity ,water and sewer lines should be available
- ✓ Should be away from hazardous industries
- ✓ Flood prone areas, water logged areas and reclaimed land should be avoided
- ✓ Should have natural ventilation and lighting
- ✓ Amenities like schools, recreation centres, shopping centres, hospitals should be nearer

Site selection for Residential Buildings

- ✓ Should have quick drainage properties
- ✓ May have regular shape with sufficient frontage
- ✓ Area must be sufficient for present and future development
- ✓ Places prone to air and water pollution should be avoided
- ✓ Proper ownership and other legal matters have to be checked before buying a site
- ✓ Type of land use recommended at proposed site should be complied as per Town planning/ development schemes

Types of Buildings

Based on

1. Occupancy
2. Fire resisting capacity
3. Height of building
4. Mode of load transfer
5. Type of material used for construction

1. Based on Occupancy

- ✓ According to National Building Code (NBC), buildings are classified as:
  - ➢ Group A:Residential Building
  - ➢ Group B:Educational
  - ➢ Group C :Institutional
  - ➢ Group D:Assembly
  - ➢ Group E:Business
  - ➢ Group F:Mercantile
  - ➢ Group G:Industrial
  - ➢ Group H:Storage
  - ➢ Group J:Hazardous

1. Based on Occupancy

- Group A:Residential Building
  - ✓ These shall include any building in which sleeping accommodation is provided for normal residential purposes with or without cooking or dining
  - ✓ Buildings and structures under Group A shall be further sub-divided as Lodging or rooming houses, One or two-family private dwellings, Dormitories ,Apartment houses (flats) and Hotels.
- Group B:Educational Building
  - ✓ Any building used for school, college, other training institutions for day-care purposes for more than 8 hours per week involving assembly for instruction, education or recreation

1. Based on Occupancy

- Group C :Institutional Building
  - ✓ 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.
  - ✓ Buildings and structures under Group C shall be further sub-divided as Hospitals and sanatoria ,Custodial institutions and Penal and mental institutions
- Group D:Assembly Building
  - ✓ Any building or part of a building, where number of persons not less than 50 congregate or gather for amusement, recreation, social, religious, patriotic, civil, travel and similar purposes
  - ✓ Eg: theatres, assembly halls,, exhibition halls, museums, gymnasiums, restaurants, places of worship, dance halls etc

1. Based on Occupancy

- Group E:Business Building
  - ✓ Any building or part of a building which is used for transaction of business for keeping of accounts and records and similar purposes
  - ✓ Eg: Offices, banks, professional establishments of doctors, lawyers and police stations, libraries
- Group F:Mercantile Building
  - ✓ Any building or part of a building, which is used as shops, stores, market, for display and sale of merchandise, either wholesale or retail.

1. Based on Occupancy

- Group G:Industrial Building
  - ✓ 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,
  - ✓ Eg: assembly plants, industrial laboratories, dry cleaning plants, power plants
- Group H:Storage Building
  - ✓ Any building or part of a building used primarily for the storage or sheltering of goods, ware or merchandise (except those that involve highly combustible or explosive products or materials) vehicles or animal
  - ✓ Eg: warehouses, cold storage, transit sheds, storehouses

1. Based on Occupancy

- Group J:Hazardous Building
  - ✓ Any building or part of a building which is used for the storage, handling, manufacture or processing of highly combustible or explosive materials or products which are liable to burn

Based on Fire resistant capacity

1. Type 1 construction: fire proof constructions in which all the structural components are incombustible and should be fire resistant for 4 hours.
2. Type 2 construction: fire proof constructions in which all the structural components are incombustible and should be fire resistant for 3 hours.
3. Type 3 construction: external portion are incombustible and inner portions are combustible and fire resistant for 2 hour.
4. Type 4 construction: exterior walls and floor constructions are of combustible materials and fire resistant for 1 hour.

Based on Height of building

- ✓ High rise building : height > 15 m
- ✓ Low rise building: height < 15 m

Based on Load transfer

1. Load bearing masonry building : load of building from the floors are transferred through masonry wall to foundation.
2. Framed building : frame work of beams and columns transfer the load to the foundation.

Based on Type of Materials Used

- ✓ Earthen building
- ✓ Thatched building
- ✓ Masonry building
- ✓ Steel building
- ✓ Wooden building
- ✓ RCC building

Components of A Residential Building

Sub structure or foundation — Portion of building below ground level

- Transfers the load of super structure to the soil

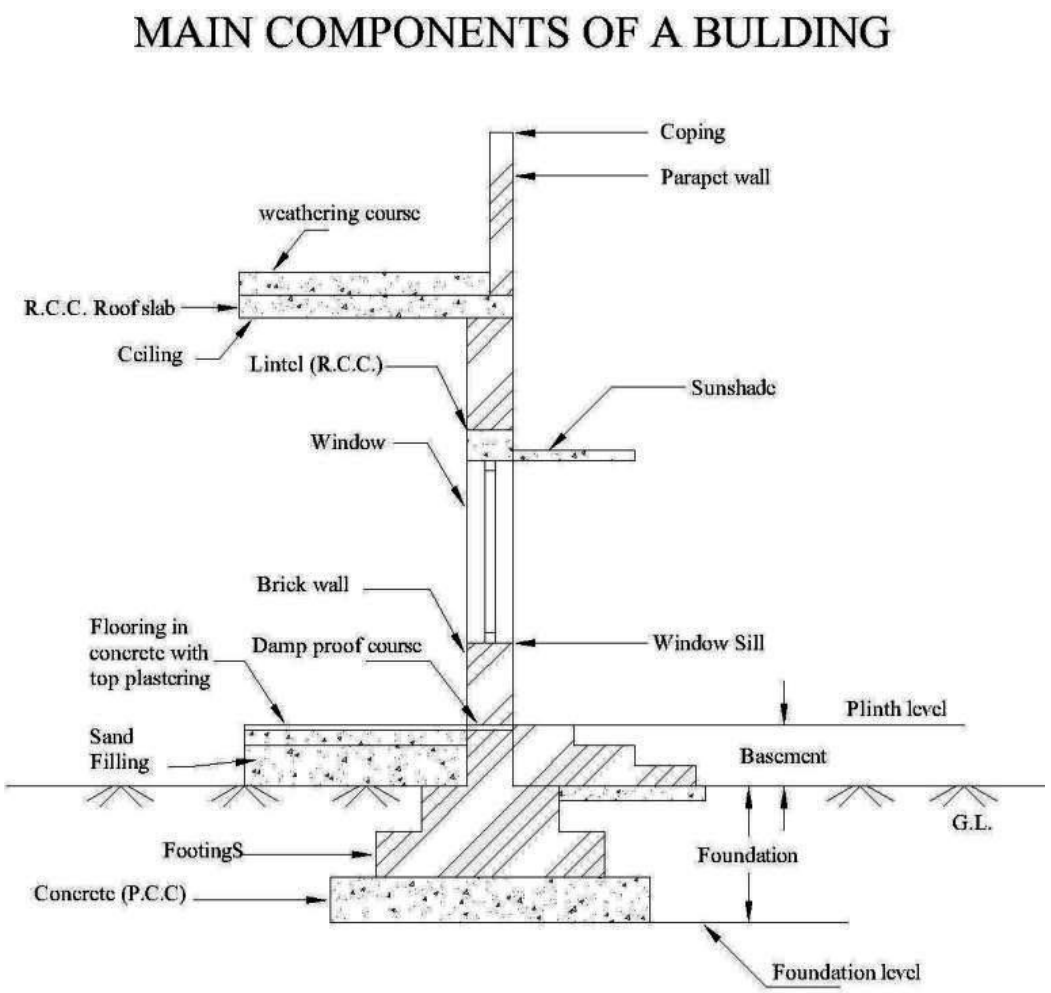
Plinth — part of the building above ground level and up to the floor level immediately above the ground

- Transfer load from superstructure to sub structure

Super structure — Component of building which is constructed above the plinth level

- Includes walls , floors, doors and windows etc

Components of Residential Building



Components of Residential Building

Walls and Piers:

- The main function of the wall is to divide the space into different rooms.
- Walls support the loads from the roof, upper floor to the foundation.
- Piers or pillars are thickened sections of the wall placed at intervals to carry the concentrated loads.
- Walls are built with bricks, stones or with concrete.

Components of Residential Building

Floors :

- Floors are provided to divide a building into different stories for creating accommodation one above the other.
- The main function of the floor is to give support to occupants, furniture's and equipment of a building.
- The floor should be strong enough to carry the loads (self weight and imposed loads)
- The floor should provide a clean, smooth, impervious, durable and weather resistant
- It should have adequate resistance against fire
- Walls should have sufficient heat and sound insulation

Components of Residential Building

Steps and Stairs

- Steps and stairs are provided for access to the building or to the other floors of the building.

Doors and Windows

- Doors are provided to give access to outside of the building as well as to connect inner rooms of the building
- Window is an opening provided for ventilation and natural light

Components of Residential Building

Requirement of Doors and Windows

- Doors and windows should be weather resistant
- It should have adequate resistance against fire
- It should have sufficient heat and sound insulation
- Doors and windows should provide sufficient privacy and security against burglary

Components of Residential Building

Beams and Lintels

- Beam is a horizontal structural member, which carries floor slab or roof.
- Lintel is a beam that support the masonry work over the opening in the wall

Sunshade

- It is a projection provided outside a building above doors and windows to prevent direct sunlight and rain to the rooms

Roof

- Roof is a cover for the building, to protect it from rain, wind, snow, sunlight etc.
- Roof may be flat, sloping or curved type

Components of Residential Building

Requirements of Roof

- Roof should be strong, stable and weather resistant
- It should have adequate resistance against fire
- It should have sufficient heat and sound insulation

Parapet

- A short masonry wall built on top of the roof of a building is called parapet.
- It serves as an enclosure above the roof and as an element for good appearance

Components of Residential Building

Weathering Course

It is a layer provided over the roof slab to protect the roof from weathering agencies like sunlight, rain and wind

Finishes for Wall

- Finishes for wall are pointing, plastering, painting, distempering etc..
- These finishes protect walls from effect of weather
- It covers the defective materials or poor workmanship to some extent
- It improve the aesthetic appearance of the building

NATIONAL BUILDING CODE (NBC)

- Comprehensive building code
- A national instrument providing guidelines for regulating the building construction activities across the country.
- Serves as a Model Code for adoption by all agencies involved in building construction works be they Public Works Departments, other government construction departments, local bodies or private construction agencies.
- Code was first published in 1970 at the instance of Planning Commission and then first revised in 1983.

NATIONAL BUILDING CODE (NBC)

- Code mainly contains
  - ✓ administrative regulations, development control rules and general building requirements;
  - ✓ fire safety requirements; stipulations regarding materials, structural design and construction (including safety);
  - ✓ building and plumbing services;
  - ✓ approach to sustainability;
  - ✓ asset and facility management

COASTAL REGULATION ZONE (CRZ)

- Coastal zone means the coastal water ,wet land and shore land strongly influenced by marine water
- Coastal Regulation Zones (CRZ) are the areas along the 7,500 km-long coastal stretch of India.
- Development of buildings, tourism infrastructure and other facilities is regulated in these areas by the Government of India.

COASTAL REGULATION ZONE (CRZ)

- Coastal Stretches of creeks, bays, seas, rivers and backwaters that are affected by the tidal actions of up to 500 metres from the High Tide Line and the land between the Low Tide Line and the High Tide line are Coastal Regulation Zones (CRZ).

Objectives of CRZ

- ✓ To ensure livelihood security to the fisher communities and other Local communities living in the coastal area.
- ✓ To conserve and protect coastal stretches, its unique environment and its marine area
- ✓ To promote develop through sustainable manner based on scientific principles taking into account the dangers of natural hazards in the coastal area, sea level rise due to global warming

Classification of CRZ

For the purpose of conservation and protection of coastal areas and marine water, coastal areas are of four categories as CRZ-1, CRZ-2, CRZ-3 and CRZ-4.

1. **CRZ-1**:

- ✓ Ecologically sensitive areas which are essential in maintaining the ecosystem of the coasts.
- ✓ These include national parks/marine parks, sanctuaries, reserve forests, wildlife habitats, mangroves and corals/coral reefs.
- ✓ These areas are situated between the high and low tide lines.

Classification of CRZ

2. **CRZ-2:**

- ✓ The areas that have already developed up till the shoreline of the coast are included in this zone.
- ✓ Construction of unauthorised structures is prohibited in this zone.

3. **CRZ-3:**

- ✓ Rural and urban localities that are relatively undisturbed and do not belong to the first two categories are included under CRZ-3.
- ✓ Only specific activities related to agriculture or some public facilities are allowed in this zone.
- ✓ It includes areas within municipal limits or in legally designated urban areas that are not substantially built-up.

Classification of CRZ

- ✓ It includes areas within municipal limits or in legally designated urban areas that are not substantially built-up.

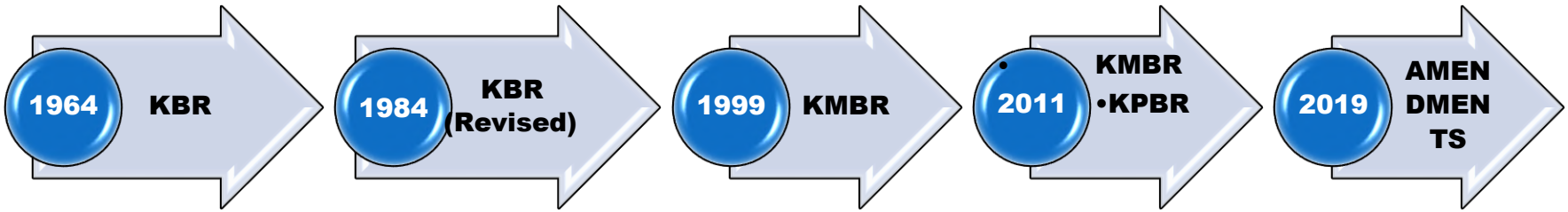
4. **CRZ-4**:

- ✓ These areas include the coastal stretches in Lakshadweep, the Andaman and Nicobar Islands and some other small islands, except those termed as CRZ-I, CRZ-II, or CRZ-III.
- ✓ These areas reside in the aquatic region up to the territorial limits.
- ✓ Activities such as fishing and other allied services are permitted in this zone.
- ✓ Releasing solid waste is prohibited on such land.

Kerala Building Rule (KBR)

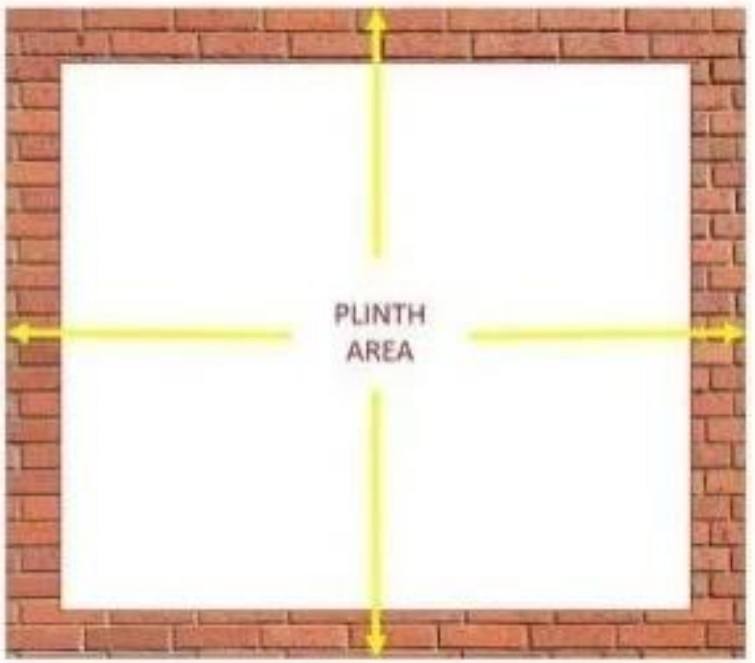
- ✓ Building regulations are framed based on NBC guidelines to suit the town and country planning schemes and proposed land use patterns of particular area.
- ✓ Rules are framed based on aspects like:
  - Development and land use pattern
  - Utilization of natural resources like sunlight and breeze
  - Scope for future development of roads and public utilities
  - Current and projected population growth
  - Settlement patterns of people engaged in various sectors
- ✓ Building rules ensures quality and safety in construction
- ✓ It provide a legal base to authorized constructions and also for tax collecting authorities like local body institutions and revenue authorities

Kerala Building Rule (KBR)



Building area

- **Plinth area:**
  - ✓ Plinth area is the covered built-up area measured at the floor level of any storey or at the floor level of the basement.
  - ✓ Plinth area is also called as built-up area
  - ✓ The entire area occupied by the building including internal and external walls.
  - ✓ Plinth area is generally 10-20% more than carpet area.
  - ✓ does not include the area of open porch [(not enclosed by wall)], uncovered staircase



Building area

- **Built – up area**:
  - ✓ Total area covered by the building at all floor levels
  - ✓ It includes area of mezzanine floor, galleries, barsati and pent house at terrace level.

Building area

- **Floor area**:
  - ✓ the built up area in all floors including basement floor. OR
  - ✓ Total area of floor between walls and consists of all rooms, verandah,passages,corridor,staircase room, entrance hall, kitchen, bath and latrines etc
  - ✓ Sill of doors and windows are not included in floor area

$$Floor\ area = plinth\ area - area\ occupied\ by\ wall$$

Building area

- **Carpet area or liveable area or useful area or lettable area**
  - ✓ Carpet Area' means the usable floor area excluding the area of staircases, lift wells, escalators, ducts, toilets, air condition plant room and electrical room.
  - ✓ For calculating carpet area, twenty percent of the floor area shall be deducted from the total floor area in each floor.[in the absence of sufficient data]

$$Carpet\ area$$
$$= total\ floor\ area$$
$$- [circulation\ area, verandah, corridor, passages, staircase, lift, sanitary\ accomodation$$

Building area

- **Floor area ratio[FAR]**
  - ✓ The quotient obtained by dividing the total floor area on all floors by the plot area.

$$FAR = \frac{total\ floor\ area}{plot\ area}$$

It is similar to Floor Space index

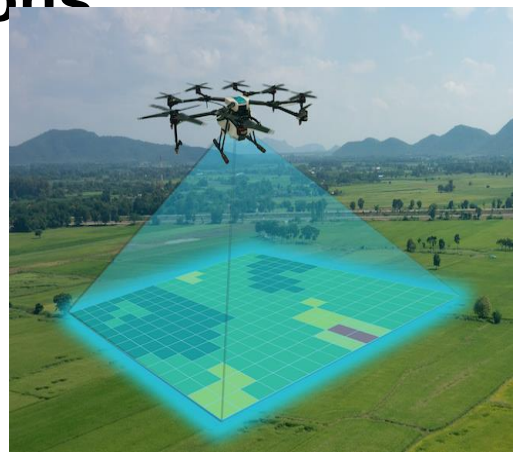
Basic Civil Engineering
Module 2

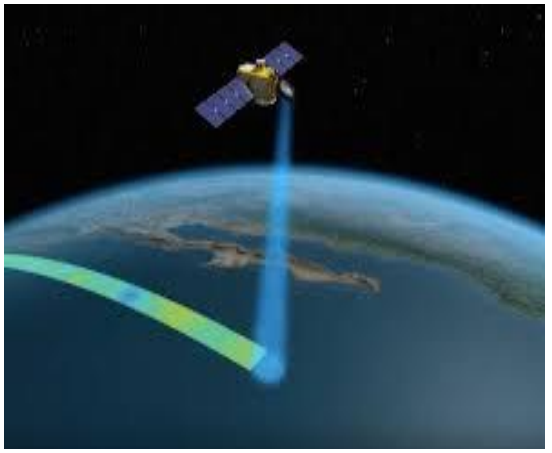
Outline of the module

Surveying
Cement
Timber
Bricks
Stones and Aggregates
Sand
Cement Concrete
Steel
Modern Constructional Materials

Surveying

Surveying is defined as an art of determining the relative positions of points on, above or beneath the surface of the earth, with respect to each other, by measurements of horizontal and vertical distances, angles and directions





Surveying

- Surveying plays a very important role in many branches of engineering.
- It is essential to plan, construct and maintain a wide variety of civil engineering works like railways, highways, buildings, bridges, tunnels, canals, dams, irrigation and drainage works, water supply and sewerage systems etc.
- Surveying methods are commonly employed in laying out assembly lines, fabricating large equipment, constructing missile ranges and in many other related tasks in archeology, astronomy, forestry, geology, geography etc.

Surveying

OBJECTIVES

The main objectives of surveying are:

To prepare plan or map of the area surveyed

To establish the boundaries.

To prepare navigational charts for use on land, air and sea

To set out engineering projects

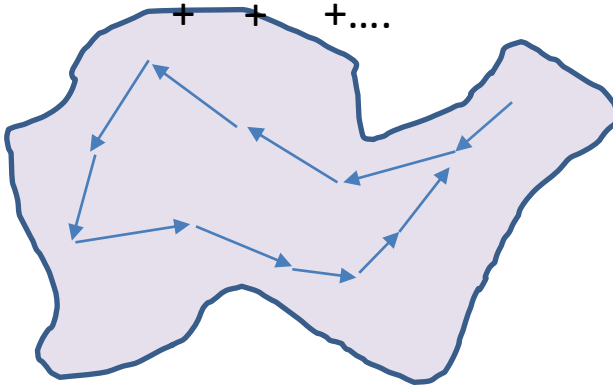
To prepare astronomical charts showing locations of sun moon etc

Principle of Surveying

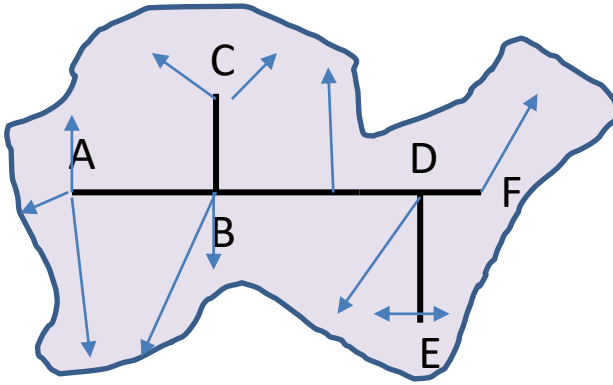
Error = Δx

Total error = Δx + Δx + Δx + Δx +....

1.Working from whole to part



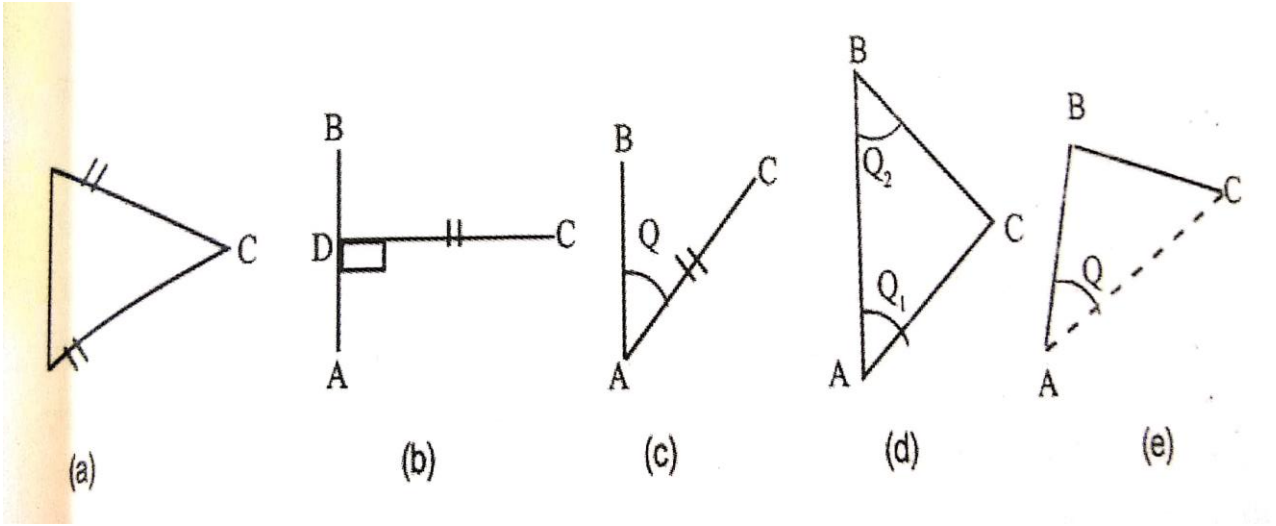
The ruling principle of surveying is to work from whole to part.
It is essential to establish a system of control points first and to fix them with higher precision. Minor control points can then be established by less precise methods and the details can then be located using these minor control points by running minor traverses.
The idea of working in this way is to prevent the accumulation of errors and to control and localize minor errors which, *otherwise*, would expand to a greater magnitude if the reverse process is followed, thus *making the* work uncontrollable at the end.



Principle of Surveying

2.Fixing a point with reference to other two points

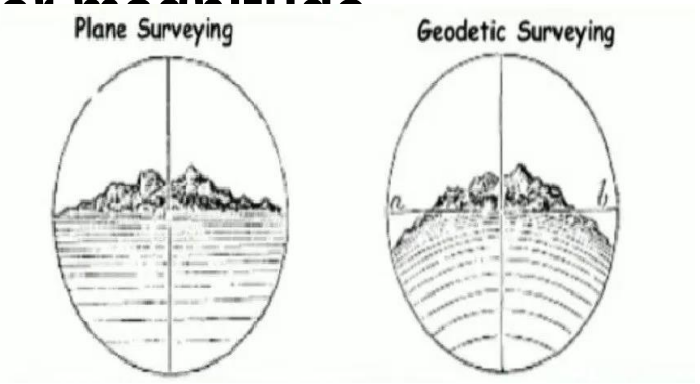
Let A, B be the reference points on the ground then, any other point C can be located by taking two linear measurements, one linear and one angular measurement or two angular measurements



Classification of Surveying

Plane surveying
In plane surveying, the mean surface of the earth is considered as plane and spherical shape is neglected. The error caused by assuming the earth to be a plane area is not serious if the area measured is small, say within 250 square km.

Geodetic surveying
In geodetic surveying, the curvature of the earth is considered. Geodetic surveys are conducted with a high degree of accuracy for works of larg

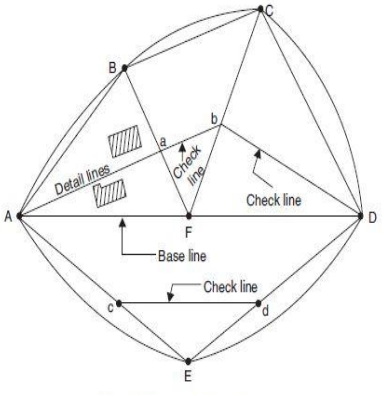


Surveying is further classified depe

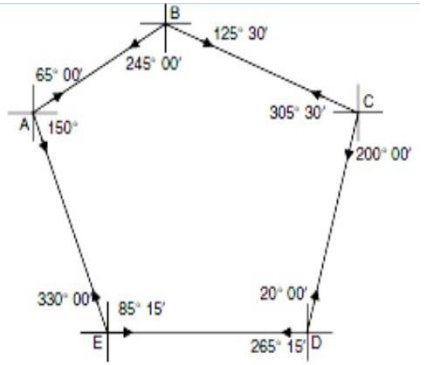
i)Nature of survey field. ii) Frame
iii) Instruments usediv) Purpose of s

Classification of Surveying: Based on Instruments used

Chain survey
In chain surveying, only linear measurements are made in the field, the principal equipment being the measuring chain. This method is well suited to relatively small areas with simple details.

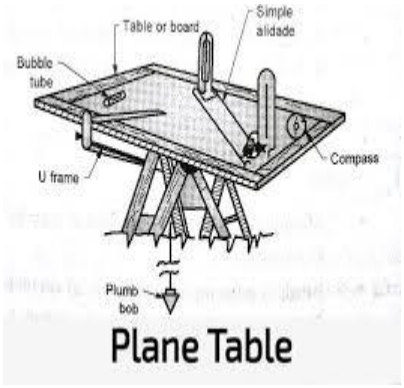


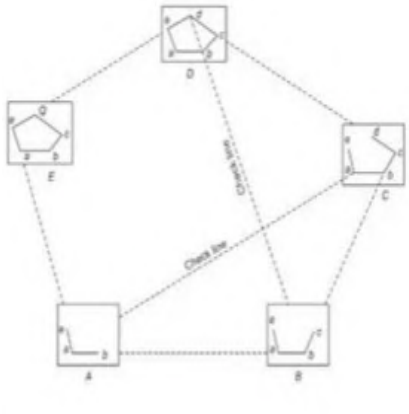
Compass survey
In compass surveying, directions of survey lines are determined with a magnetic compass. A chain or tape is used for linear measurements.



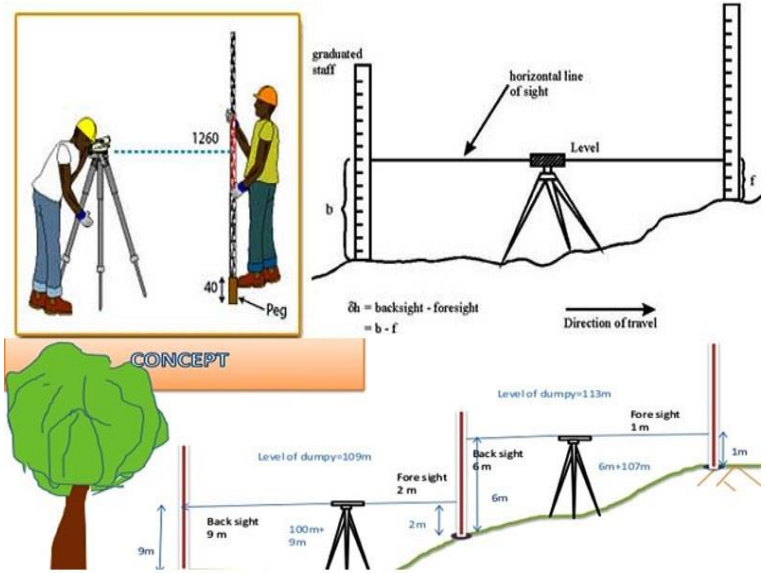
Classification of Surveying: Based on Instruments used

Plane table survey
It is a graphical method of survey in which field observations and plotting proceed simultaneously.





Levelling
This is a method of surveying in which the relative vertical heights of the points are determined by employing a level and a graduated staff.



Classification of Surveying: Based on Instruments used

Theodolite survey
In this survey theodolite is the main instrument used. It is used for measuring both horizontal and vertical angles. Distances and altitudes arc computed later

Tachometric survey
This is a rapid and economical surveying by which the horizontal distances and the differences in elevation are determined indirectly using a theodolite and a graduated rod.

Photogrammetric survey
In this, features on the surface of the earth are located by measurements from photographs taken from sky using aircrafts.

Total station surveying
Electronic survey equipment to perform horizontal and vertical measurements. Latest method of surveying.

Classification of Surveying: Based on Purpose of survey

Engineering survey
Surveys which are done to provide sufficient data for the design of engineering projects such as highways, railways, water supply, sewage disposal, reservoirs, bridges etc., are known as engineering surveys.

Military survey
Surveys have a very important and critical application in military. They provide strategic information that can decide the course of the war. Aerial and topographical maps of the enemy areas indicating important roads, airports, factories, missile sites, anti-aircraft positions and other topographical features can be prepared.

Mine survey
Mine Surveys are directed towards the exploration of mineral deposits and to guide tunneling and other operations associated with mining.

Classification of Surveying: Based on Purpose of survey

Archeological survey
These are done to unearth the relics of antiquity, civilizations, kingdoms, towns, forts, temples etc ., buried due to earthquakes, landslides, or other calamities and are located, marked and identified.

Geological Survey
These are done to determine different strata of the earth's crust and other geological features They are also used for geographical exploration.

BUILDING MATERIALS

Concrete is the most consumed material on earth, second only to **water**

Why has concrete been so popular ?

- Can be fabricated practically anywhere.
- Can be moulded and cast into a wide range of shapes and geometries.
- Is relatively cheap.

Cement

Cement is a binder, a substance that sets and hardens independently, and can bind other materials together.

L. J. Vicat: Prepared artificial hydraulic lime by calcining an intimate mixture of limestone (chalk) and clay – principal forerunner to Portland Cement

1824 – Joseph Aspdin, while obtaining a patent for his hydraulic cement, termed it as Portland cement, upon Portland stone (limestone from Dorset, UK), which had a high quality and durability and a similar appearance – 'Proto' Portland cement

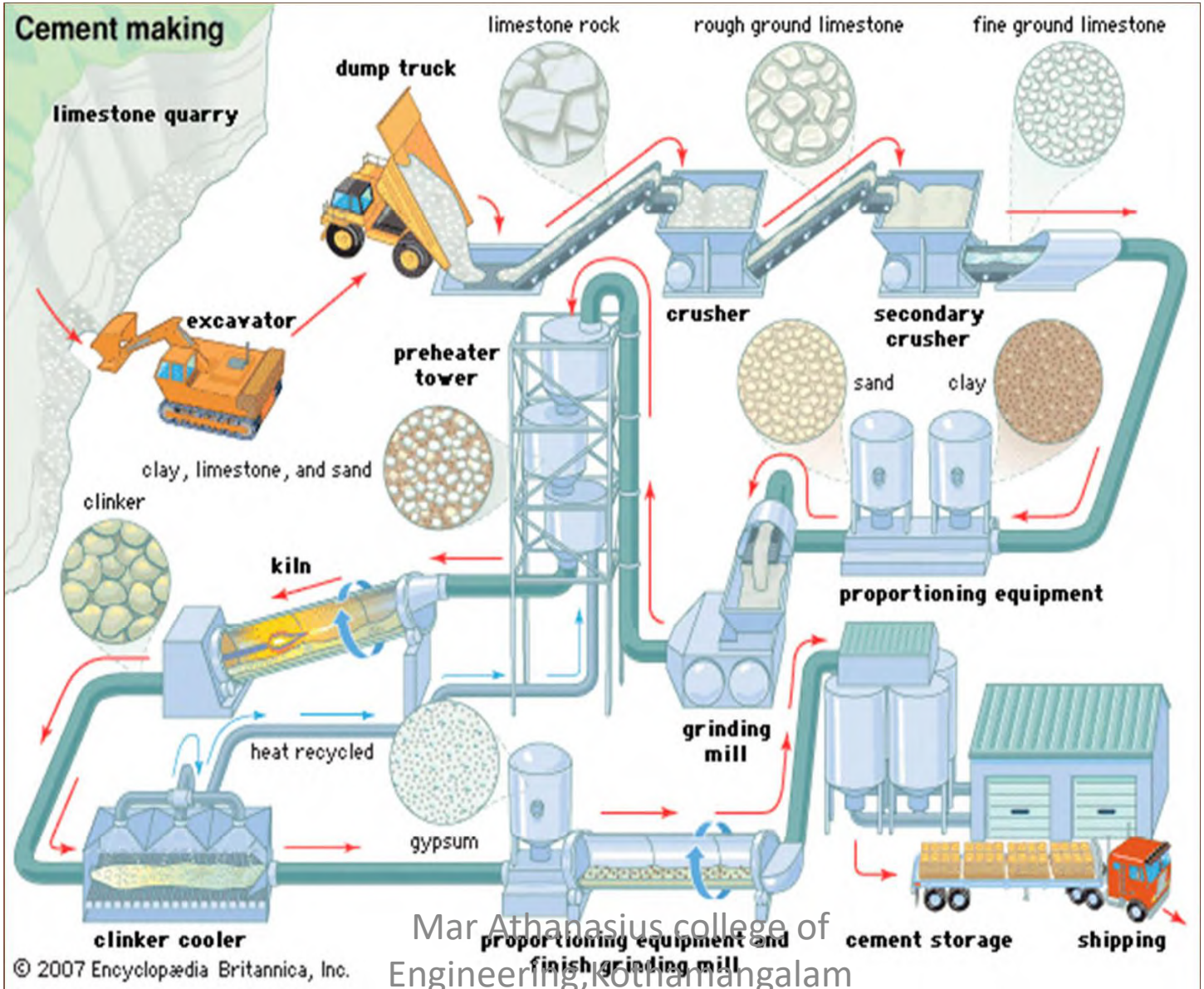
Raw Materials for Cement

Calcareous material – Containing $CaCO_3$ (primary source – limestone); impurities such as iron and alumina are sometimes present

Argillaceous material – Containing clayey matter, source of SiO_2, Al_2O_3

Gypsum – Added in the final stages of manufacture as a set regulator

Cement Production



Cement Composition

Bouge's chemical composition: **The raw materials used for the manufacture of cement consist of lime, silica, alumina and iron oxide. These oxides interact with one another in the kiln at high temperature to form more complex compounds**

C3S-leads to early strength
C2S-hydrates slowly and contribute to progressive strength
C3A-responsible for initial setting and early hardening thus contribute to early strength within 24hrs
C4AF-combines with C3A and water to produce hydrated products

Physical and chemical properties of cement

Physical

1. The color of OPC should be uniform.
2. Cement should be free from lumps
3. Cement should be cool when felt with hand
4. If a small quantity of cement is thrown in to a bucket of water, it should sink
5. Average compressive strength of cement mortar cube should not be less than 11.5 N/mm^2 at the age of 3 days and 25 N/mm^2 at the age of 7 days
6. Initial setting time of cement should not be less than 30 minutes and final setting time should not be more than 10 hrs(600 minutes)
7. Fineness of cement should be less than 10 percent in sieve test
8. Soundness of cement by Le-Chatelier test should be less than 10 mm

Grades of Cement

Cement is classified into various grades according to its compressive strength.

Currently there are three grades of cement, designated as grade 33, grade 43 and grade 53 .The number in the designation denotes the compressive strength in N/mm2 at 28 days of curing

Types of Cement

i) Rapid Hardening Cement

It develops strength more rapidly and hence the name.

The increased rate of gain of strength is due to more fineness, higher percentage of C_3S and lower percentage of C_2S compared with ordinary Portland cement.

Rapid hardening cement is best suited in situations where early attainment of strength is desirable like repairs to bridge decks, roads and manufacture of precast products.

ii) Low heat Portland Cement

The considerable amount of heat liberated during hydration of cement may lead to harmful effects like serious cracking in the case of mass concreting such as dams, bridge abutments and retaining walls.

For this reason it is necessary to limit the rate of heat evolution of the cement used in such structures. The same can be achieved by reducing C_3A and C_3S and increase in the C_2S content in the cement.

The rate of increase in compressive strength is slow and hence not used for structures where early removal of shuttering is needed.

Types of Cement

iii) Portland Pozzolana Cement (PPC)

Pozzolana means a siliceous material (powdered brick or roof tile), which is cementitious.

The pozzolana content varies from 20 to 25% by weight of cement.

It is produced by grinding together Portland cement clinker and Pozzolana .

Portland Pozzolana cement produces less heat of hydration and offers better resistance to chemical attack.

PPC being finer than OPC and due to be pozzolanic action, it improves the pore size distribution and thus reduces the mirocracks.

The long term strength of PPC is higher than that of OPC if enough moisture is available for contained pozzolanic action. But the setting time is normally.

It is particularly useful in marine constructions and mass concreting. Production cost of pozzolana cement is less than opc.

Types of Cement

iv) Portland Slag Cement

Slag is a waste product of steel industry.

This cement is produced by grinding cement clinkers and granulated blast furnace slag (not more than 65%) with gypsum.

The Strength gain is slow and requires longer period of curing .It generates less heat of hydration & has better resistance to attack, by alkalis and sulphates.

It is suitable for mass concrete work and constructions in marine environment.

v) High Strength Ordinary Portland Cement

The higher strength is obtained by increasing the content of C3S and increasing the fineness.

It has properties similar to that of ordinary Portland cement except in compressive strength.

This is specially used for prestressed concrete, railway

Types of Cement

vi) Quick Setting Cement

Quick setting is achieved by reducing gypsum during the manufacture of ordinary Portland cement.

As it sets quickly, it is ideal for underwater construction and grouting.

vii) Hydrophobic cement

The ordinary cement clinker is ground with water repelling substances such as oleic acid and stearic acid.

These substances form a thin film around cement grains preventing moisture attack hence it can be stored and used in the region of very heavy rainfall and high humidity.

When water is added to hydrophobic cement, the films are torn off from the surface of particles and they do not prevent the normal hardening of cement.

However , in the initial stage the gain in strength is less as hydrophobic film prevents the interaction with water but

Types of Cement

viii) Expansive cement

Ordinary Portland cement shrinks slightly during setting and drying

Expansive cement is produced by adding an expanding medium like sulphoaluminate and stabilizing agent to the ordinary cement .

It is used for the construction of water retaining structures, 'foundation, grouting of pre-stressed ducts and for rehabilitation works.

ix) Coloured cement

Cement of desired colour may be obtained by adding pigments with ordinary cement.

The quantity of pigments varies from 5% to 10 %.

The coloured cement are widely used for finishing floors, external surfaces, artificial marble

Aggregate for concrete

Quarried material is crushed or mined and sorted.

Aggregates may be washed before

Aggregate Production

Mining or
Excavation

Fractioning

Stockpiling

Role of Aggregates in Concrete

60-80% of the volume of concrete is occupied by aggregates.

Main significance:

- Cost
- Dimensional stability
- Strength and stiffness
- Abrasion resistance

Classification of Aggregates

Grain size ranges:

- Fine aggregate: 60 µm – 4.75 mm
- Coarse aggregate: > 4.75 mm

Roundness:

- Well-rounded is better (improves packing and workability)

Crushing strength and Modulus of elasticity:

- Higher the better; should be considerably higher than the values expected in concrete

Sand or fine aggregate

Sand is a fine aggregate which is used in mortars and concrete

(a) Natural sand: The fine aggregates formed by natural disintegrate of rocks and deposited in the beds of steams, rivers and glaciers are called natural sand

(b) Crushed stone sand: The fine aggregates made by crushing natural gravels are called crushed stone sand

Sand or fine aggregate

Fine aggregate (sand) is available from these sources.

- River sand: This is obtained from riverbeds and riverbanks. This sand is bright and clear and consists of sharp or rounded particles. This sand is considered to be the best suitable sand for making mortar. Its interlocking value is less since it has more round corners. More suitable for plastering work.

- Pit sand: This sand is obtained from pits dug at depth of 1.5 m to 2m in the soil. The particles are sharp, angular porous and free from harmful salts.It is suitable for making mortar.

- Sea sand: This is the sand available in seashores.This sand is brown in colour consists of rounded particles, Generally this sand also contains objectionable salts. So it is not recommended tor construction. The salt present inthis sand absorb moisture from atmosphere and cause dampness.

Qualities of good sand

It should contain quartz of white or light gray colour and free from silt.
It should pass through 2mm I.S. sieve and retained on 90 micron I.S sieve.
It should be free from all organic matter.
Loss of weight due to ignition should be less than 0.25% .
It should be free from hygroscopic salts.
It should have coarse, angular, hard and sharp grains.
It should be chemically inert.
It should be strong and durable.

Manufactured Sand in Concrete

Manufactured sand – aggregate material less than 4 mm in size, processed from crushed rock or gravel

Advantages	Disadvantages
Less prone to bleeding and segregation	Higher need for vibration due to higher cohesion
High fines content gives good finish	Higher wear on equipment due to abrasion
Cheaper	Difficult to control fines content

CONCRETE

Concrete may be defined as a building material obtained by mixing cement, aggregates and water in suitable proportions which when allowed to cure, becomes hard like a stone

The proportion of the ingredients varies with the nature of work for which the concrete is to used.

It can be readily moulded into durable structural items of various sizes and shapes.

It is possible to make economical concrete mix by using locally available raw materials.

Careful supervision is required for getting the

Plain Cement Concrete

Plain Cement Concrete (PCC)
Concrete formed by using cement, coarse and fine aggregates and water is called plain cement concrete.
It is used, in structural members subjected to pure compression and for floorings, foundations etc.

Reinforced cement concrete

Reinforced cement concrete (RCC)
Concrete is weak in tension, but steel is strong in tension.
Hence steel road are introduced in the cement concrete members in the places where tensile stresses are developed.
Concrete thus prepared with steel reinforcement is called RCC.

Ingredients of Concrete

There are three ingredients which make up the composite mixture of cement concrete.

i) Cement
ii) Aggregates
iii) Water

i) Cement

Generally ordinary Portland cement conforming to Indian Standard specification is used for preparing concrete. But other special varieties of cement are used under certain circumstances.

ii) Aggregates

These are inert or chemically inactive materials which form the bulk of cement concrete. These are bound together by means of cement.
There are two types of aggregates, the coarse aggregates (crushed stone) which form the main matrix and the fine aggregates which form the filler matrix between the coarse aggregates.

The aggregates should be clean, free from organic matter and other impurities.
They must be sound and resistant to weathering action. Aggregates should be well graded for obtaining good quality concrete.

iii)Water

The quality of water used in concrete is important because impurities in it may interfere with the setting of the cement, adversely affect the strength of the concrete or cause staining of its surface and may also lead to corrosion of the reinforcement.
Generally, water fit for drinking is found safe.
The quality of concrete depends upon the amount of water used.
The presence of various salts in sea water adversely affect the qualities of concrete and hence it is not used without treatment .

Properties of Concrete

The properties of green concrete include:

Workability, Segregation and Bleeding

The properties of hardened concrete are:

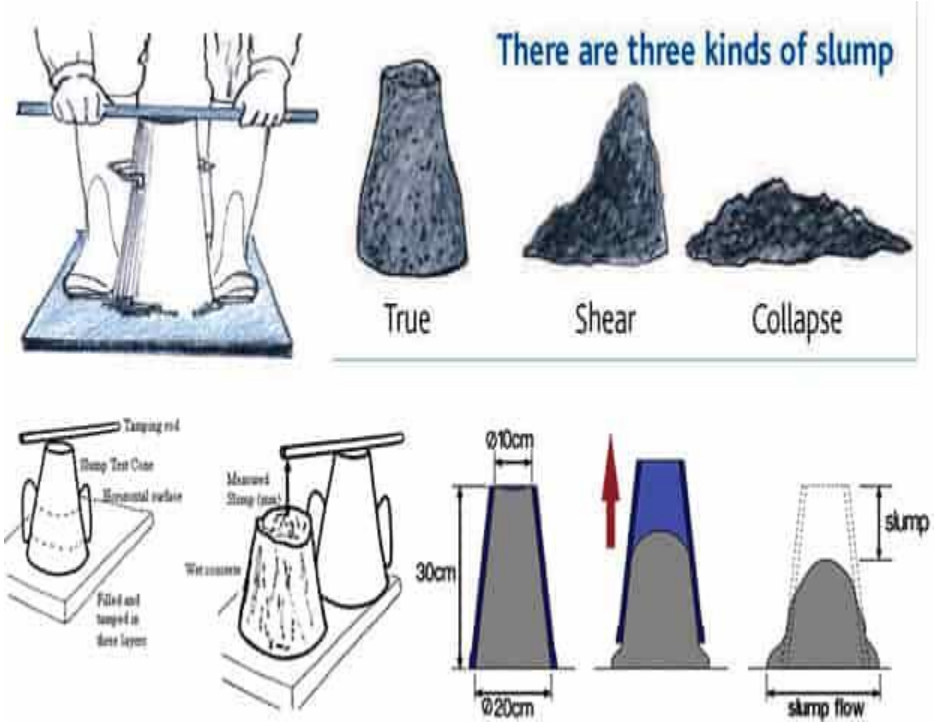
Strength, Resistance to wear, Durability, and Impermeability.

Workability

The ease with which concrete can be mixed, placed and compacted

Depends on

- Water cement ratio
- Aggregate properties
- Time after mixing
- Admixtures



Slump test

Grades of Concrete

Indian Standard (IS 456:2000) specifics grades of concrete designated as given in Table 4 1.

In the designation of concrete mix, M refers to the mix and the number refers to 28 days compressive strength of 150 mm size cube expressed in N/mm2

M 10 and M 15 grades are used for plain concrete.

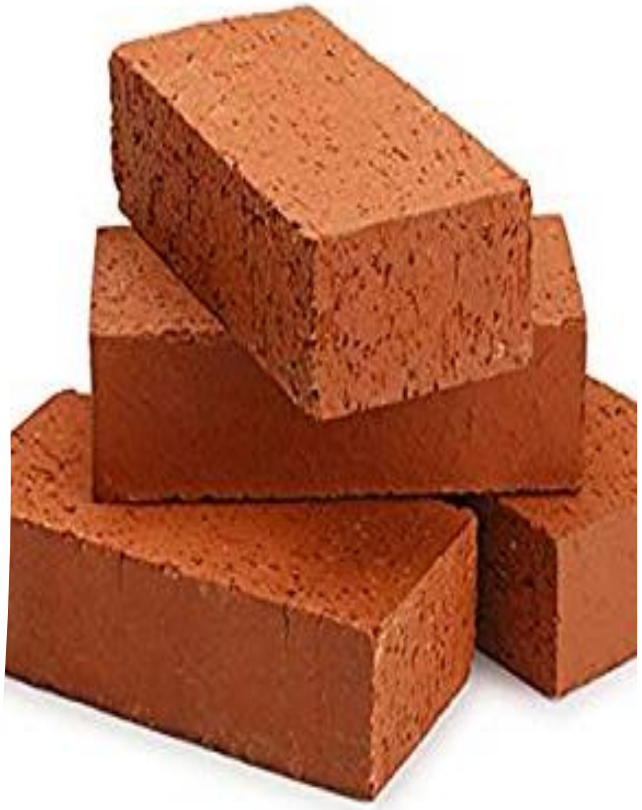
M 20 and M 25 for reinforced concrete structures and higher grades for prestressed concrete structures.

Grades of Concrete

Grades of concrete	Proportion of concrete (by volume)	Strength at 28* Day (N/mm)	Uses
M 10	1:3:6	10	Mass concrete works like culverts and retaining walls.
M 15	1:2:4	15	Plain cement concrete works
M 20	1:1.5:3	20	For general RCC works in buildings such as slabs, beams.
			columns, stairs, machine foundations,piles etc.
M 25	1:1:2	25	Water retaining structures, piles, precast products etc.
M 30	Design mixes	30	Heavily loaded RCC columns and arches of long spans.
M 35onwards		35onwards	For prestressed concrete works.

BRICKS

Brick is the commonly used building material in India.
It is light, easily available, uniform shape and size , and relatively cheaper
Bricks are easily moulded from plastic clays, also known as brick clay or brick earth.



Classification of Bricks

Bricks are broadly classified as unburnt (or) sun-dried bricks and burnt bricks.
Unburnt bricks are dried with the help of heat received from sun after moulding, can be used only for temporary and cheap construction. These are also called sun-dried bricks. The bricks used in construction works are burnt bricks and they are classified into the following four categories.

First class bricks: **These bricks are table moulded and edges are sharp, square, smooth and straight. These bricks are used for superior works.**
Second class bricks: **These bricks are ground moulded. The surfaces are not**

Third class bricks: **These bricks are ground moulded; they have rough surfaces with irregular and distorted edges. They are not hard and are used for unimportant and temporary constructions.**

Fourth class bricks: **These are over burnt bricks, dark in colour and irregular. These are used as aggregates for concrete in foundation, floors, roads etc.**

Size and Weight of Bricks

190 mm x 90 mm x 90 mm. (Standard size)
With mortar thickness, 190 mm x 90 mm x 90 mm brick becomes 200mm x 100mm x 100mm and is known as the nominal size of the modular brick.
The average weight of a brick is about 3 to 3.5kg.

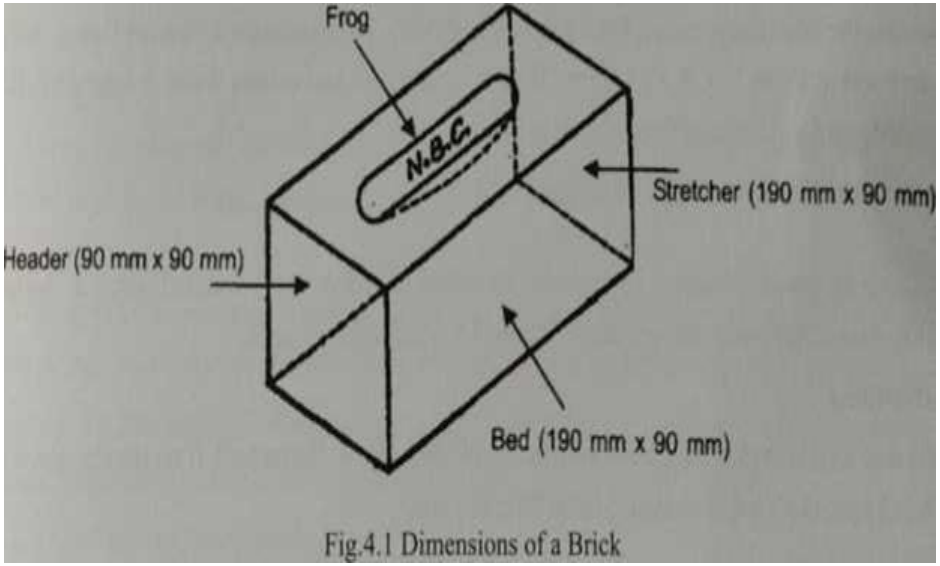


Fig.4.1 Dimensions of a Brick

Properties and Specifications

Bricks are generally subjected to the following tests to find out their suitability for construction work.

1. **Compressive strength**
2. **Water Absorption**
3. **Hardness**
4. **Shape and size**
5. **Efflorescence**
6. **Soundness**
7. **Warpage**

Qualities of Good Bricks

The bricks should be table moulded, and well burnt in kilns.

Bricks should be copper coloured with sharp and square edges.

Bricks should be of standard size and shape.

Brick should give a clear metallic ringing sound when struck with each other.

The bricks, when broken should show a bright homogeneous and compact structure.

Water absorption after 24 hours immersion should not exceed 20% by weight for first class bricks and 22% by weight for second class bricks.

Qualities of Good Bricks

The bricks should be sufficiently hard.

The bricks should not break into pieces when dropped flat on hard ground from a height of about 1 m.

The bricks should have low thermal conductivity.

Crushing strength of brick should not be below 10.5 N/mm2.

Bricks should be sound

Bricks when soaked in water for 24 hours, should not show deposits of salts when allowed to dry in shade.

STONES

Building stones
Building stones are mainly obtained from rocks in the nature.
The basic classifications of rocks with examples are given below

- **Igneous rocks: Granite, Basalt & Trap**
- **Sedimentary rocks: Laterite, Sandstone, Limestone & Shale**
- **Metamorphic rocks: Slate, Quartzite, Marble & Schist**

Chemical classification

Siliceous rocks: **In these rocks, silica is the predominant matter. These rocks are hard and durable. They are not easily affected by weathering agencies. Silica, however, in combination with weaker minerals may disintegrate easily. Rocks with maximum amount of free silica make them hard and durable. Granites, quartzite, etc are examples of siliceous rocks**

Argillaceous rocks: **In these rocks, clay predominates than other components. Such rocks are dense and compact or they may be soft. Slate, laterites, etc are examples of siliceous rocks.**

Calcareous rocks: **In these rocks, calcium predominant matter. The durability of these rocks depends upon the constituents present in the surrounding atmosphere. Limestone, marbles, etc are examples of calcareous rocks.**

Physical classification

Stratified rocks

These rocks have planes of cleavage or stratification and can be easily split up along these planes, Sedimentary rocks are stratified rocks.

Un-stratified rocks

These rocks are crystalline granular or compact granular and no stratification. Igneous rocks are un-stratified rocks.

Foliated rocks

These rocks have the tendency to be split up in definite direction only. Metamorphic rocks are foliated

Qualities of good building stones

A good building stone should have a minimum crushing strength (compressive strength) of 100 N/mm^2
It should have sufficient hardness. (i.e a minimum coefficient hardness of 14)
It should have high resistance to wear and tear.
The specific gravity of good building stone should be greater than 1.
It should have a high impact value (i.e toughness index should be greater than 13)
It should not absorb water. The percentage of water absorption after 24 hours should be less than 0.6 %.
Suitable texture for carving and dressing.
It should be durable. Igneous and metamorphic stones are more durable than sedimentary stones.
Good crystalline structure and better appearance.
It should have good resistance against weathering agenciec like rain, frost and wind etc.

Common Building stones

Granite: Granite is an igneous rock and is hard and durable. Most of these rocks possess excellent building properties, like high strength, very low abrasion value, good resistance to frost and other weathering agencies, and are available in different appealing colours.

Uses: It is used for facing work, walls, bridge piers, columns, steps etc. It is used where weight and durability are essential

Laterite: Laterite is a sedimentary rock found in hot and wet tropical areas which is enriched in iron and aluminum and developed by intensive and long lasting weathering of the underlying parent rock. Laterite stones are mainly used for masonry

Common Building stones

Limestone: They are sedimentary rocks composed mainly of calcium. They are rarely useful as building stones.

Uses: They can be used as road aggregate for construction floors, steps, walls. etc.

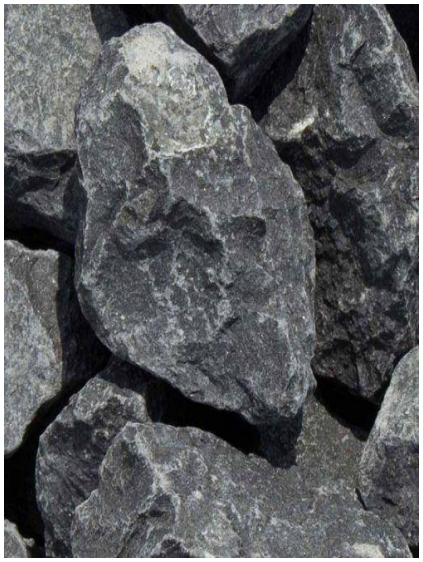
Sandstone: These are sedimentary rocks and consist mainly of quartz. Sandstone occurs in many colours. The most suitable and durable type is that which is light coloured, having silica and a homogeneous compact texture.

Uses: It can be used for steps, flooring, columns, etc

Common Building stones

Marble: These are metamorphic rocks and have been formed from limestone under high temperatures. Marbles vary greatly in colour, structure and texture.

Uses: Marble is used both as an ornamental stone and as a constructional material. As these stones can take brilliant polish, are used extensively for flooring.



Basalt and Trap: These are igneous rocks and generally heavier and darker than granites and also stronger, but may contain cavities and pores within them.

Uses: They are extensively used for rubble masonry

Common Building stones

Slate: Slate is a metamorphic rock and splits into thin sheets

Uses: In building construction, its use is limited to roofing purpose for ordinary buildings or as paving stone or as insulating materials.

Gneiss: Gneiss is a metamorphic rock and closely resembles granite and road construction. But, sometimes it may be rich in mica and useless as a building stone.

Uses: They can be used for street paving rough stone masonry work.

Quartzite: Siliceous sand stones under the action of metamorphism yields quartzite. It is very dense and strong stone with crystalline structure.

Uses: It is used in rubble masonry and as aggregate for concrete.

TIMBER

- **Wood is a naturally occurring, biological material. It is probably the world's oldest structural material.**
- **Since it is easy to produce and handle, it is a widely used construction material.**
- ***The annual production of wood is about 1 billion metric tons.***
- **Wood has good structural properties, is aesthetically appealing and relatively cheap. Though it is vulnerable to fire and decay through biological attack, it can last for a long time if properly maintained.**

Wood Species

Trees are divided into two broad classes:

- Hardwoods: Tropical, broad-leaved, deciduous (shed leaves annually), porous (contain vessel elements). Examples: Teak, Sal, Oak.
- Softwoods: Conifers, have needle- or scale-like evergreen leaves, non-porous. Examples: Fir, Pine, Cedar.

Some Common Indian species:

- Teak: Good dimensional stability and natural durability. Heartwood varies from yellow-brown to dark golden-brown.
- Padauk: Medium density hardwood. Deep red/orange in colour.

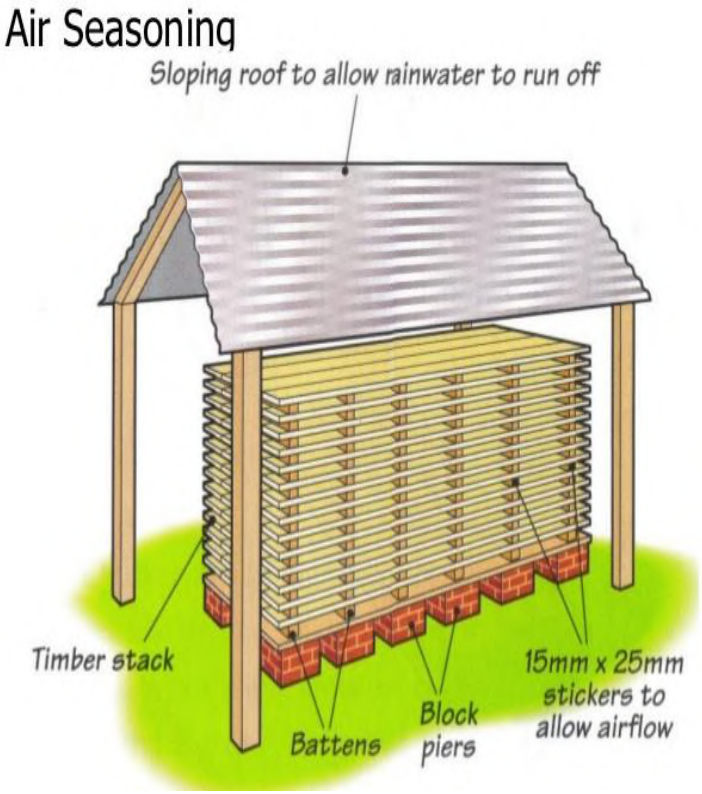
- Rubberwood: Light hardwood. Seasons to light brown.
- Sal: Strong and hard wood. Dark brown in colour.
- Deodar: Light and durable. Light brown in colour.
- Rosewood: Heavy wood with high strength. Heartwood varies in colour from golden brown to dark purplish brown.

Seasoning of timber

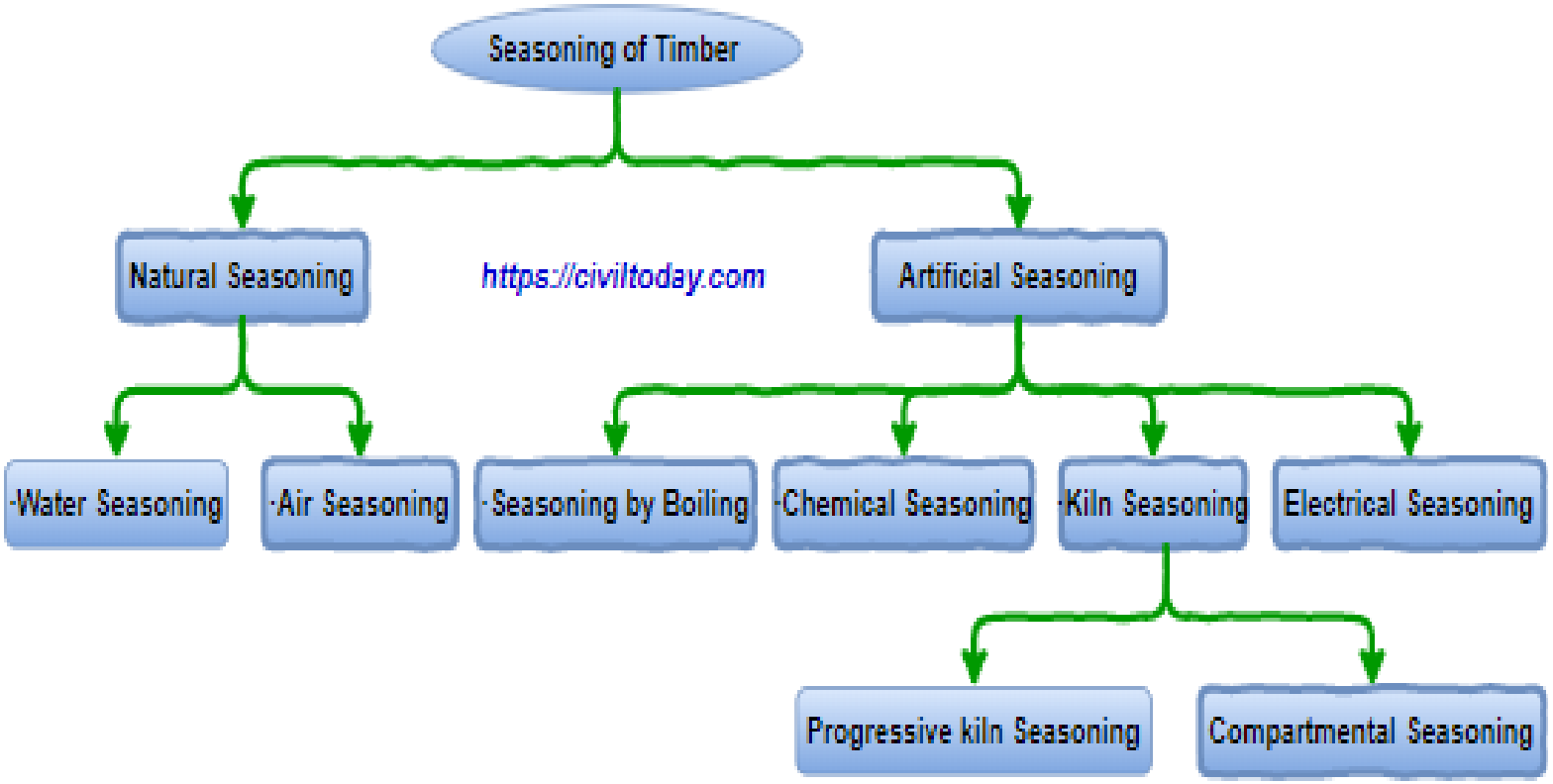
The fresh timber contains about 50% or more of its own dry weight as water.

The water is to be removed before it used for any engineering purposes.

The process of drying/ reducing the moisture content of timber is known as seasoning of timber. The moisture content should be reduced under controlled conditions, at a uniform rate from all parts of the timber.



Seasoning methods



Objects of seasoning

To impart hardness, stiffness, strength and better electrical resistance to timber.
To increase the resisting power of timber.
To maintain the shape and size of the components of the timber article which are expected to remain, unchanged in form.
To decrease weight of timber and thereby to reduce the cost of transportation and handling.
To make timber easily workable and to facilitate operations during conversions.
To make timber suitable for receiving treatment of paints, preservatives. varnishes, etc.
To make timber safe from the act of fungi and insects.
To make suitable for joinery works.
To reduce the tendency of timber to crack, shrink and warp.

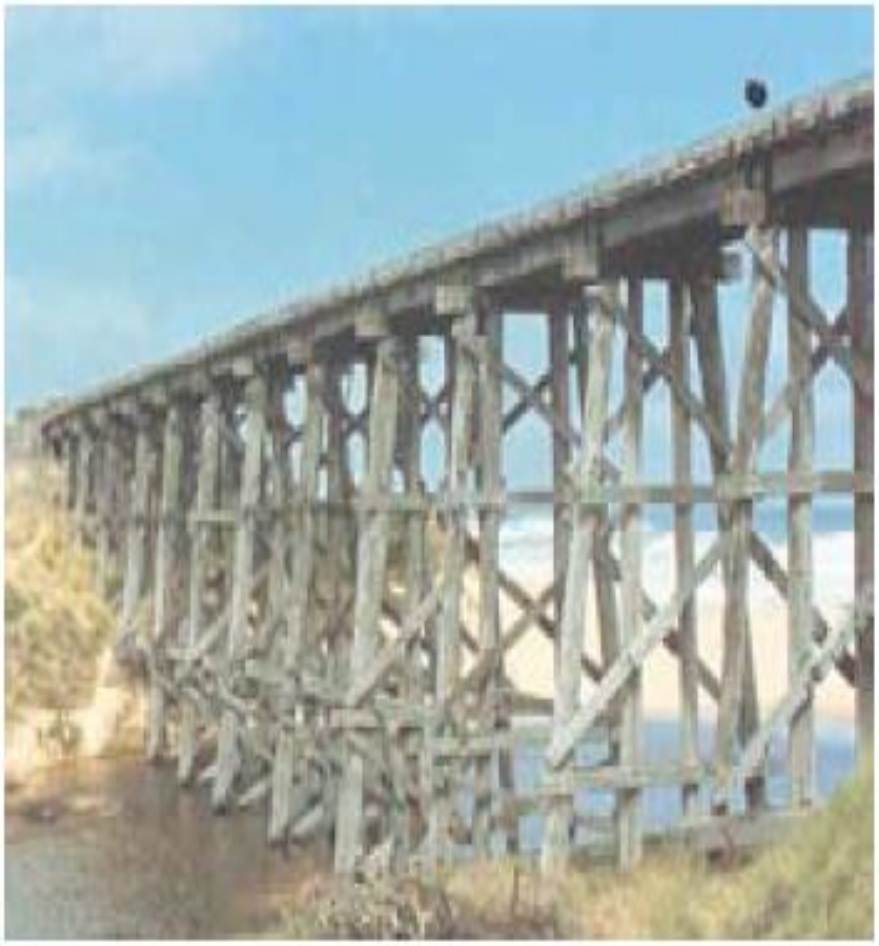
Applications of Timber

Commercial buildings

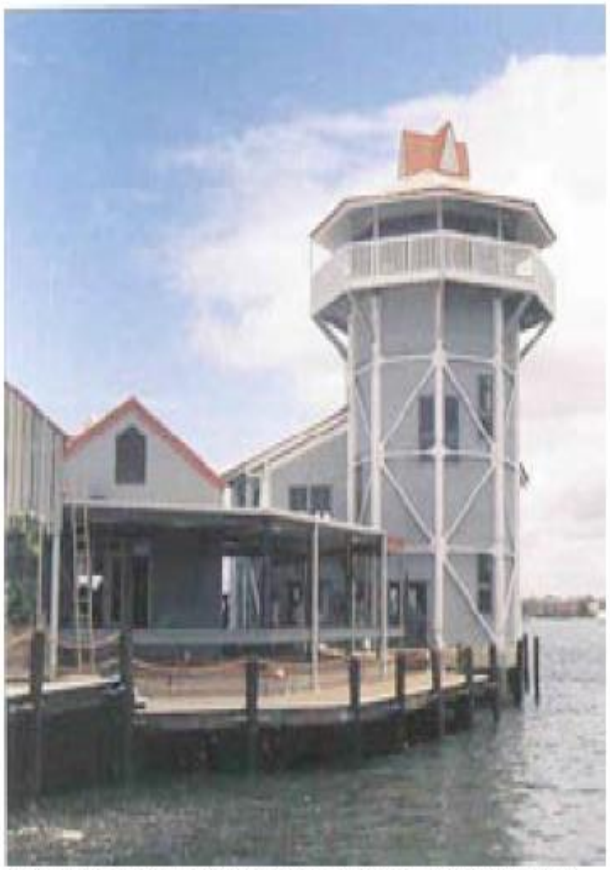
USDA

Applications of Timber

Bridge



Applications of Timber



Buildings and wharf structures must be designed and protected against marine hazards.

Fender piles require protection against marine borers and need high wear resistance.

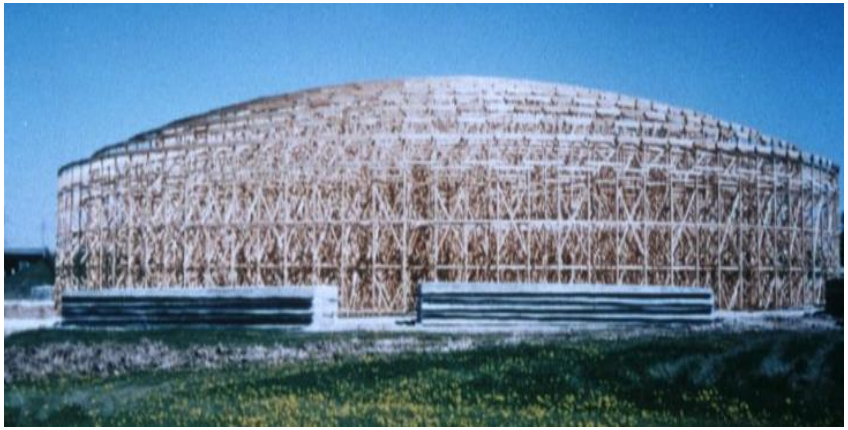
Applications of Timber

Preservative treated softwood decking delivers long-term, excellent performance in weather exposed situations.

PEC-treated utility pole. (Photo courtesy Dr. Harry Greaves)

Applications of Timber

Formwork and scaffolding



Wood-Based Composites

Glued-Laminated Timber (Glulam)

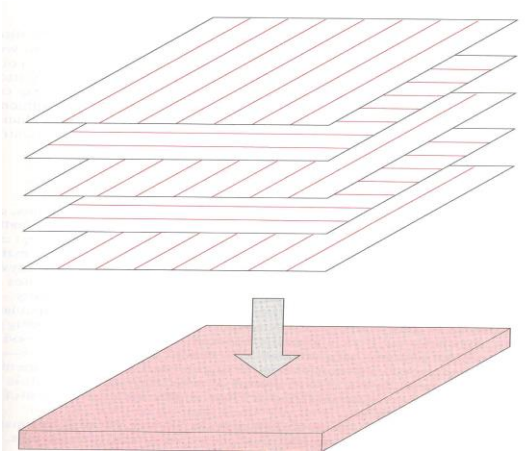
- Timber manufactured by gluing together a large number of relatively short pieces of timber.

Figure 11–3. Erected in 1934 at the Forest Products Laboratory in Madison, Wisconsin, this building is one of the first constructed with glued-laminated timbers arched, designed, and built using engineering principles.

Young et al., USDA

Wood-Based Composites

Plywood



Panels or sheets made from wood by gluing together thin veneers in layers. The layers are placed such that the grains of the successive plies are at right angles to each other.

Particle Board

- Chips are soaked in water, dried, mixed with resin and pressed together to form boards.
- Typical particle boards have three layers: the faces consist of fine

Steel

Based on carbon content in iron it can be classified into 3

a) **Wrought iron : carbon content less than 0.15%**
b) **Steel : carbon content between 0.15% and 1.5 %**
c) **Pig iron : carbon content exceeds 0.15% upto 4 %**

Steel is derived from pig iron by reducing the carbon content

Steel

Based on carbon content steel is classified as :

1. **Mild steel : carbon content varies from 0.15% to 0.3 %**
2. **Medium carbon steel : carbon content varies from 0.3% to 0.8 %**
3. **High carbon steel : carbon content varies from 0.8% to 1.5 %**

Steel

Depending on use mild steel is classified as :

- **Reinforcing steel**
- **Structural steel**

Reinforcing steel :

Concrete is week in tension and strong in compression

Steel bars are commonly embedded in concrete subjected to tension these bars are known as reinforcing bars .

Mild steel is commonly used as reinforcing bars as the coefficient of thermal expansion of both steel and

Steel

The commonly used steels are
i) Mild steel conforming to IS 432
ii) High Yield Strength Deformed bars
iii) Thermomechanically Treated (TMT) bars

Mild steel conforming to IS 432
It has definite yield point and plastic strain.
The yield strength is 250 N/mm2 and the steel is called F
which is popularly known as plain bars.
These bars have circular cross section, plain surface, and the bond strength is low.
It is available from 6 mm to 32 mm diameter

Steel

ii)High Yield Strength Deformed bars (HYSD) conforming to IS: 1139 & IS :1786.

High yield strength deformed steel bars have lugs, ribs or deformations on the surface, hence bond strength is more when compared with plain bars.

There are two types of HYSD bars available :

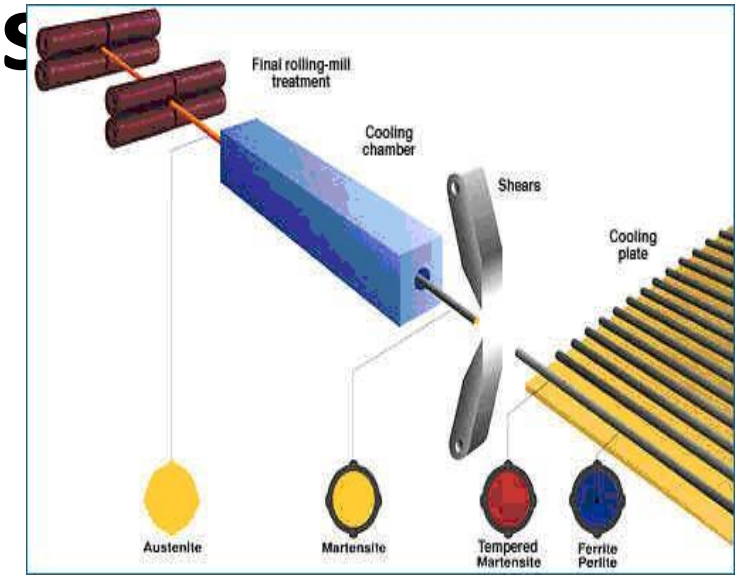
a) Fe-415 grade steel (TOR 40)

b) Fe-500 grade steel (TOR 50)

Steel

They do not have any definite yield point and plastic deformation but decreases ductility.
These bars are formed by either hot rolling or cold twisting of mild steel bars.
HYSD bars are available with a mean diameter of 5 mm to 40mm.
To improve the properties like ductility, fatigue strength and corrosion a new brand steel named Thermo Mechanically Treated steel bar (TMT) has introduced.
Excellent ductility and higher fatigue strength makes it ideally suitable to bear the dynamic and seismic loading during earthquake.
Structural Steel
Steel can be used for construction of structural members like footing, columns, beams,truss etc.
Structural steel is rolled into a variety of shapes and

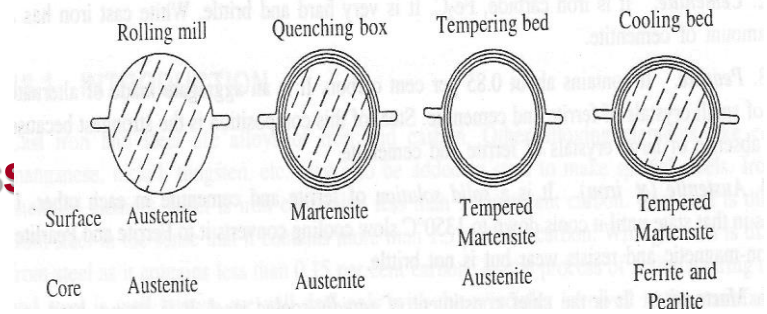
Thermo-mechanically Treated (TMT) or Quenched and Tempered (Q&T) Bars



Grades

Fe - 415, Fe- 500 & Fe- 550

Process



- After hot rolling to the desired size and shape, the low carbon steel bars are quenched with water and then cooled.
- Quenching converts the surface layer to (hard) martensite while the core remains as austenite.
- As the bar cools, heat flows from the core to the surface layer turning it to tempered martensite. The core transforms to ductile ferrite-pearlite

Market forms of steel

i) Rolled steel bar section

(a) Indian Standard Round bars (ISRO)
This type of bar is usually designated by ISRO 10 (Round bar having 10mm diameter). Round bars are available in various diameters like 6mm,8mm, 10mm, 12mm, 16mm,20mm,22mm, 25mm etc., in the market.

b) Indian Standard Square Bars (ISSQ)
ISSQ 10 (square bars of size 10 mm) designates this bar. Bar sections are used as reinforcement, grill for windows, hand rails of stair cases, gates etc. it)

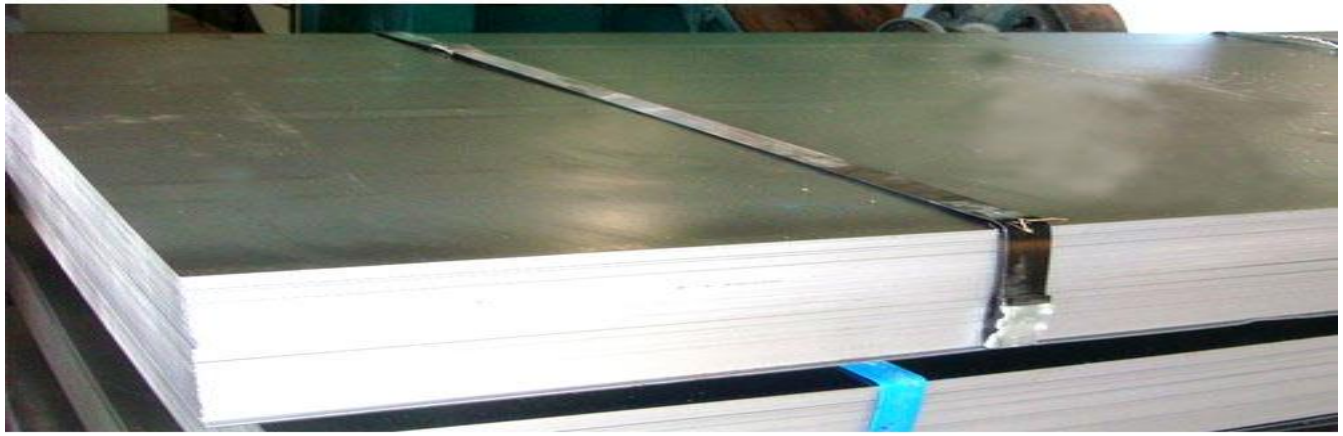
Rolled Steel Plate Section (ISPL)

Rolled steel plate sections are used for the construction of water tanks, and other storage structures (silos, bunkers etc), built up beams, columns, walls, floor panels, base plate foundation etc.

Plate sections are usually designated by ISPL 500 x 5 (500mm width and 5mm thickness).

Indian Standard Sheet Sections (ISSH)

Plates having thickness less than 5mm are called sheet., Sheets arc generally designated by ISSH 1800 x 600 x 4 (sheet section of length 1800mm , breadth 600mm and thickness 4mm).These are widely used for the construction of boxes and vehicle bodies.

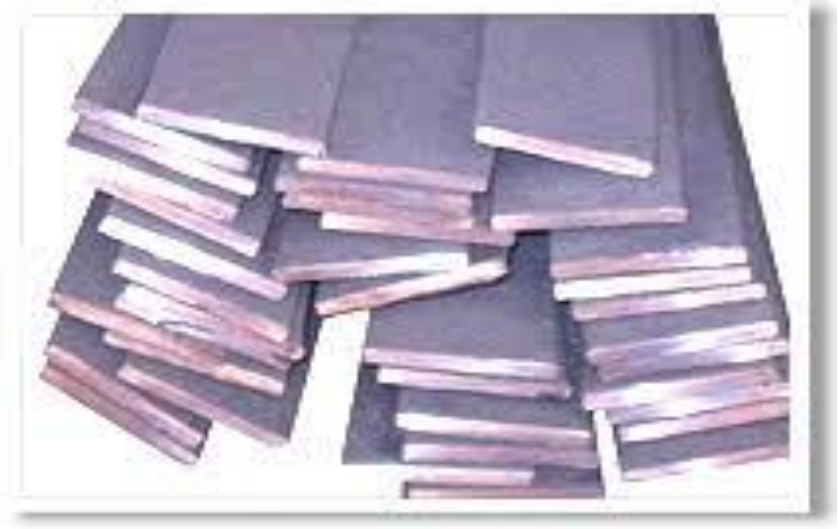


Indian Standard Strips (ISST)

They are designated as ISST 100 x 2 (steel strip with a width of 100 mm and thickness of 2 mm).

Indian Standard Flats (ISF)

Commonly used for the fabrication of steel windows, grills, etc. They are designated by ISF 10 x 3(flats of width 10 mm and thickness 3 mm).



Rolled Steel Tubes

Rolled steel tubes are efficient structural sections for form work and steel trusses. Inner diameter of tube varies from 15 to 150 mm and wall thickness varies from 2 to 5.4 mm

Rolled Steel Angle Section (ISA)

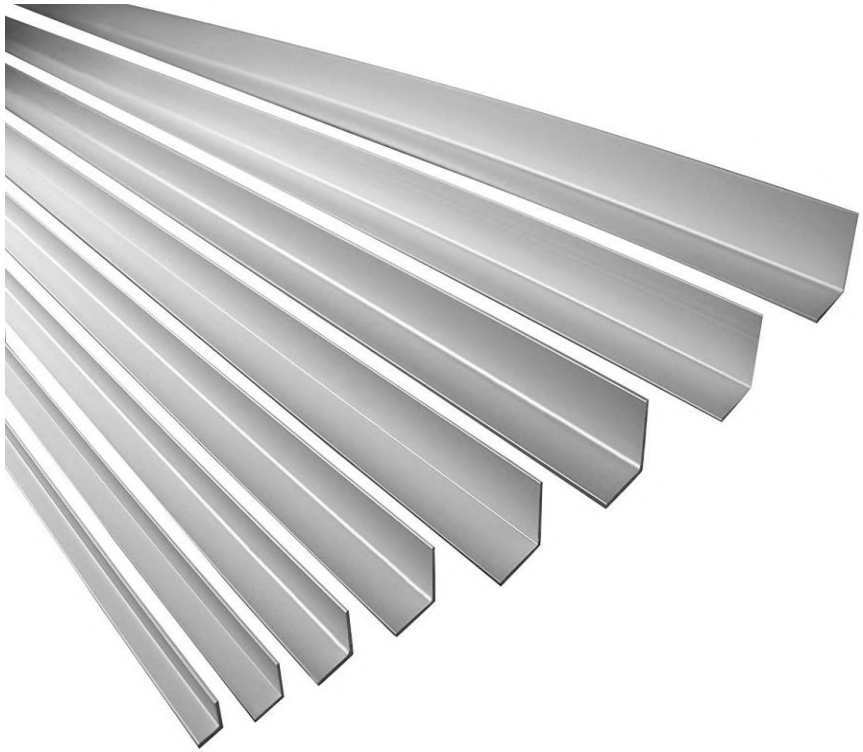
Three series of angle sections are available in the market.

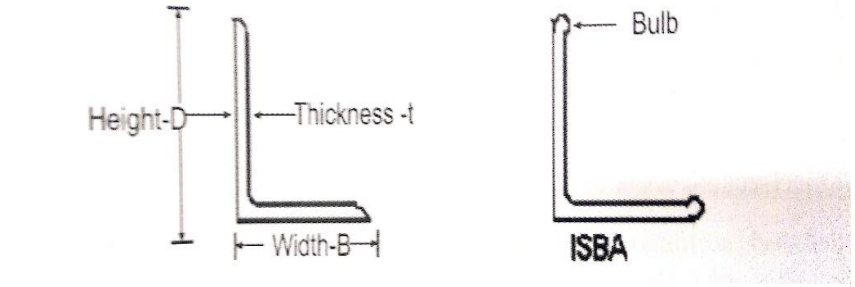
a) Equal Angles (ISA)
b) Unequal Angles (ISA)
c) Bulb Angles (ISBA)

Since equal and unequal angles are designated by the same series ISA, the width and height of legs are mentioned along with the series. Hence equal angles are designated as ISA 50 x 50 x 5mm (height D is 50 mm, width B is 50 mm and thickness t is 5mm) and unequal angles as ISA 60x50 x 5mm (height D is 60mm, width B is 50 mm and thickness t is 5mm),.

Angle sections are extensively used in structural steel works like roof trusses and as connecting member for different structures.


Equal
Unequal




Height-D
Thickness -t
Width-B
Bulb
ISBA

Rolled steel Tee sections
Each Tee sections is designated by the series to which it belongs, followed by its depth in mm, and weight per meter
Indian Standard Normal Tee (ISNT)
Indian Standard Heavy Tee (ISHT)
Indian Standard Short Tee (ISST)
Indian Standard Junior Tee (ISJT)

Mar Athanasius college of Engineering,Kothamangalam

Rolled Steel Channel Sections

Four series of channel sections are mentioned in the Indian Standard Hand Book. Each Channel sections is designated by the series to which it belongs, followed by its depth in mm. Various channel sections available are

Indian Standard Junior Channels (IS JC)

Indian Standard Light Channels (ISLC)

Indian Standard Medium Channels (ISMC)

Indian Standard Special Channels(ISSC)

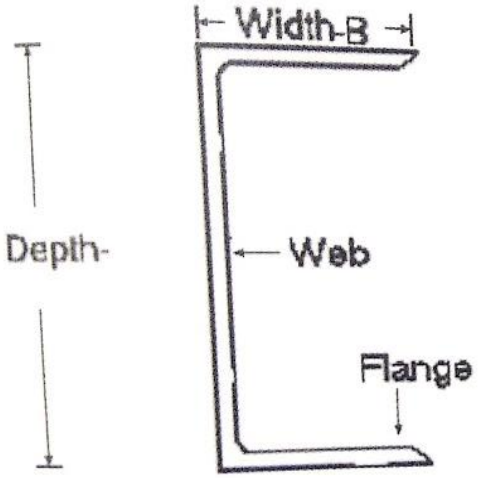
Rolled steel I sections

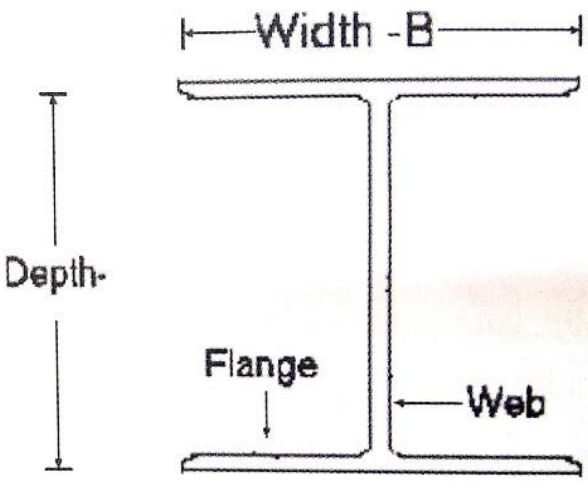
Five series of beam sections are available in the market as

a) Indian Standard Junior Beams (IS JB)
b) Indian Standard Light Beams (ISLB)
c) Indian Standard Medium Beams (ISMB)
d) Indian Standard Wide Flange Beams (IS WB)
e) Indian Standard Heavy Beams (ISHB)

Each beam section is designated by the series to which it belongs followed by the depth in mm of the section.
IS JB 150 refers to Indian Standard Junior Beam of depth 150 mm. Other properties of the sections can be had from the hand book or steel table.
I-sections are the strongest and most economical sections for beams of various types.
These can also be used as columns, purlins in roof truss and for grillage foundation.

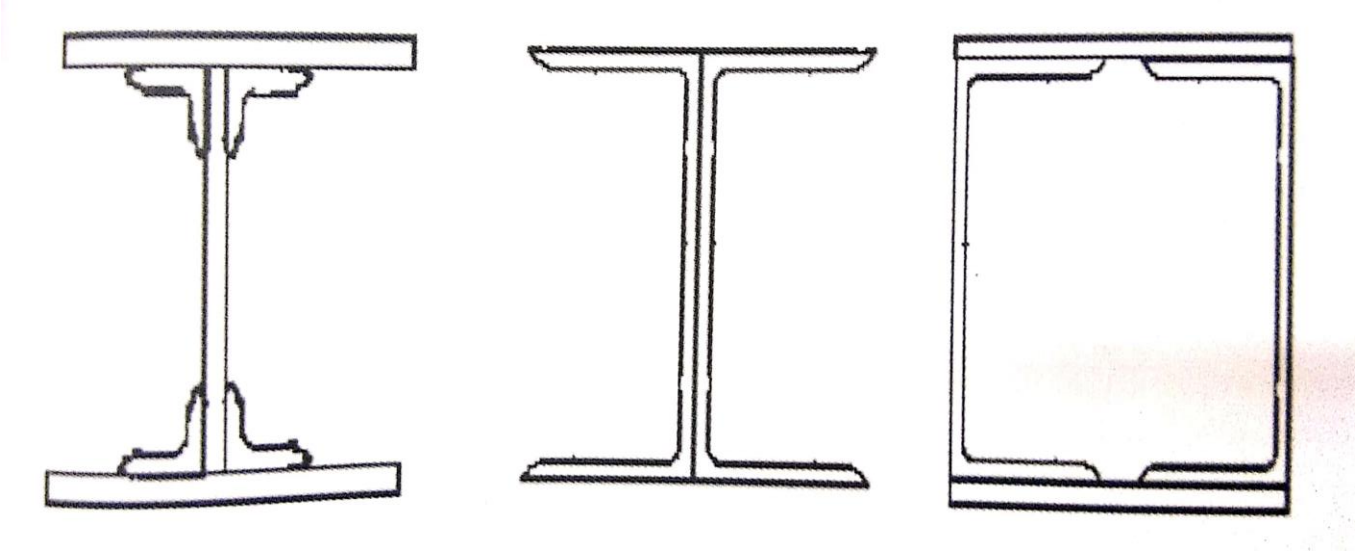
I-Sections





Built up sections

A built up section is one which is composed of a combination of available basic sections like plates, angles, channels etc.



Advantages of Steel as Structural Material

The main ad vantages of steel as structural material are

high strength.

gas and water tight due to high density,

long service life.

can be used in prefabricated members because of the ease of handling, fabrication and erection.

readily dismantled and replaced.

Disadvantages of Steel as Structural Material
Costly
Low fire resistance
Susceptible to corrosion

Outline ……

Foundations
Masonry
Roofing
Flooring
Basic infrastructure services
Green buildings

Foundation

A foundation is the lower portion of building structure that transfers its gravity loads to the earth

The soil /rock on which the foundation rests is called natural foundation or foundation bed and it ultimately bears the load of the structure.

The structural foundation or simply, foundation is therefore the connecting link between the superstructure and the natural foundation (soil).

Objectives/ Functions of Foundation

The objectives of providing foundations are;

- To distribute the total load of the superstructure on a larger area without causing failure of the soil.
- To prevent excessive settlement of the building.
- To provide stability to the structure against various disturbing forces such as wind, rain, earthquake etc.
- To provide a level and firm surface for the construction of the super structure

Foundations design parameters

i. **Bearing capacity of soil**
ii. **Settlement of foundations**

Bearing capacity

The supporting capacity of a soil or rock bed is defined as its bearing capacity. The foundation of any structure transmits the load of the structure to the soil underneath and hence it is highly important to know the strength and behavior of the soil.

Bearing capacity

Ultimate bearing capacity

Ultimate bearing capacity may be defined as the maximum intensity of pressure (maximum load per unit area) which a foundation soil can withstand without the occurrence of failure or excessive settlement.

Safe bearing capacity

It is the maximum intensity of pressure that can be transmitted to the soil without the risk of failure. Safe bearing capacity is obtained by dividing ultimate bearing capacity of soil by a suitable factor of safety.

Safe bearing capacity = Ultimate bearing capacity/Factor of safety

Types of Foundations

Foundations can be broadly classified into shallow foundation and deep foundation.

A foundation is considered to be shallow if its depth is less than or equal to its width (D/B < 1). In the case of deep foundation, depth is greater than its width (D/B >1).

Shallow foundation

Common types of shallow foundations are

i) Wall or strip footing
ii) Isolated footing
iii) Combined footing
iv) Cantilever footing (Strap footing)
v) Raft or mat foundation

Wall or strip footing

The footing which is provided under a wall throughout its length is known as wall footing or strip footing.

This can be either simple or stepped.

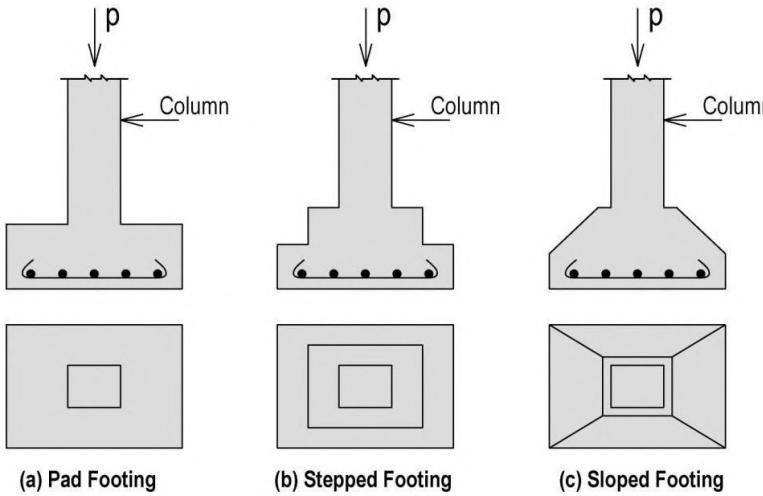
Width of footing is obtained by dividing the load per metre length by allowable bearing pressure of the soil.

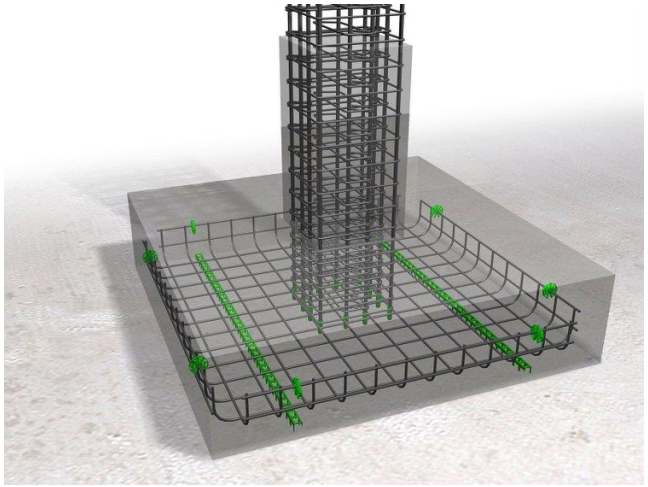
Isolated footing

Isolated footings are footings provided under columns.

It can be square, rectangular or circular in shape.

Simple footing may be adopted for lighter loads while stepped footing may be adopted for heavy loads.





Combined Footing

A footing which supports two or more columns is termed as a combined footing.

Combined footing should be proportioned so that its centroid coincides with the centre of gravity of column loads under normal conditions and the maximum pressure beneath the footing does not exceed the allowable soil pressure under the most severe loading.

The combined footing may be rectangular in shape if both the columns carry equal loads or may be trapezoidal if they carry unequal loads.

Combined Footing

Combined footings are commonly adopted when

a) two columns are spaced so closely that individual footings are not practicable due to overlapping.

b) when a column is very close to the property line so that it is not possible to centre an individual footing under the column.

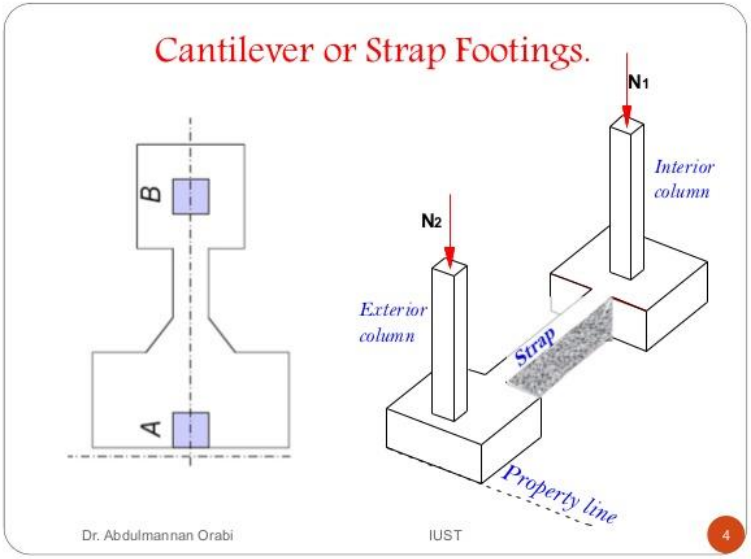
c) to prevent differential settlement in the structure

Strap or cantilever footing

Strap footing is also a type of combined footing.

This is usually provided when two columns are far apart so that a combined rectangular or trapezoidal footing may not be economical.

A cantilever footing consists of two isolated footings connected with a structural strap so that they behave as a single unit.
The strap simply acts as a connecting beam and does not take any soil reaction.



Raft or mat foundation

A raft or mat foundation is a combined footing which covers the entire area beneath a structure and supports all the walls and columns..

Raft foundations are usually recommended when

I. The building loads are heavy

II. The allowable soil pressure is small.

III. Individual footings would require more than half the building area.

IV. Soil is erratic so that differential settlement would be difficult to control

V. The structure is subjected to hydraulic uplift

Deep Foundation

In situations where soil at shallow depth is poor, in order to transmit the load safely the depth of foundation has to be increased till a suitable soil stratum exists.

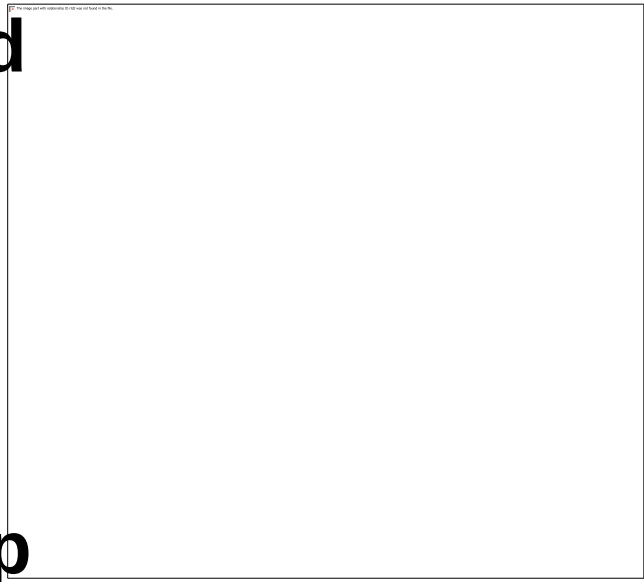
In view of the increased depth, such foundations are called deep foundations. Piles, piers and wells are examples of deep foundation.

Pile foundations

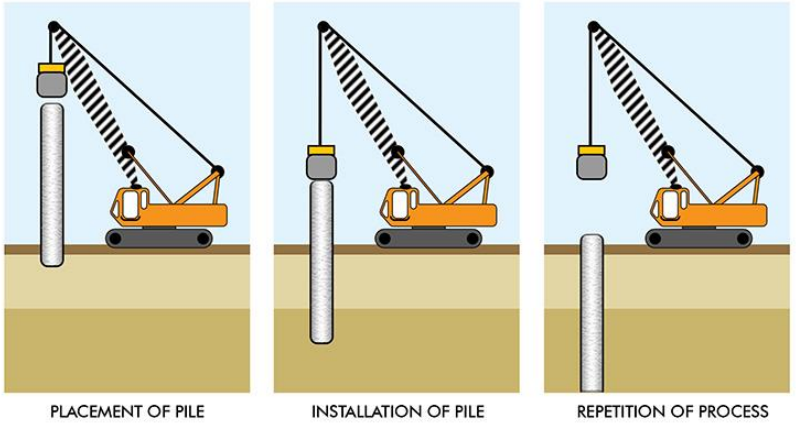
Piles are relatively long slender members that are driven into ground or cast at the site.

Piles have been used from prehistoric times.

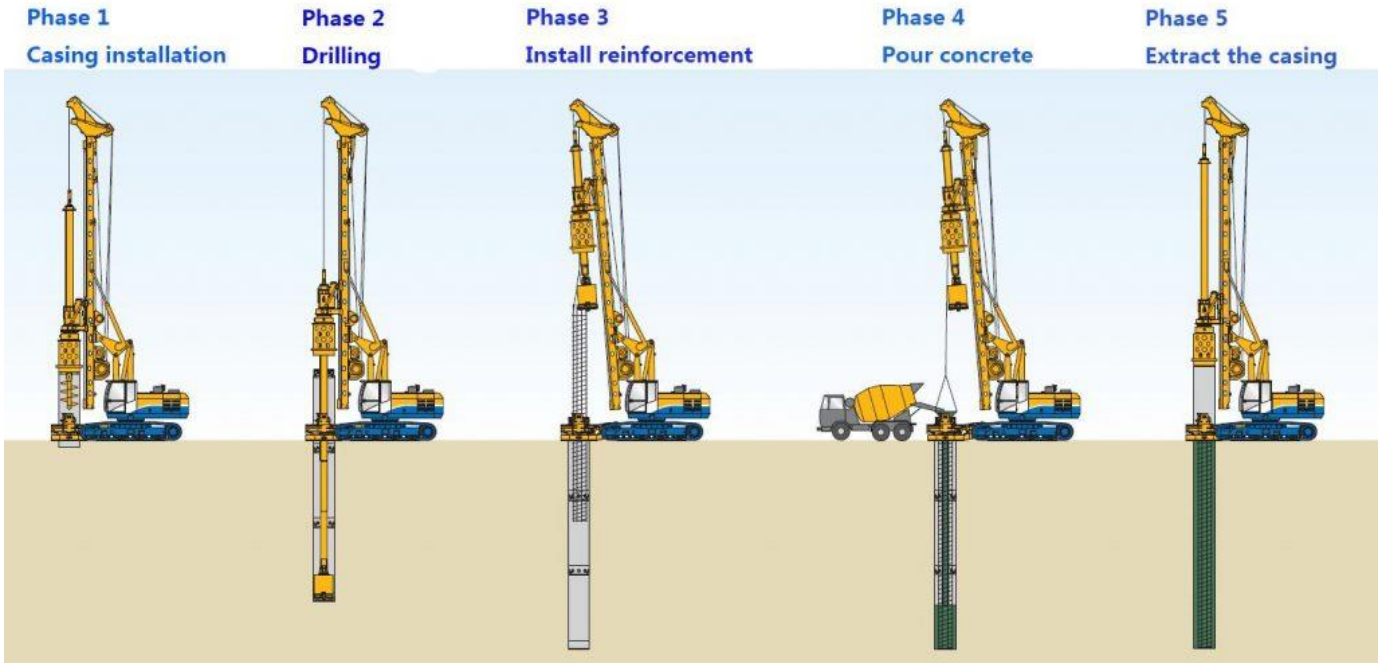
Today pile foundations are more common than any other type of deep foundation, especially where the soil conditions are unfavorable for the use of shallow foundations.



Type of pile installation



Driven pile



Cast in situ piles

Pile Foundations

Classification of Piles

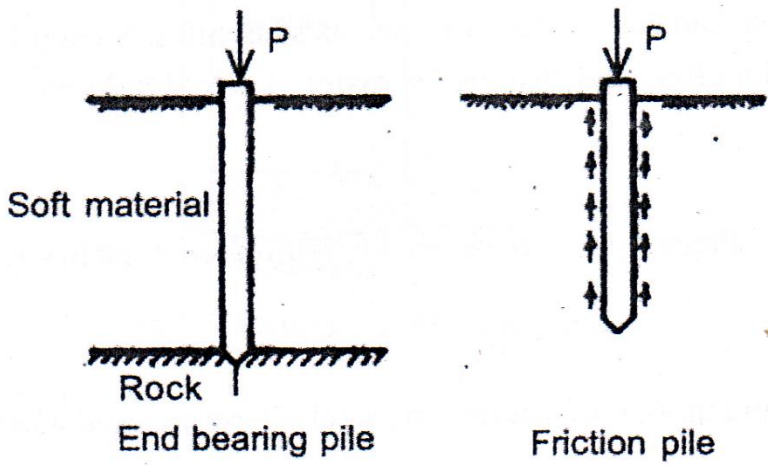
Piles may be classified based on different criteria.

a) Method of load transfer
b) Function or action
c) Composition and Material
d) Installation

Method of load transfer

End bearing piles

End bearing piles are used to transfer load to a suitable bearing stratum. They are used in soft soil.



Friction Piles

Friction piles are used to transfer loads to a depth by skin friction along the surface area of the piles

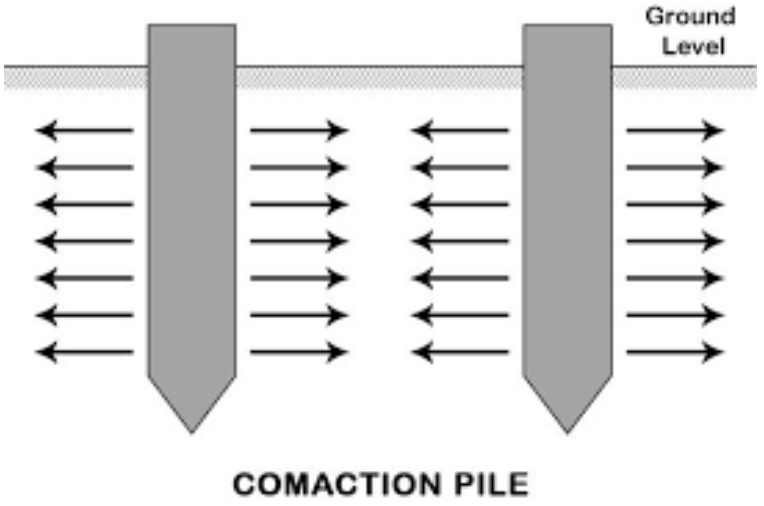
Function or action

Compaction Piles

Compaction piles are used to compact granular soils in order to increase the bearing capacity.

The compaction piles themselves do not carry any load.

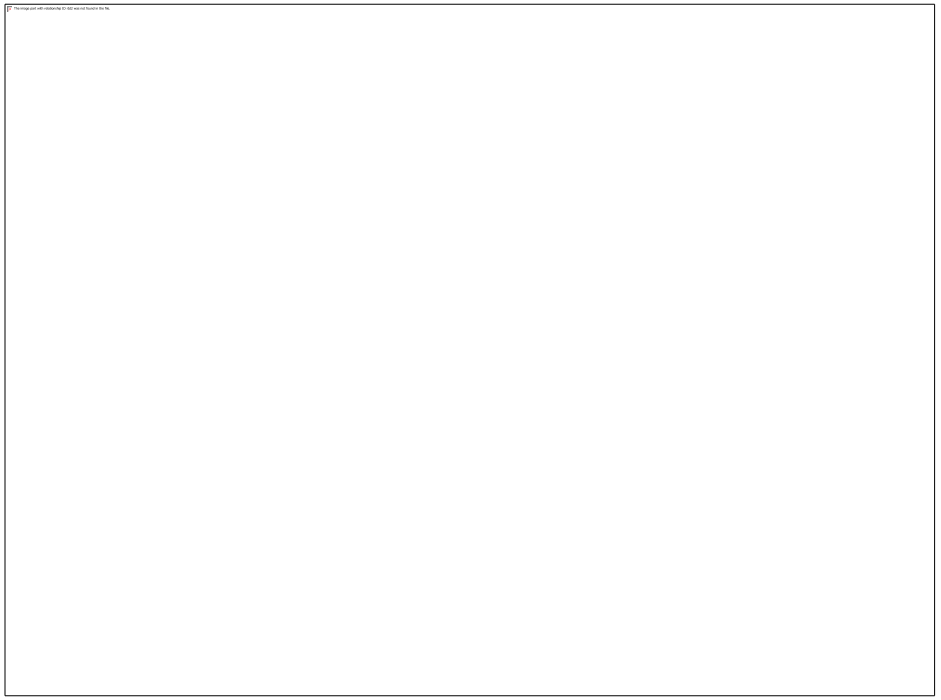
The pile tube, driven to compact the soil, is gradually taken out and sand is filled in its place thus forming a "Sand Pile".



Function or action

Tension or uplift piles

Tension or uplift piles are used to anchor structures subjected to uplift due to hydrostatic pressure or overturning moment due to horizontal forces.



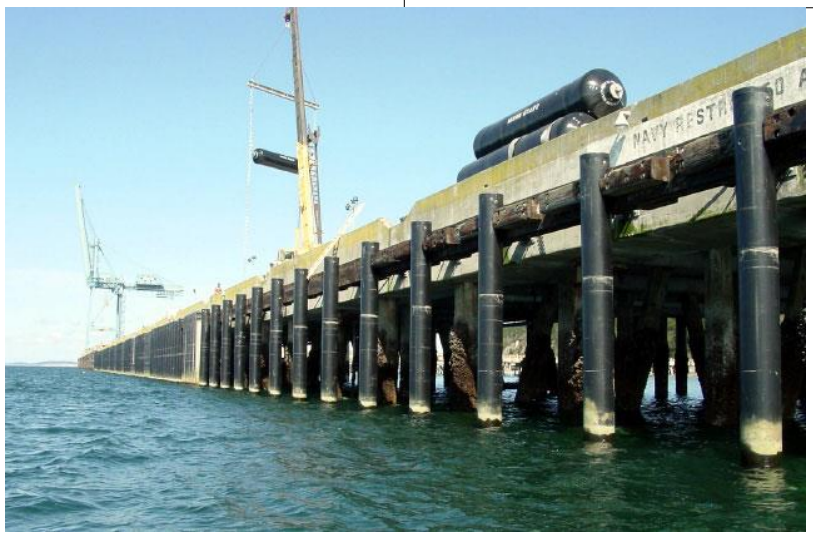
Function or action

Anchor piles

Anchor piles are used to provide anchorage against horizontal pull.

Fender piles

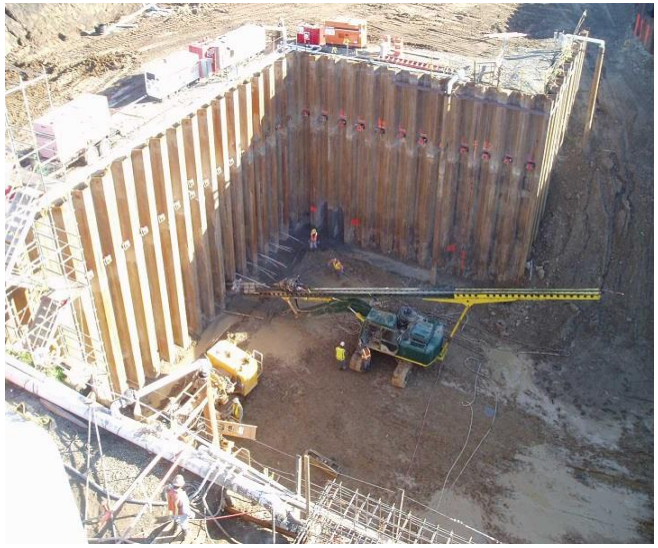
Fender piles are used to protect waterfront structures against impact from ships or other floating objects.



Function or action

Sheet piles

These piles are used to retain earth or to reduce seepage flow of water in hydraulic structures



Composition and material

Timber piles

Timber piles perform well both in fully dry condition and in submerged condition. Trunks of trees are used as piles with an iron shoe at the bottom.

Steel piles

Rolled steel H-sections, thick pipes and steel sheets are used as steel piles. Steel piles can resist lateral or horizontal forces. Handling and driving is easier. Their durability is also considerably high.

Composition and material

Concrete piles

These may be precast or cast in situ. Precast piles are invariably reinforced. Cast in situ piles are installed by pre-excavation.

Composite piles

These can made of either concrete and timber or concrete and steel.

Installation

Driven pile/precast pile

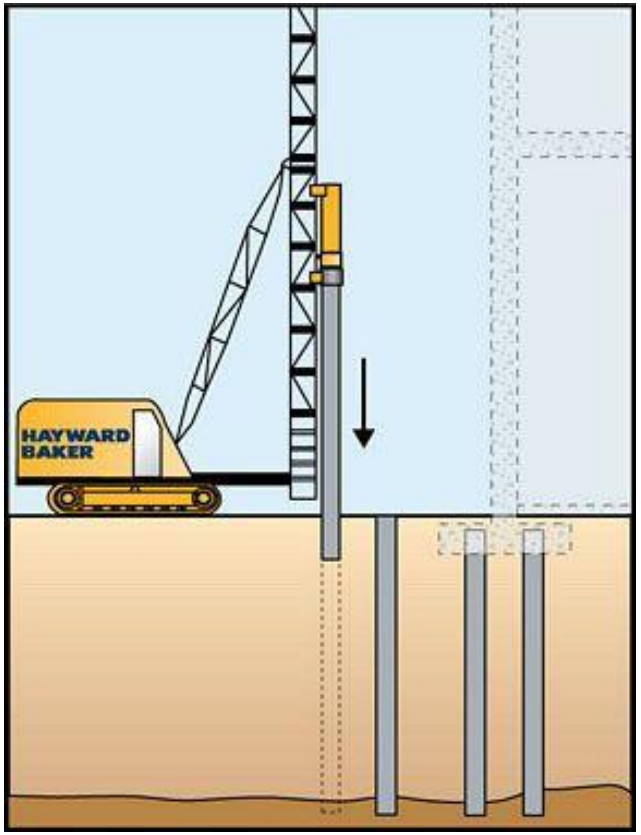
These are precast concrete piles, cast and cured in a yard, transported to the site and are driven into the ground.

The concrete mix used is M25 and above.

The size of the pile may be 250mm to 600 mm and length may be from 3 m to 30 m.

Reinforcement is provided in all pre-cast piles to take up the stresses during driving and handling operations.

Installation: Driven pile



Installation

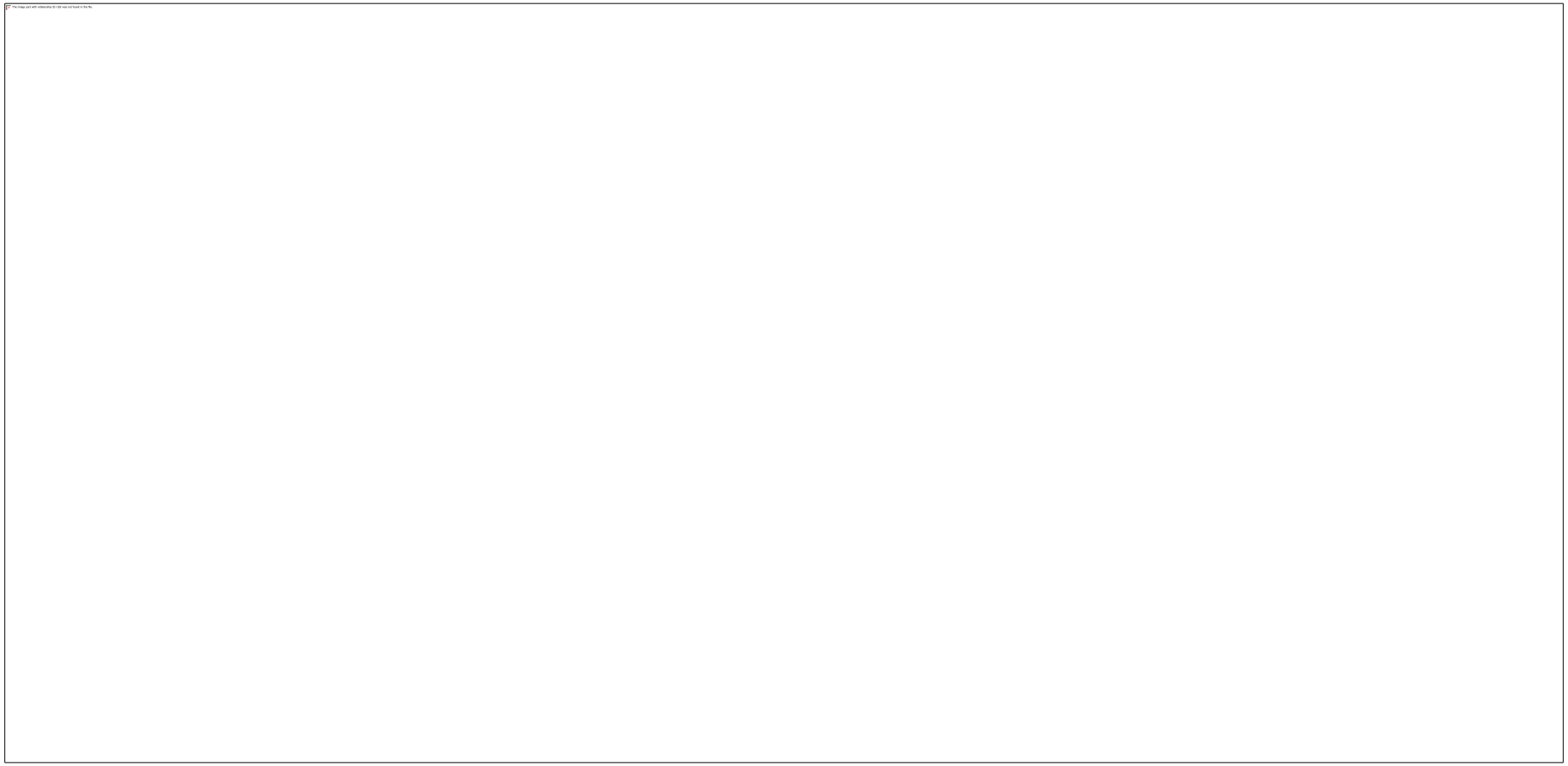
Cast in situ piles

A hole is made by excavating with auger or by driving a casing.

The hole is filled up with cement concrete.

Since the pile is not subjected to handling or driving stresses, it is not essential to reinforce the pile when the pile is subjected to only vertical pressure. When the lateral forces are also acting on the piles, the piles are essentially provided with the reinforcement.

Installation: Cast in situ piles

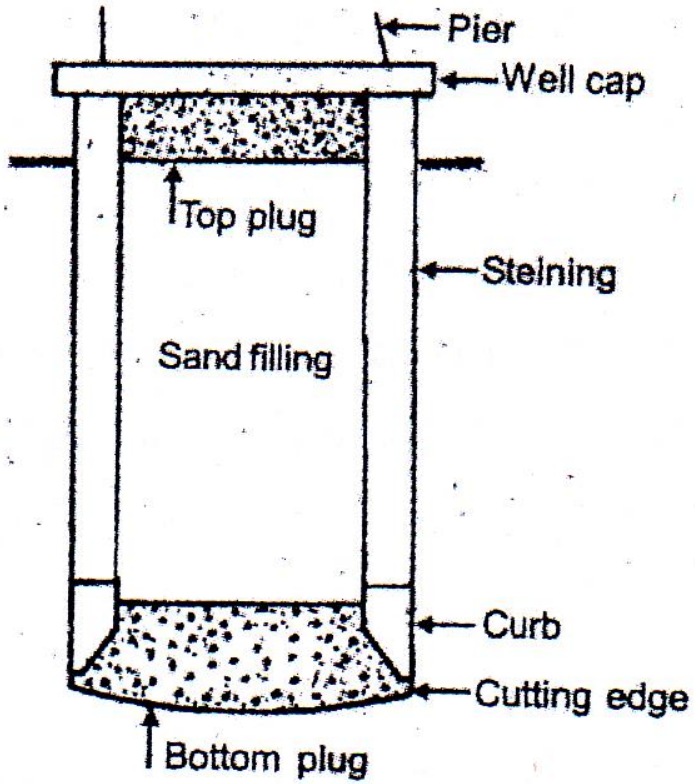


Well foundations

Wells which are also known as open caissons, have been in use for the foundation of bridges and other important structures.

Well foundations provide a solid and massive foundation for heavy loads and are useful in situations where the loads have to be transferred to a soil stratum deep below.

Well foundations



Structural configurations

Load bearing masonry

Framed structures

Load bearing masonry structures

In a load bearing masonry structure, the walls of the building carries load from the floors and roof to the foundation.

For ordinary residential buildings up to two floors we usually adopt this method.

Load bearing structure has limitations to resist earthquake.

Walls are thicker and carpet area available may be less .

Load bearing masonry structures

Room dimensions cannot be changed as walls have to be above walls

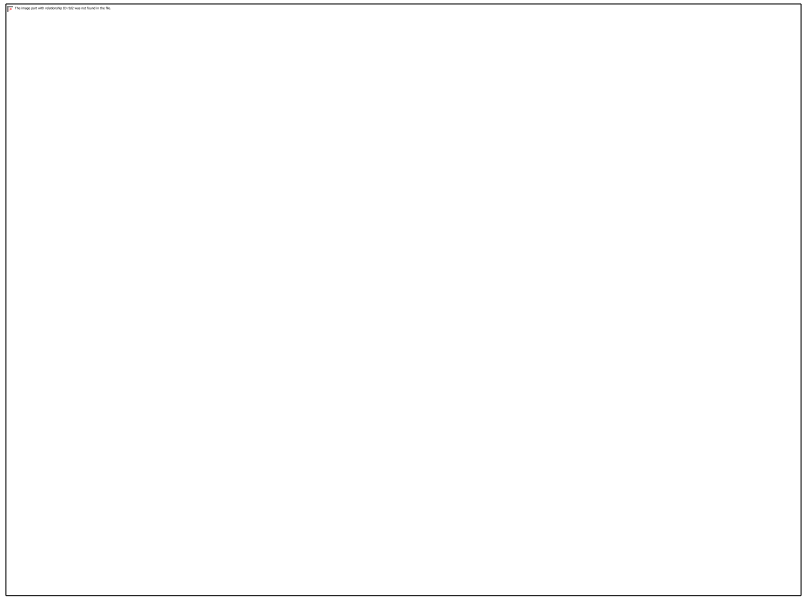
Large span areas are not possible. Limitation of span i.e. room sizes.

Limitations are there for providing openings walls, which will affect the light and ventilation in room.

Walls have to be built first as they support the slab/ roof and hence all walls have to be built simultaneously which is time consuming

Framed structures

In a framed structure, a framework or 'skeleton' of beams or columns is used to carry the structural loads down the building to the foundations.
The framework is usually of steel or reinforced concrete, but in small structures may be of timber or aluminum.



Framed Structures

They are more resistant to earthquake.
Walls are thinner and carpet area available may be more.
Room dimension can be altered.
Here the walls are for privacy and security. No limitation exists in form of taking walls over walls and rooms over rooms.

Framed Structures

They are more resistant to Earthquake.
Walls are thinner and carpet area available may be more.
Room dimension can be altered.
Here the walls are for privacy and security. No limitation exists in form of taking walls over walls and rooms over rooms.

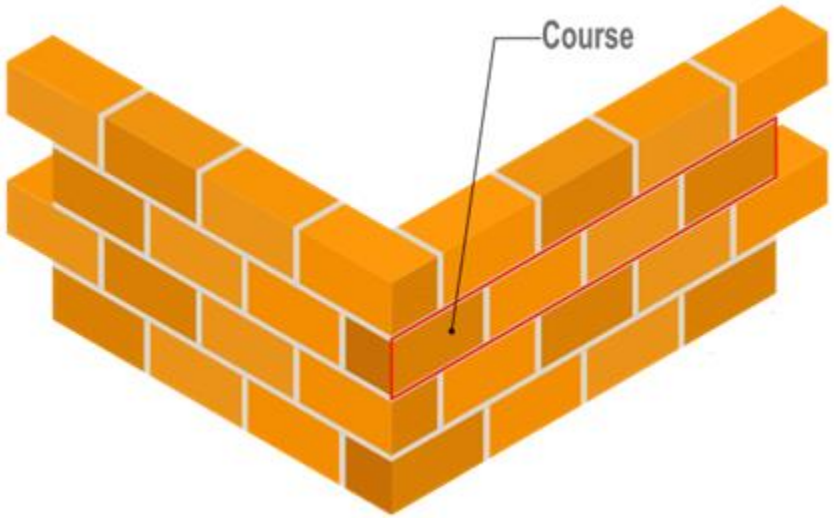
Brick Masonry

Masonry may be defined as the construction of building units bonded together with mortar

When bricks are used as building units it is called brick masonry and when stones are used it is called stone masonry

Terms used: Course

A complete layer of bricks laid on the same bed is known as course and its thickness is equal to the thickness of a brick plus the thickness of one mortar joint.



Terms used:

Bed

The bottom surface of the brick when it is laid flat is known as bed

Stretcher

The longer face of a brick visible in elevation when the brick is laid flat is known as stretcher

Header

The end surface of the brick when it is laid flat is known as header

Lap

Lap is the horizontal distance between the vertical joints of successive brick courses

Terms used:

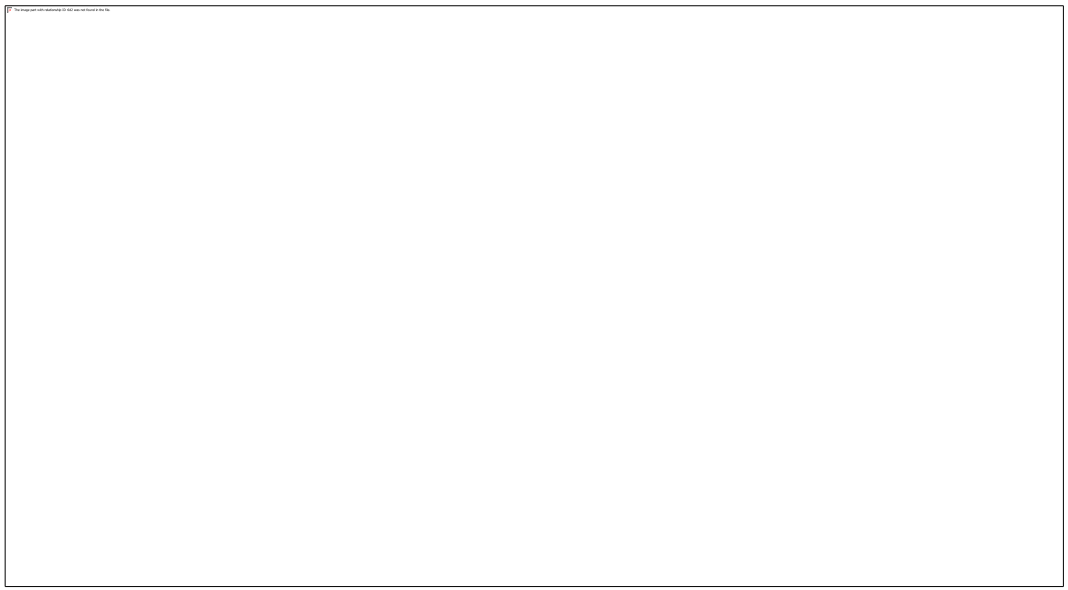
Occasionally you will have to cut brick into various shapes to fill in spaces at corners and other locations where a full brick does not fit

Bat

When a brick is cut across the width, the resulting piece is called ***bat***. Thus a bat is smaller in length than the full brick.

Closure

It is the portion of the brick cut along the length in such a way as one long face remains intact



Types of bonds

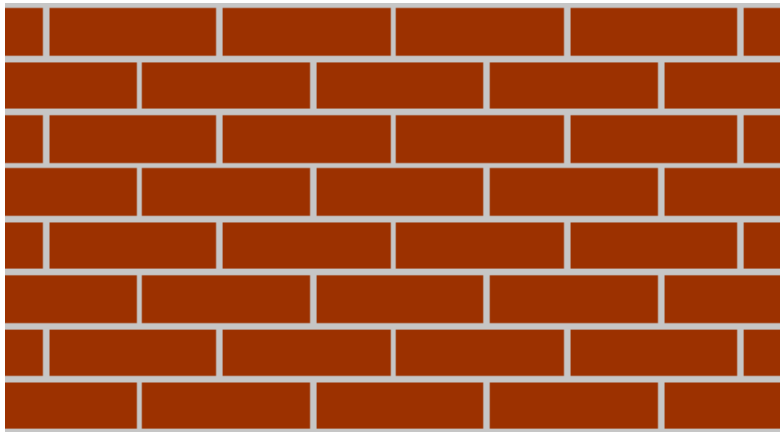
Stretcher bond

In this type of bond, all the bricks are laid with their lengths in the longitudinal direction of the wall

Used when thickness of wall equal to half brick

Used for partition walls and cavity walls

Isometric view

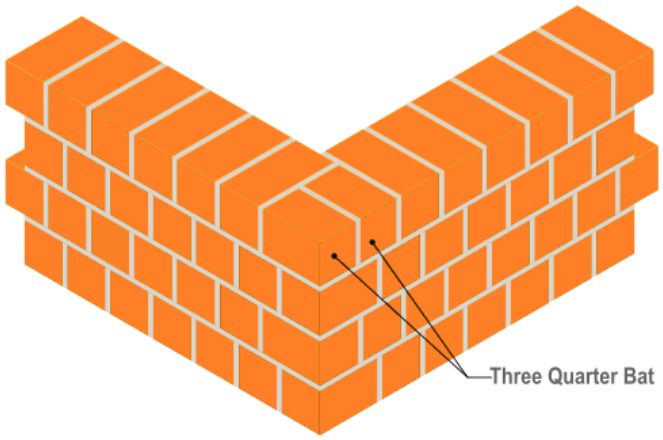


Elevation

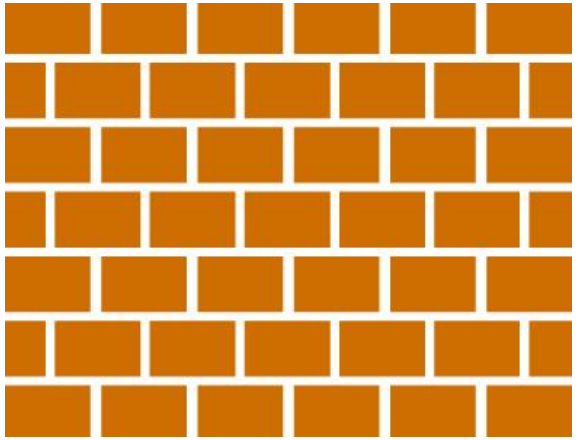
Types of bonds

Header bond

In this type of bond, all the bricks are laid as headers towards the face of the wall.
This can be made when thickness of wall is equal to one brick.
Suitable for partition walls and for curved brickwork.



Isometric view

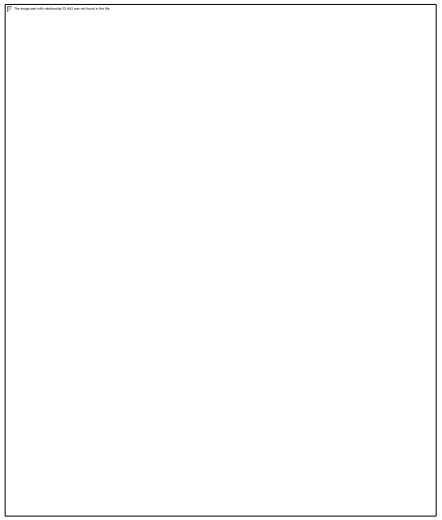


Elevation

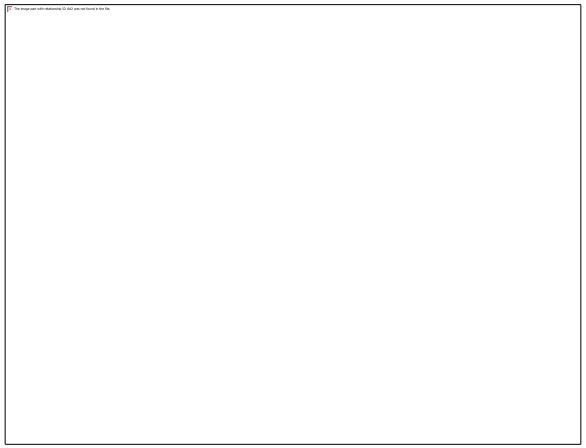
Types of bonds

English bond

This is the most commonly used bond for all thicknesses of walls
Considered to be the strongest.
This bond consists of alternate courses of headers and stretchers.
No continuous vertical joints.

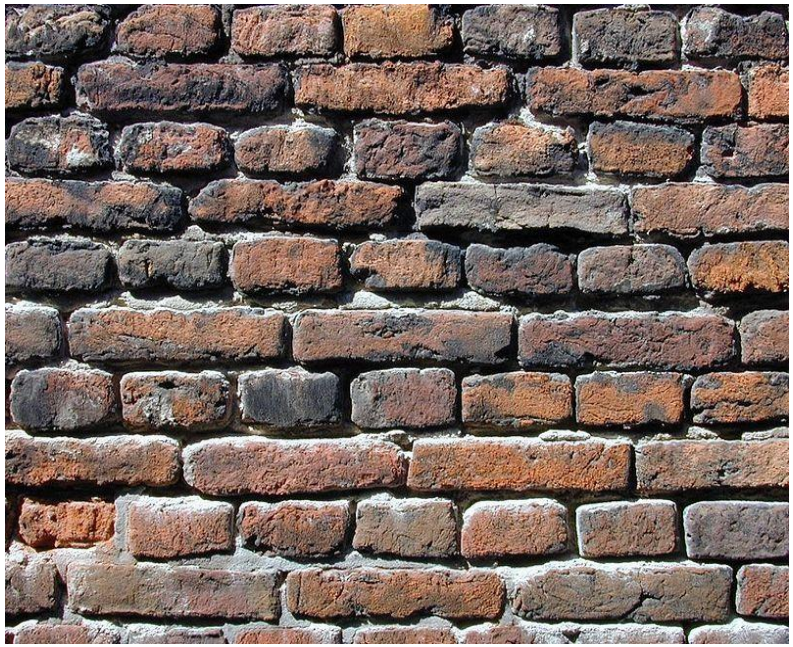


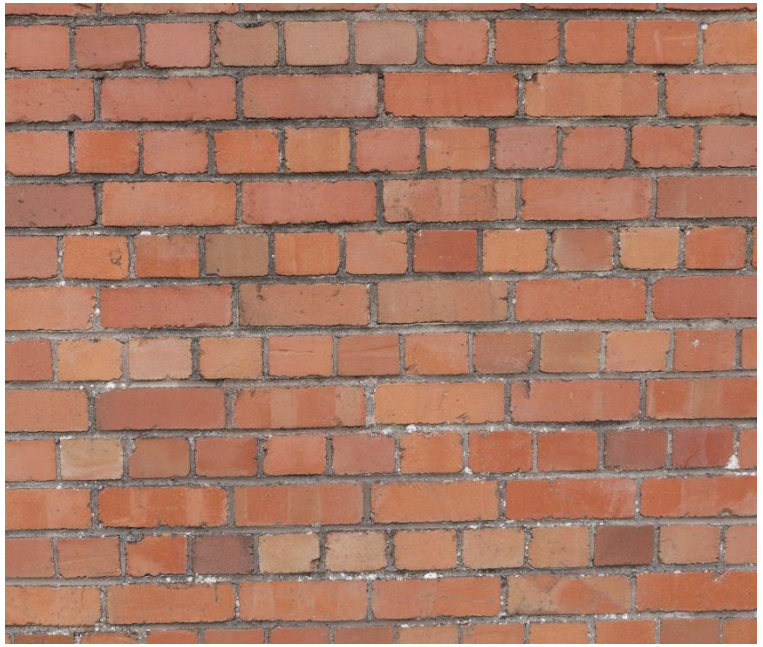
Isometric view



Elevation

English bond

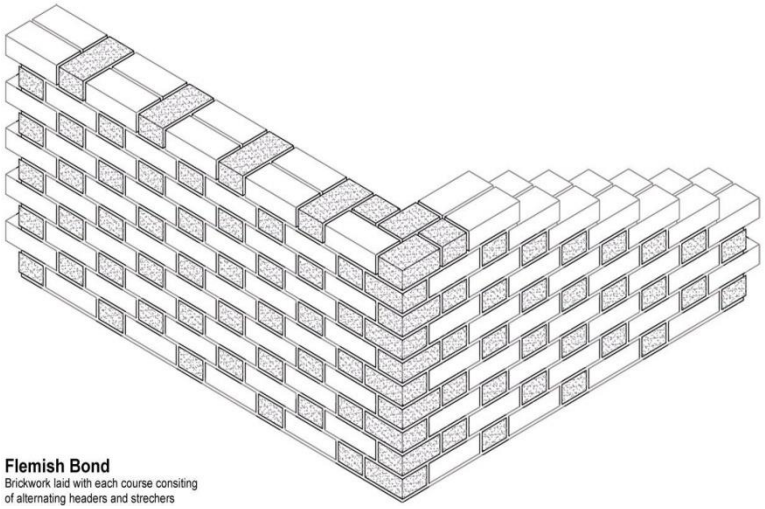




Types of bonds

Flemish Bond

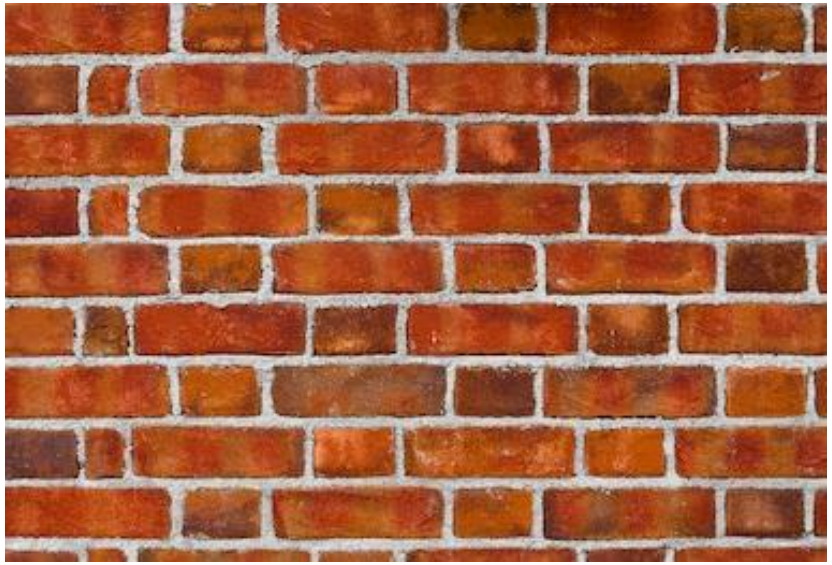
Each course comprise of alternate headers and strechers
Every alternate course starts with a header from the corner
To develop the gap queen closers are placed
Every header is centrally supported over the stretcher below

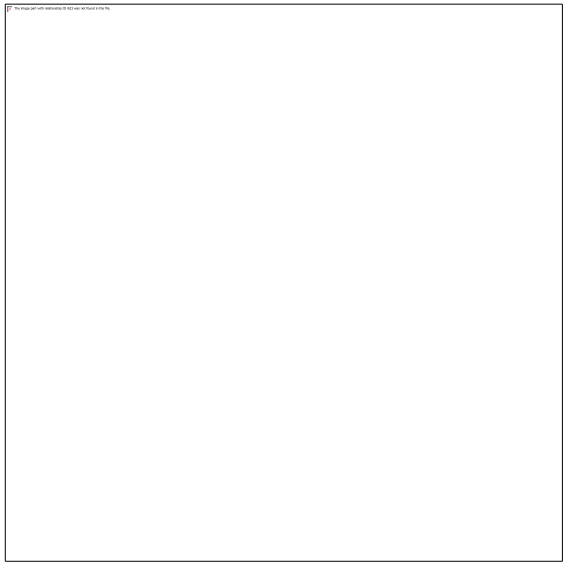


Isometric view

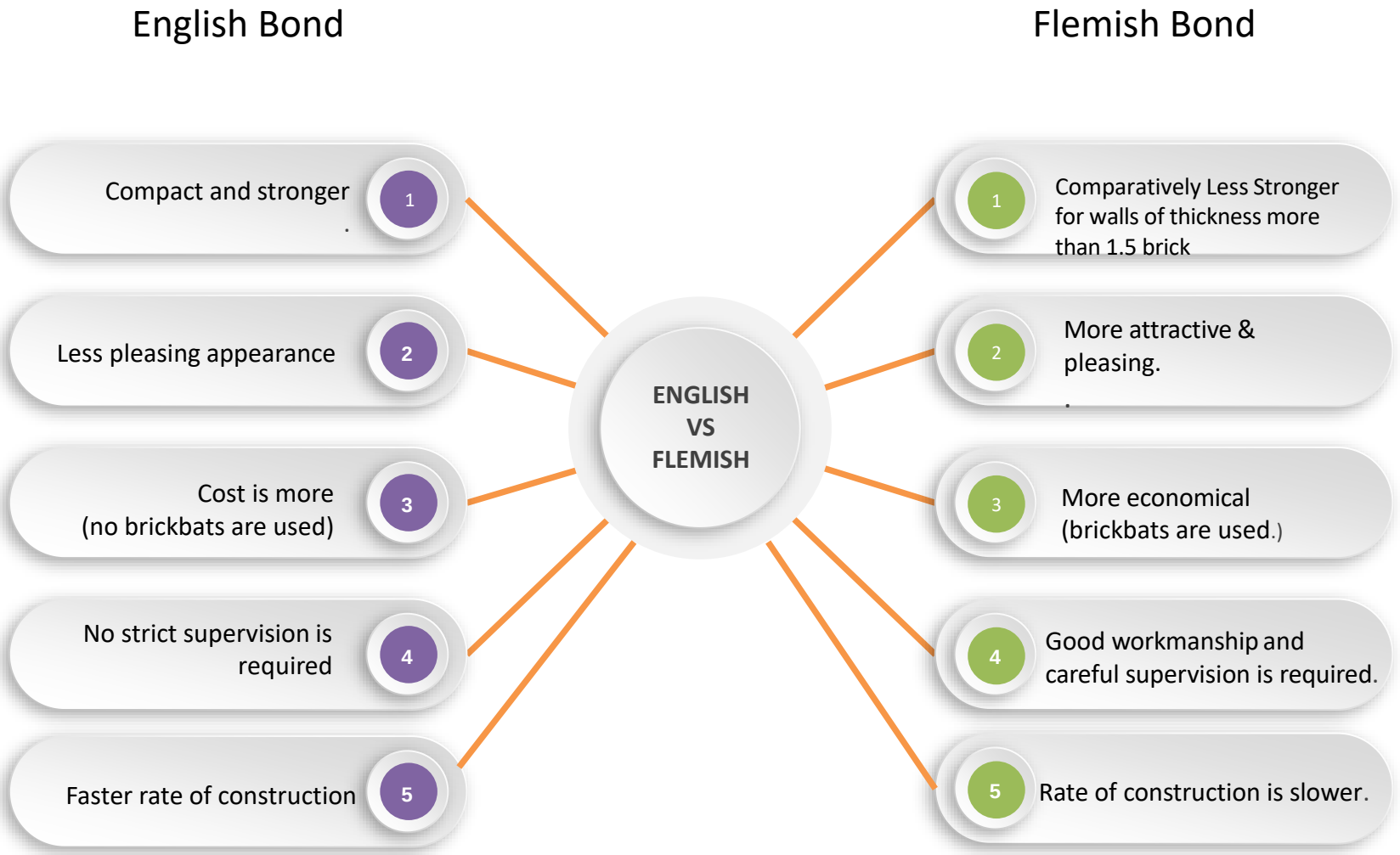
Elevation

Flemish Bond





English Bond VS Flemish Bond



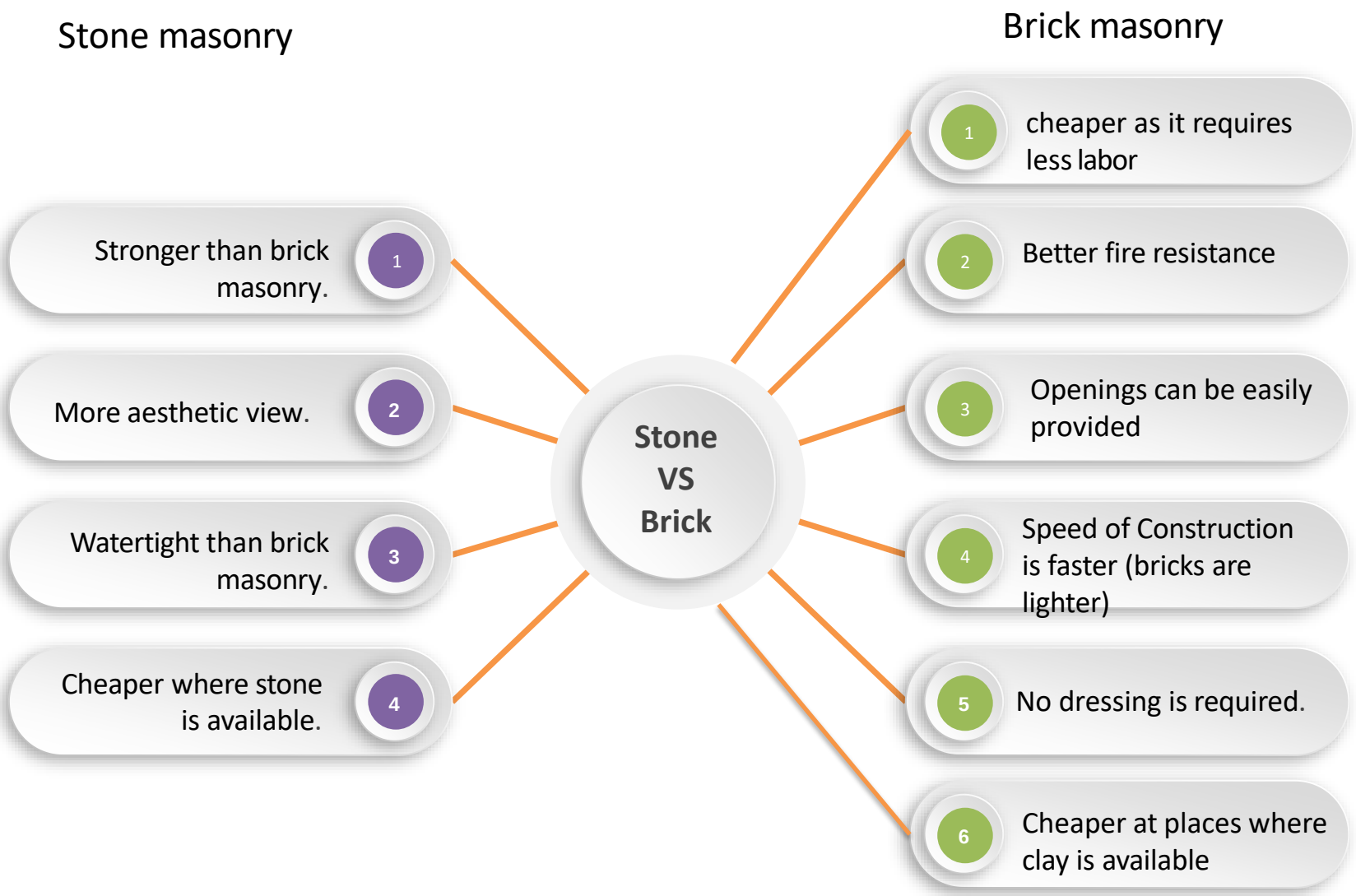
Rubble Masonry

Roughest and cheapest form of rubble masonry.
Stones of different shapes and sizes are used.
Two types of rubble masonry

Un coursed: The stones are so arranged that the vertical joints are staggered. Better load distribution is achieved in this.

Built into courses: Done in a manner that the stonework is brought to courses of thickness varying from 30-45 cm. All the courses need not be of same height.

Stone masonry VS Brick masonry



Roofs

Roof is defined as the covering provided over the top of a building. The function of roof is to protect the building from the weathering agencies like sun, rain, wind etc.
A roof basically consists of roof covering materials supported on structural elements installed in the building top. Structural elements may be trusses, beams, etc.
The roof covering may be of asbestos cement sheets, tile, galvanized iron sheets, concrete slab, aluminum sheets, fiber glass sheets etc.

Functions/requirements of a roof

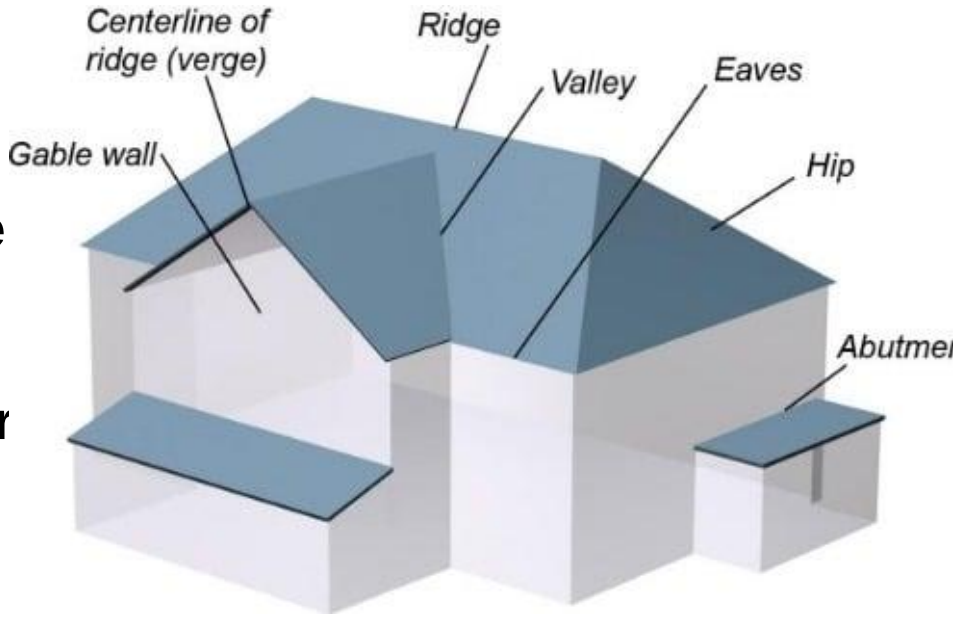
An ideal roof should be structurally sound and strong enough to carry the loads coming over it.
Roof should be waterproof with good drainage arrangements.
It should protect the building against rain, wind, sun etc., and it should be durable against the adverse effects of these agencies.
It should provide adequate thermal and sound insulation.
It should be fire resistant.

Types of Roofs

Pitched or sloping roofs

Various shapes which can be given to roofs of this type depend on the area covered, material available, type of lighting and ventilation, etc.

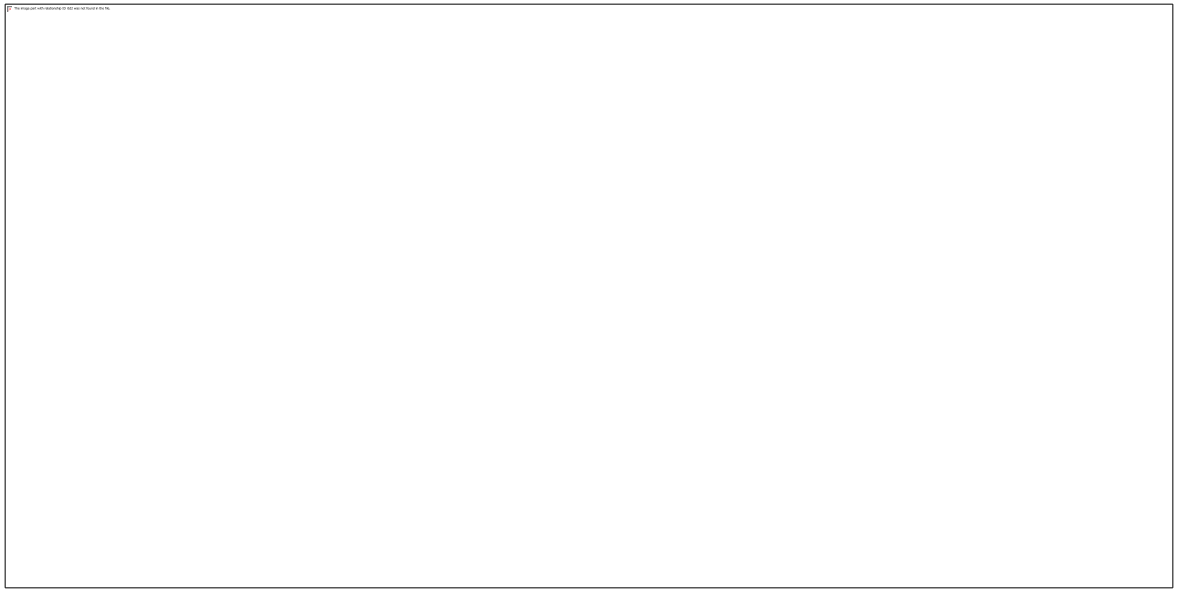
This type is suitable where rainfall or snowfall is heavy. Sloping roofs may be wooden, steel or reinforced concrete.



Types of Roofs

Flat roofs or terraced roofs

Flat roofs are suitable for buildings where rainfall is moderate. These are applicable to buildings of any shape and size. Reinforced concrete roof is the best example of flat roof.



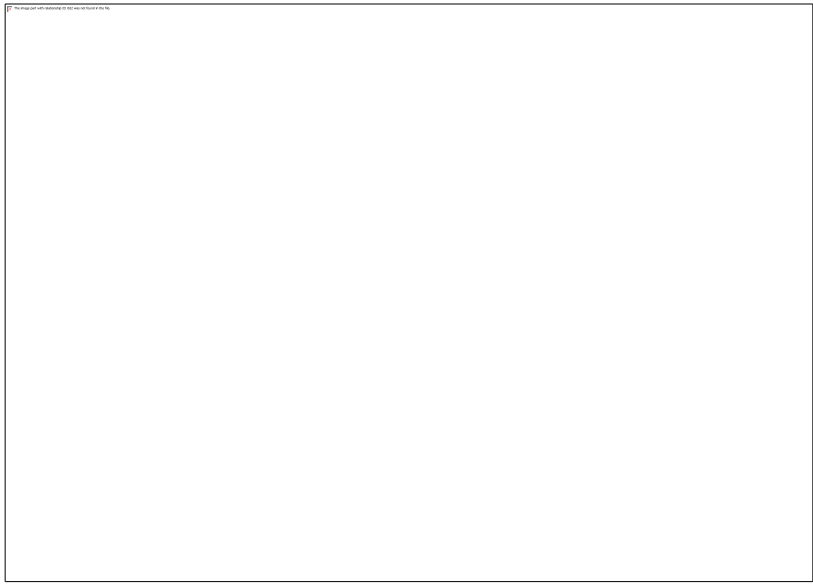
Types of Roofs

Curved roofs

Curved roofs have their top surface curved

Such roofs are usually provided for public buildings, theatres, recreation centers etc., to provide an architectural effect

Shells and domes are adopted when large column free areas are required. This type has an advantage that a lot of material is saved as the structure is very thin.



Zaha Hadid's Heydar Aliyev Centre, Baku

Roofing Materials

Asbestos-Cement Sheets

Asbestos- cement is a material consisting of cement and asbestos.
Roof coverings made of this material are cheap, fire resisting and light in weight.
It does not rust and needs no protective coating. It cannot be eaten away by vermin.
The cost of fixing is considerably less than other types of roofing material.
This material has also got a very low thermal conductivity and heats the room when it is used in summer or keeps the room very cool in winter.
Presently not popular due to possible health risks

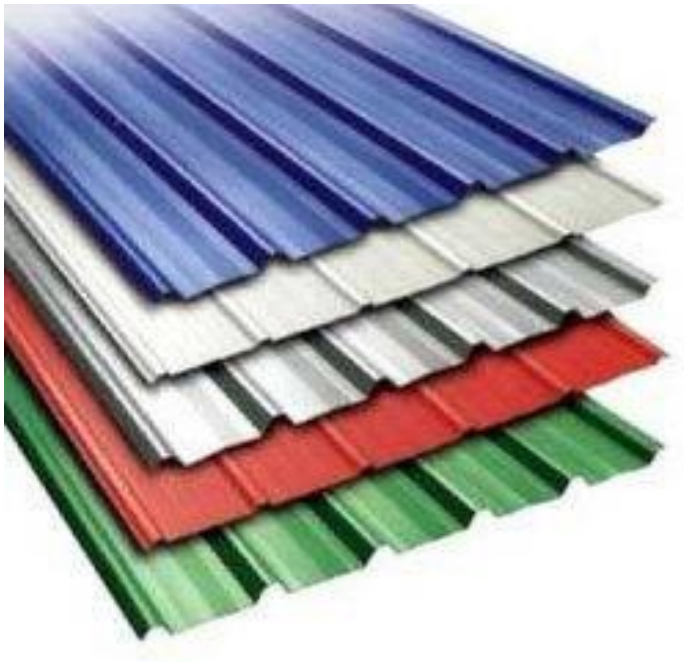
Asbestos-Cement Sheets

Roofing Materials

Aluminum sheets

Aluminum roof sheeting consists of Aluminum alloyed with a small percentage of manganese for strength.
It is the lightest of all roofing.
It will reflect off the heat making the inside atmosphere cool.
Due to light weight nature of the sheet, structural supports required can be light.
The most important advantage is that it is corrosion free. These are used for warehouses, industrial buildings, automobile sheds etc.

Aluminum sheets



Roofing Materials

Galvanized Iron sheets

Galvanized iron sheets are extensively used as a roof covering material in factories, work shops, sheds, cost effective buildings, etc. because they are very durable, light and fire proof.

They are stronger than Aluminum sheets and are made of iron sheets, which are galvanized with zinc to protect them from rusting action of water and wet weather.

Galvanized Iron sheets

Roofing Materials

Fiber sheets

Usually made of fiber glass or other polymeric materials.
Require low maintenance.
It is available in different colors and shades. It has got many advantages such as light weight, rust proof, can be easily cut to suit the plan of the building.
Examples are PVC sheets, Poly carbonic sheets etc.

Fibre sheets

Roofing Materials

Roofing Tiles

Tiles are one of the oldest roof covering materials. They are available in various shapes and designs. Some of them have been patented and are known by the name of the area in which they are popular such as Allahabad tile, Mangalore tile

Roofing Tiles

Roofing Materials

Reinforced Concrete Roof

This consists of reinforced cement concrete slabs and beams. They are made up of cement concrete reinforced with steel bars. Flat roofs and sloped roofs are usually constructed using reinforced cement concrete.

According to the structural behavior, RCC roof slabs can be classified as one way slabs and two way slabs.

Floors

Floors are the horizontal elements of a building structure which divide the building into different levels for the purpose of creating more accommodation within a restricted space one above the other and provide support for the occupants, furniture and equipment of a building.

Floors

A floor consists of the following two components:

Sub-floor (or Base Course of Sub-grade). The purpose of this component is to impart strength and stability to support floor covering and all other superimposed loads.

Floor Covering (or Paving or Flooring). This is the covering over the sub-floor and is meant to provide a hard, clean, smooth, impervious, durable and attractive surface to the floor.

Functions

The main function of any floor is to carry the self weight of the floor itself and more importantly the dead load of any structures placed upon it together with the live loads associated with the use of the property
The ground floor is required to keep the moisture out and the warmth in, enabling it to maintain a comfortable environment for its inhabitants to live in and carry out the social activities that the building was designed.

Flooring Types

Concrete Flooring:

This type of flooring is most commonly used these days in commercial, institutional and public buildings of all types.
This flooring is also known as Indian Patent stone flooring.
The concrete flooring consists of two components.
(a) a base course on subgrade
(b) a wearing course on floor finish

Flooring Types

Hardwood Flooring :

Hardwood flooring presents a combination of beauty and durability

This type of flooring provides a long-lasting product, wear resistant surface that could be refinished if necessary

Flooring Types

Ceramic Tile:

Some types of ceramic tile with high glass finish tend to scratch over the time. Ceramic tiles with unglazed finish are the best alternative for outdoor flooring because of the possibility of standing water.

Finishes available are matte, embossed, glazed and textured ones for ant-slip.

Flooring Types

Laminate Flooring :

One of the cheapest flooring types available, laminate flooring are very easy to maintain. Laminate flooring provides a strong, durable surface that can resist burns, scratches, and chipping It is an excellent solution for high traffic areas, resembles natural materials and comes in a wide range of colors and designs. However, laminate flooring could not be refinished and can be scratched easily.

Flooring Types

Marble and Granite Flooring :

These tiles are one of the most durable and versatile tiles to use.
They can be used for your floors, walls and columns.
These titles are easily cleaned and maintained.
They are also very easy to engrave with stylish textures and designs that suit the artistic tastes

Flooring Types

Glass Flooring :

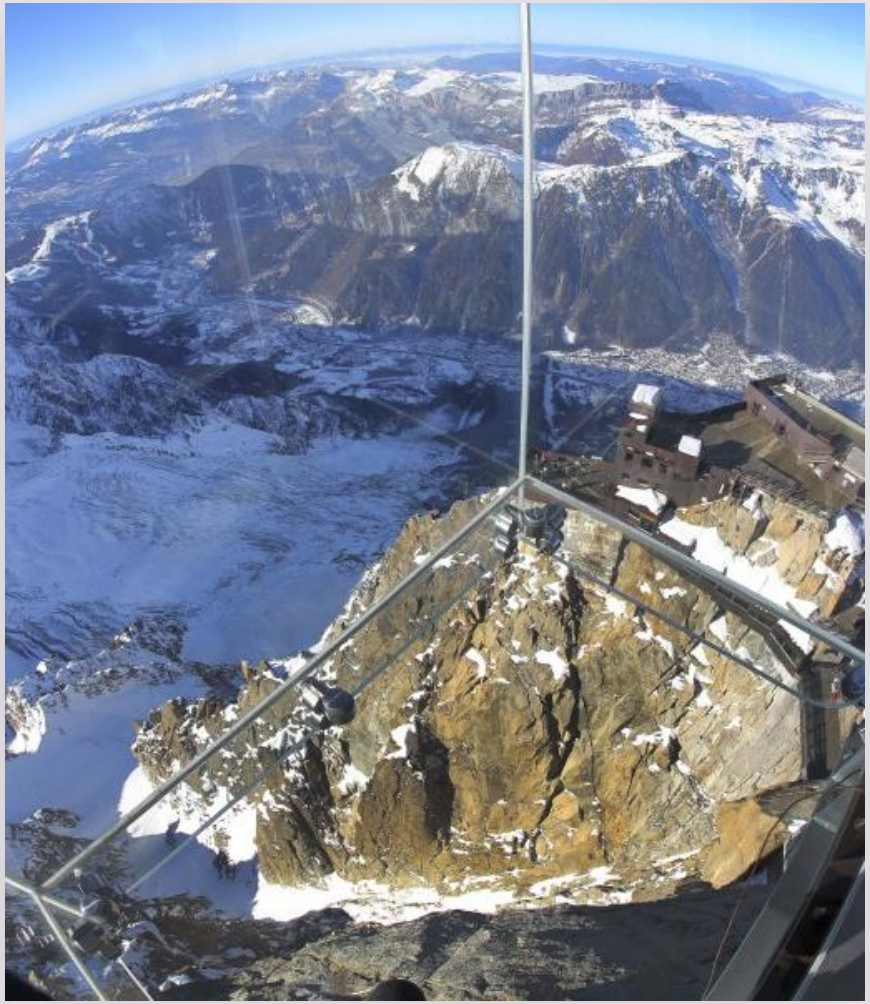
This type of flooring can be used for special purposes where it is desired to transmit light from an upper floor to a lower floor such as from a ground floor to a basement.

This flooring is not commonly used for floors, in general.

In the construction of glass flooring, the structural glass in the form of tiles, blocks, etc., is fitted within frames of various types.

Grand Canyon Skywalk

Chamonix Mont Blanc, Geneva



Taihang Mountains, China

Thank You