Introduction to Basic Civil Engineering

Lecture 1 - Introduction

Sreejith Krishnan, *PhD*

Class Policies – Important!!!

- Please mute the microphones during the lecture
- Join 5 minutes before the start of the lecture
- Questions and clarifications – Last 5 minutes.
- Course Language – Primarily in English
- Please refer to the syllabus/references from the KTU website for the exam pattern/sample questions
- Feel free to contact me via email in case of additional clarifications – sreejith@mec.ac.in

Course Objectives

- To provide an introduction to the civil engineering to students
    - Civil engineering is everywhere – building, dams, roads…….

- To learn about fundamental aspects of civil engineering
    - Different sub-branches
    - Different types of building materials
    - Different building types

- To highlight the role of a civil engineer in the modern society

- Ultimately, you should be able to understand the basic civil engineering terms!!!

Introduction

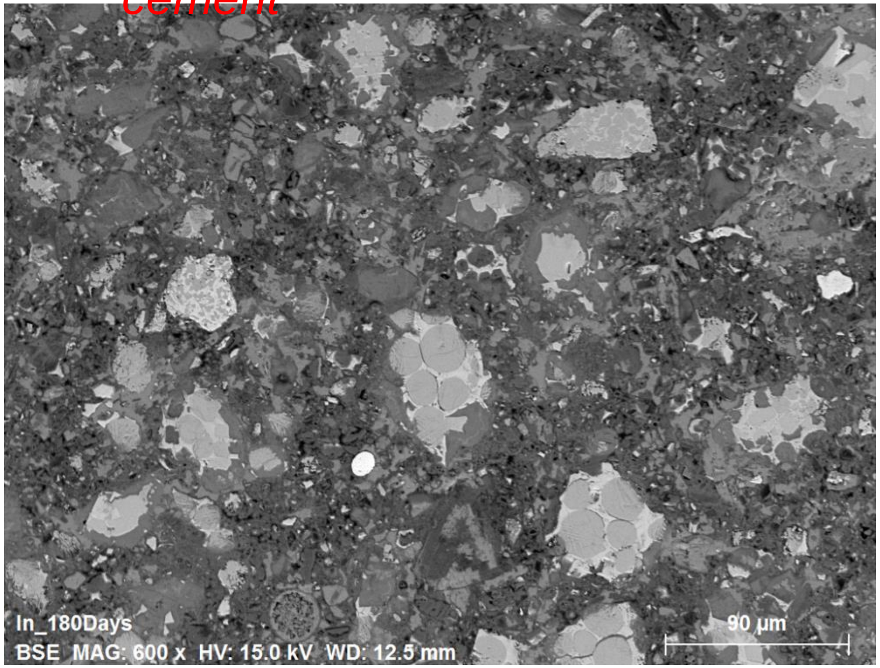
- Oldest branch of engineering
  - Deals with civilian infrastructure – design, construction, and maintenance
  - Historical evidence of engineering in ancient civilisations.
- First engineering school in France opened in 1747!!
- Thomson College of Engineering in India at Roorkee. Now an IIT.
- Cement and concrete are not new materials!!
  - Stone, lime mortar, mud etc also used
  - Newer modifications for a newer age

Scale of Civil Engineering

- From mega-structures to nano-materials..
- Complex structures also means complex science!!!

Hoover Dam

Microstructure of hydrated cement



Why should you care???

- Because when everything goes well, we get →

Why should you care???

- But when something goes really bad, it will be catastrophic
  - Loss of lives, money and resources

Why should you care???

- Even failures can lead to something positive!!!

Importance of Civil Engineering in Society

- A significant section of the society does not have a home
  - Requires the construction of buildings and houses.
  - Housing for all by 2022 scheme – PMAY
- Schools, hospital and factories
- Dams/nuclear power plants are required for generating electricity
- Roads/Railways are required for transportation of the goods and people
- Maintenance of critical infrastructure!!

Investment in Infrastructure leads to Economic Development!!!

Sub-Branches of Civil Engineering

- Civil Engineering is not a monolith and contains several sub-branches
  - Structural Engineering
  - Geotechnical Engineering
  - Environmental Engineering
  - Transportation Engineering
  - Hydraulics and Water Resources Engineering
  - Remote Sensing and GIS
  - Building Technology and Construction Management

Structural Engineering

- Deals with design, plan and analyse structural elements of the buildings like beams and column

- Design the skeleton of the building
  - Building must with stand different load combinations – wind loads, live loads, earthquake loads etc.
  - Design the reinforcement/steel in the cement
  - Bad design example near us – A bridge

Geotechnical Engineering

- Deals with engineering aspects of soil and rocks
  - Calculate the bearing capacity of the soil
  - Design of the foundations of the soil

Environmental Engineering

- Deals the environmental implications of civil engineering
- Sewage and waste water management
- Design of structures to reduce air pollution air pollution etc.

Transportation Engineering

- Deals with the design of transportation related infrastructure
  - Roads
  - Railways
  - Airports and Seaport

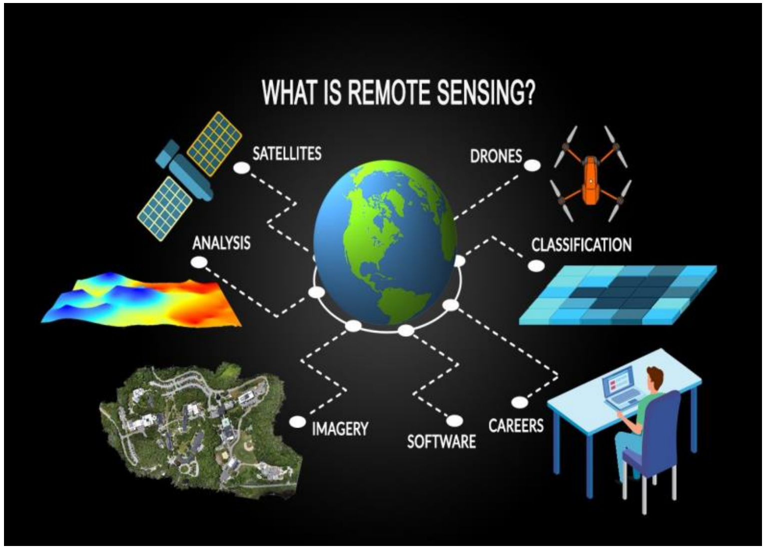
- Design of traffic signals, roundabouts, railway lines etc.

Hydraulics and Water Resources Engineering

- Design of structures and systems for managing the water resources
  - Flow and transportation of fluids – water and sewage
  - Design systems for irrigation
  - Managing hydrological cycle and ground water management

Remote Sensing and GIS

- Mapping and analysing features of earth
- Remote sensing means detecting from a distance
- Sensors detect energy reflecting from earth
  - Generally mounted on satellites
  - Light is the most common source of energy
- Useful for disaster management
  - Floods, fire etc.
- Monitoring farm land, predict weather etc.



Building Technology & Construction Management

- Deals with civil engineering materials and functional design of buildings

- Understanding the science behind building materials

- Durability of the structures, corrosion resistance etc.

- Construction management deals with organising labour, timely completion of construction projects etc.

A combination of all the branches is required in reality

Summary

- In this lecture, we had an introduction to basic civil engineering and its history
- We tried to understand the role of civil engineering in the development of the society
- We looked into the different sub-sections of civil engineering and their area of study
- In the next lecture, we will be discussing the different types of structures encountered in Civil Engineering

Thank You!

- Any doubts..???

Introduction to Basic Civil Engineering

Lecture 2 – Introduction to Buildings/Structures

Sreejith Krishnan, *PhD*

Recap

- In the previous lecture, we looked into –
  - A brief history of civil engineering
  - The importance of civil engineering in the modern society
    - Housing for all
    - Safe disposal of industrial and residential waste
    - Safe industrial and domestic water supply
    - Transportation of goods and people
    - Economic development leading to improvement in standard of living
  - Different branches of civil engineering like structural engineering, geotechnical engineering and their specific roles

Introduction

- Many types of construction are possible –
  - Residential and commercial buildings – Houses and apartments, Factories etc.
  - Roads and bridges
  - Dams
  - Towers
  - Water tanks
  - Airports
  - Seaports
  - Railways

Classification of Buildings

- As per National Building Code – 2005
  - A – Residential Buildings
  - B – Educational Buildings
  - C – Institutional Buildings
  - D – Assembly Buildings
  - E – Business Buildings
  - F – Mercantile Buildings
  - G – Industrial Buildings
  - H – Storage Buildings
  - J – Hazardous Buildings

A. Residential Buildings

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

- Further sub-divisions
  - Lodging or rooming houses
  - One or two-family private dwellings
  - Dormitories
  - Apartment houses (flats)
  - Hotels

B. Educational Buildings

- These shall include any building used for school, college, other training institutions for day-care purposes involving assembly for instruction, education or recreation

C. Institutional Buildings

- These shall include any building or part thereof, which is used for purposes, such as medical or other treatment or care of persons suffering from physical or mental illness, disease or infirmity.

- Sub-divisions
    - Hospitals
    - Custodial Institutions
    - Prisons

D. Assembly Buildings

- These shall include 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

  - D-1 Buildings having a theatrical stage and fixed seats for over 1000 persons
  - D-2 Buildings having a theatrical stage and fixed seats for less than 1000 persons
  - D-3 Buildings without a stage having accommodation for 300 or more persons but no permanent seating arrangement
  - D-4 Buildings without a stage having accommodation for less than 300 persons
  - D-5 All other structures designed for assembly of people not covered by subdivisions D-1 -to D-4

E. Business Buildings

- These shall include any building or part of a building which is used for transaction of business (other than that covered by Group F)

- Business types of building are further sub divided as per following
  - Offices, banks, professional establishments, like offices of architects, engineers, doctors, lawyers, etc.
  - Laboratories, research establishments and test houses.
  - Computer installations.

F – Mercantile Buildings

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

- Further classified as
  - Shops, stores, departmental stores markets with area up to 500 m2.
  - Shops, stores, departmental stores markets with area more than 500 m2.
  - Underground shopping centres.

G – Industrial Buildings

- These shall include any building or part of a building or structure, in which products or materials of all kinds and properties are fabricated, assembled, manufactured or processed
- Examples - Assembly plants, industrial laboratories, dry cleaning plants, power plants, generating units, pumping stations
- Buildings under Group G shall be further sub-divided as follows:
  - Buildings used for low hazard industries.
  - Buildings used for moderate hazard industries.
  - Buildings used for high hazard industries.

H – Storage Buildings

- These shall include any building or part of a building used primarily for the storage or sheltering of goods, ware or merchandise vehicles or animals
- Warehouses, cold storage, freight depots, transit sheds, storehouses, truck and marine terminals, garages, hangers, grain elevators, barns and stables
- Few numbers of people with respect to the area of the building

J – Hazardous Buildings

- These shall include 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 with extreme rapidity and or which may produce poisonous fumes or explosions

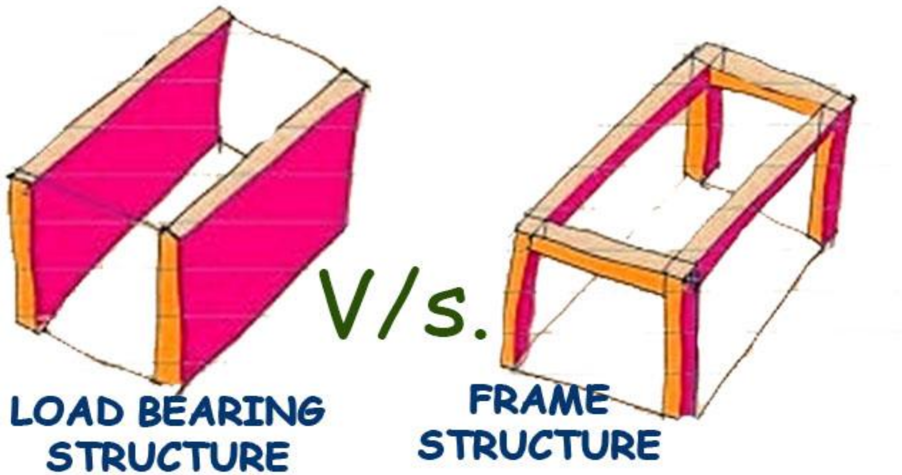
- Storage of petroleum products, ammonia etc.

Other classifications

- Load bearing structures and framed structures

- In load bearing structures, the loads are transferred to the foundation by thick walls

- In framed structures, the loads are transferred to the foundation by columns and footings
  - The walls are do not transfer any loads and serves as partition walls



Other classifications

- Based on the type of construction material used
  - RCC structures
  - Steel structures
  - Wood structures

Site Selection for a building

- Selection of an ideal site is important for the planning, design and construction of a building

- Site selection also depends upon the requirement of the building/other factors
  - You do not want to build a hospital in an heavily industrial area – Noise and other types of pollution
  - High rise buildings near airports not possible due to zoning

- In reality, a certain level of compromises are required!!!

Site Selection

- Level of the site – Should be higher than the surrounding areas for good drainage

- Climatic Conditions – Low rainfall and ground water level to prevent dampness in the building

- Sub-soil conditions – Hard sub soil within reasonable depth from the ground level

- Amenities - Must be within the city limits for getting water, electricity and sanitation facilities. Other facilities like schools, hospitals and shopping malls should be available

Some precautions

- Should avoid recently land filled sites
  - Settling of the soil leading to cracks
  - At least 2 to 3 years before construction
- Should avoid sites close to coastal areas, water bodies
  - Flooding
- Residential buildings must be away from industrial area for avoiding pollution
- Be aware of the potential legal issues
  - Flat demolition
  - Third party legal rights to the property

Thank You!

- Any doubts..???

Introduction to Basic Civil Engineering

Lecture 3 – Components of a building

Sreejith Krishnan, *PhD*

Recap

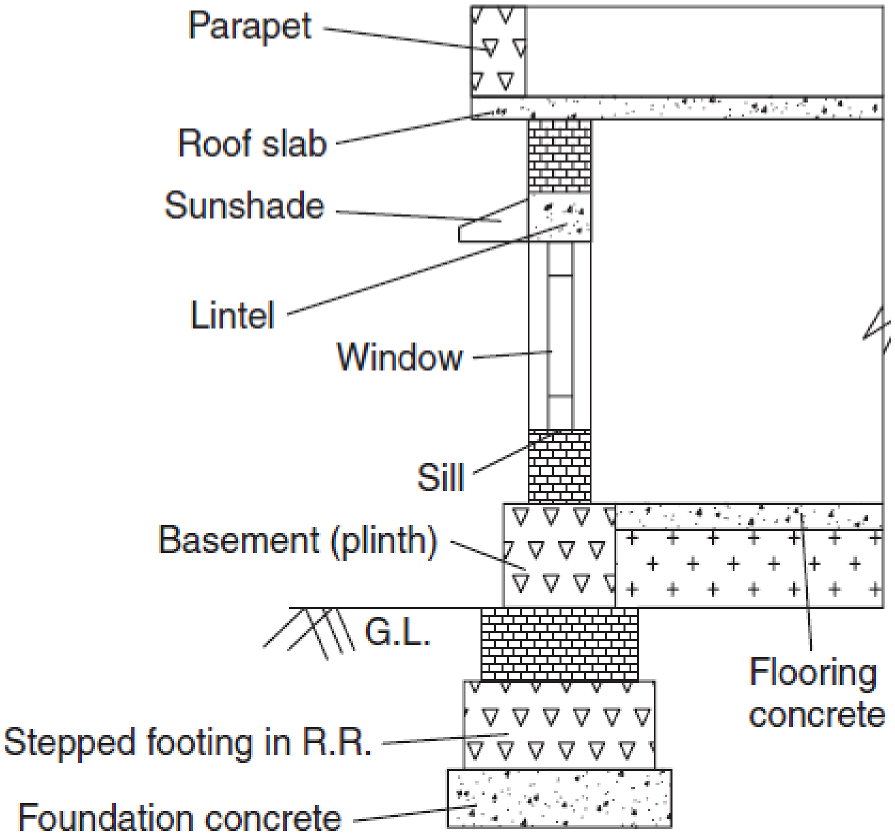
- In the previous lecture, we looked into –
  - Different types of buildings and their classification based on the National Building Code
  - Other possible classifications
    - Load bearing vs framed structures
    - RCC vs Steel Structures
  - Importance of site selection and ideal characteristics for a site

Introduction

- Basic requirements from a building
  - Strong enough to withstand the different loads
  - It should not deflect under the loads – Serviceability
  - It must give comfort and convenience to its occupants

Component of a building

- Generally consists of three parts
  - Foundation
  - Plinth
  - Superstructure



Components of a building

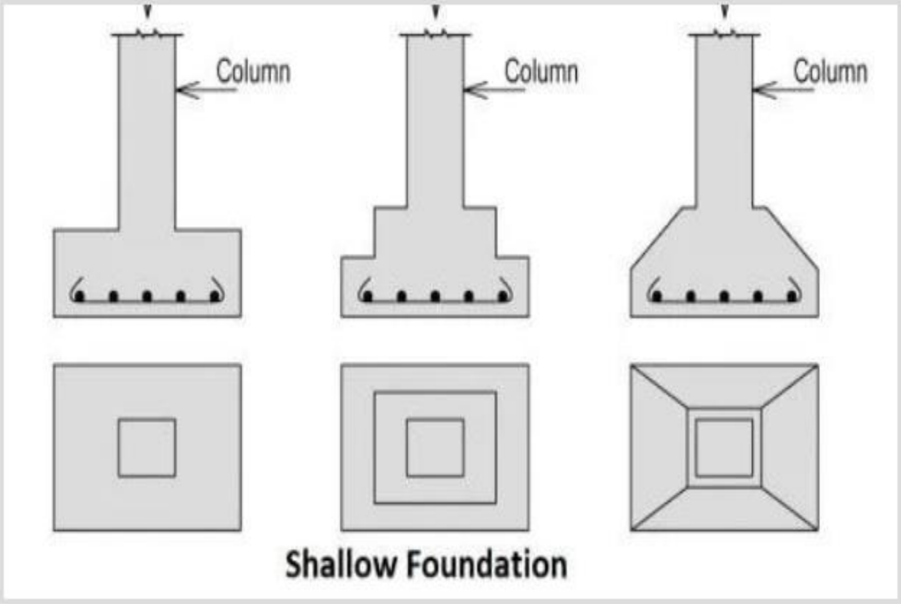
- Foundations
- Plinth
- Walls
- Doors
- Windows
- Floors
- Windows and Beams
- Staircase and lift
- Building finishes – such as plaster
- Building services – Plumbing, electrical, water supply, sewage etc.

Foundation

- The part of the structure below the ground level.
- To safely distribute the loads coming from the super structure safely to the soil below.
- To give stability to the structure against various disturbing forces such as wind and rain.
- To prepare a level surface for concreting and masonry work

Foundation

- Can be of two types
  - Shallow Foundation
  - Deep Foundation



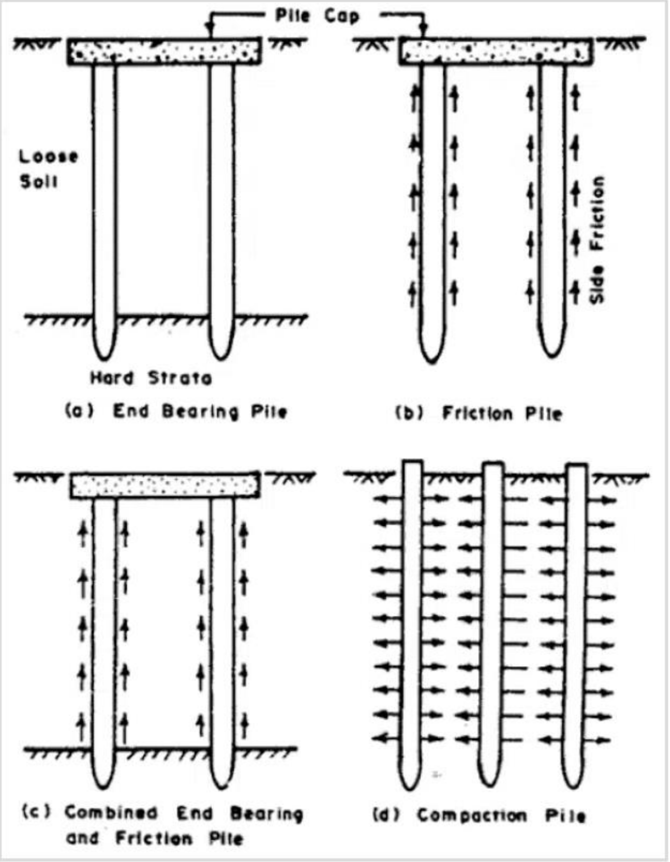
- Shallow Foundation - a foundation that transfers building loads to the earth very near to the surface

- The depth of the foundation is less than its width

- When soil at shallow depth can support the loads of the structure

Foundation

- Deep foundation – a foundation which transfers to the loads farther down the surface of the earth
- Pile foundation is an example
- Expensive but can take very high loads
- Can be up to 65m in depth



Foundation

Plinth

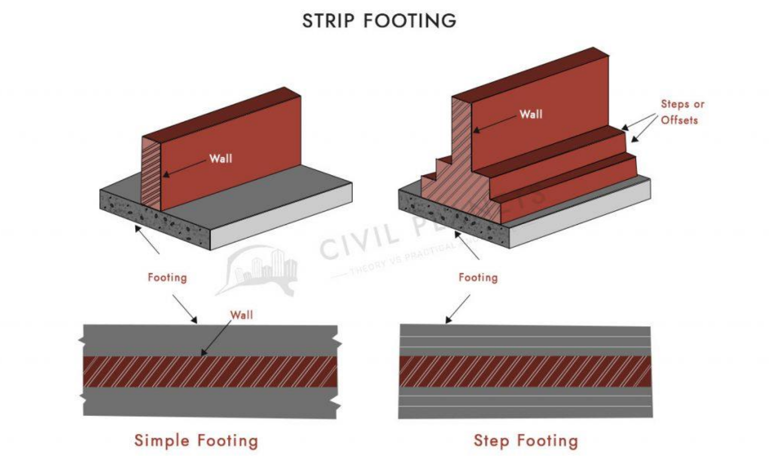
- This is the portion of the structure between the surface of the surrounding ground and the surface of the floor immediately above the ground.

  - To transmit the load of the superstructure to the foundation.
  - To act as a retaining wall so as to keep the filling in position below the raised floor or the building.
  - To protect the building from dampness or moisture.
  - To enhance the architectural appearance of the building.

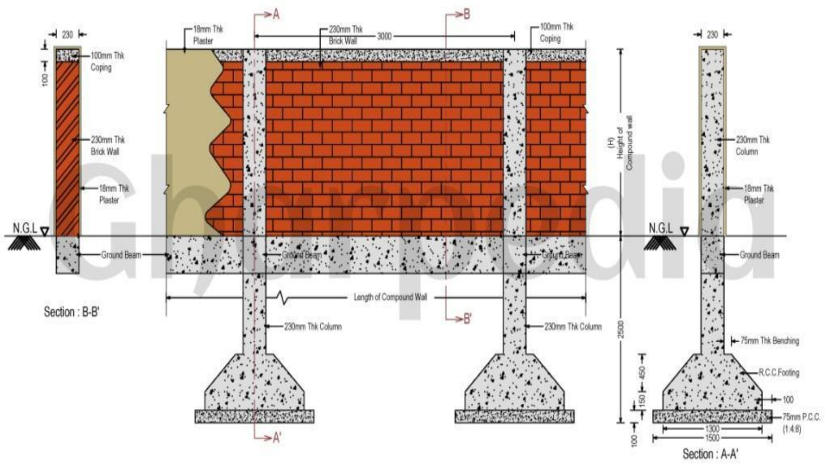
- 30 to 75 cm.

Plinth

Walls



- A masonry structure provided above plinth
- The primary function of the wall is to enclose or divide space.
- To provide privacy and security
- Two types – Partitioning and load-bearing



Floors

- The main function of a floor is to provide support for occupants, furniture and equipment of a building
- To separate the building into different floors
- Strong, stable, durable, sound resistant and fire resistant
- Timber, mosaic, marble, granite etc.

Doors and windows

- The main function of doors in a building is to serve as a connecting link between internal parts and to allow free movement to the outside of the building.

- Windows are generally provided for proper ventilation and lighting

- Weather resistance, sound and thermal insulation, fire resistance, privacy and security

Lintels

- Structural element provided on top of windows and doors for carrying the load of walls from the above

- Wood, stone, RCC, Steel etc. can be used

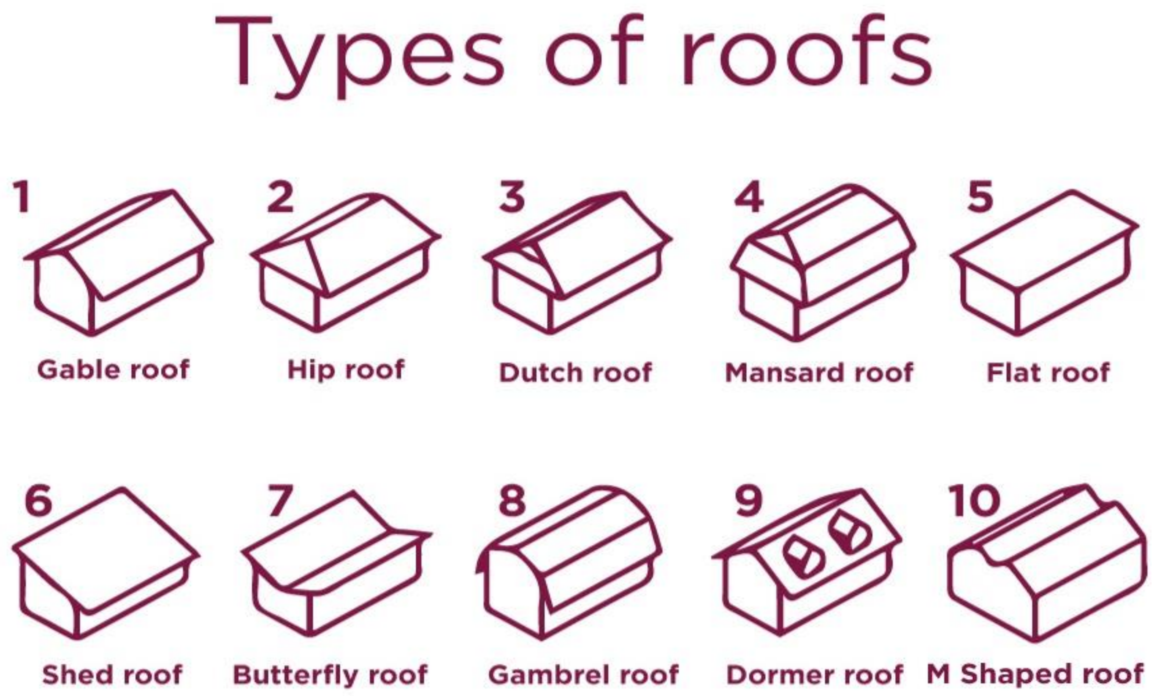
- A continuous lintel is advantageous from the view of earthquake resistance

Stairs

- A stair is a structure consisting of a number of steps leading from one floor to another.
- Act as an escape route during building fire
- Durable, strong, fire resistance, comfortable

Roofs

- A roof is the uppermost part of a building whose main function is to enclose the space and to protect the same from the effects of weather elements.



Finishing

- Finishes of several types such as pointing, plastering, painting and distempering and decorative colour washing are applied on the walls
- Protect walls from exposure
- Provide smooth surface to the walls, improved aesthetics

Thank You!

- Any doubts..???

Introduction to Basic Civil Engineering

Lecture 4 – Types and classification of structure

Sreejith Krishnan, *PhD*

Recap

- In the previous lecture, we looked into –
  - Basic requirements from a building – safety and serviceability
  - Different components of a residential building – foundation, plinth and superstructure
  - The role of different building components in a construction – beams, columns, lintel etc.

Buildings

- We had a detailed discussion on the types of buildings

- Single and double storey buildings were the most common

- Nowadays, due to cost of construction, land, family structure etc., multi-storey buildings are gaining more and more popularity

Tower

- Tower is a tall structure with a specific purpose (other than living/residential)

  - Electricity transmission tower- for distribution of electric power

  - Communication tower- for transmission of communication signals like microwave

  - Radio tower - for transmission of radio signals

  - Bell tower – for hanging bells in churches

  - Tourist tower – As a tourist attraction for the tourists to see (Eiffel tower in Paris, Leaning tower of Pisa, Italy etc)

Tower

- The towers are normally constructed with steel sections like angle, I section, Channel, square section etc.
- Connected at the junctions through welding or bolt and nut

Chimneys

- A **chimney** (flue) is a structure intended for the passing off smoke, hot flue gases from furnace or fireplace to the outside atmosphere

- Chimneys can be found in buildings, steam locomotives, ships, brick kilns, factories etc.

- The dispersion of pollutants at higher altitudes can reduce their impact on the immediate surroundings.

Chimneys

- Chimneys can be circular, square or rectangular

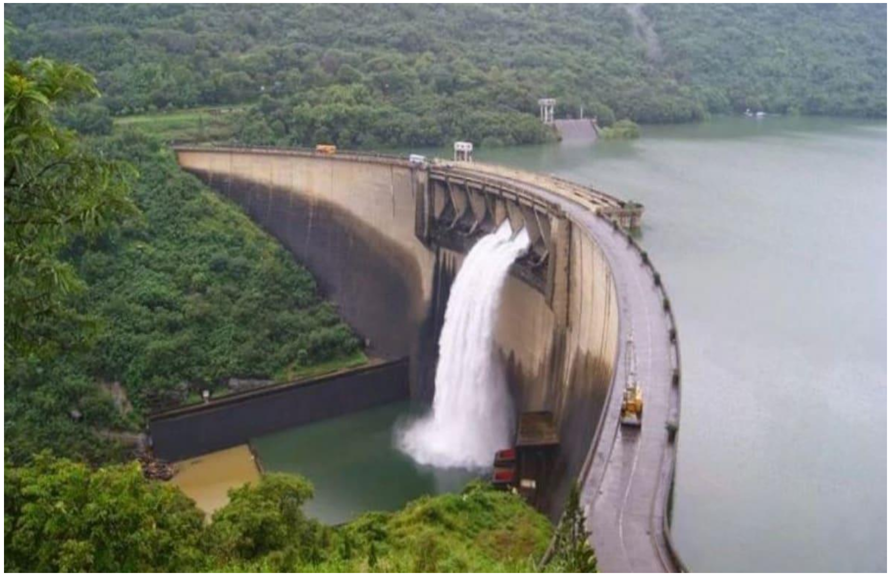
- Some considerations while building chimneys
  - Refractory lining to be provided where higher temperatures are expected

  - Wind pressure to be considered during the design

Dams

- **Dam**s are structures constructed across rivers to store water

- The water may be used for drinking, irrigation or hydro electric power generation



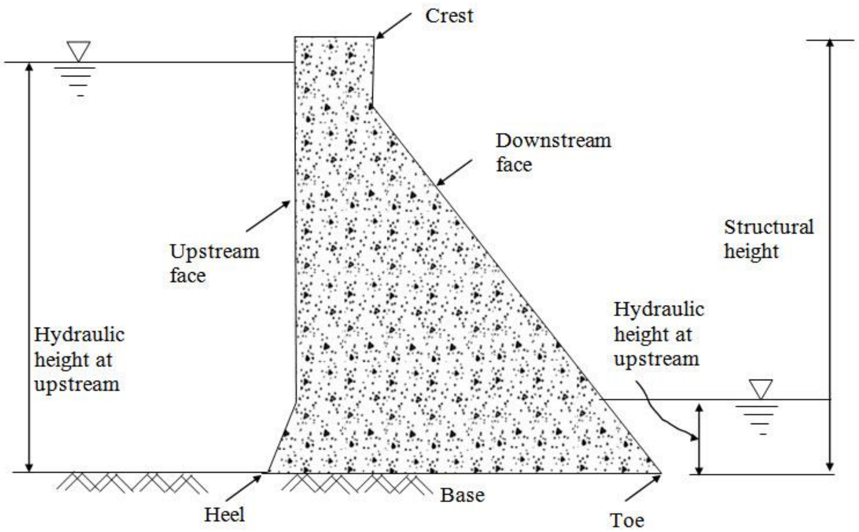
Dams - Classification

- Storage dam – Constructed to store water. The stored water may be used for irrigation, drinking or hydro electric power generation
- Flood control dam – To store the flood water and release it slowly so that the down- stream side is safeguarded against the damaging effects of floods
- Diversion dam - To divert the water from the river to a channel.
- Coffer dam – A temporary structure constructed to divert water so that the new dam or bridge can be constructed.

Dams - Classification

- Based on materials used for construction – Earthen dam, masonry dam, concrete dam, wooden dam

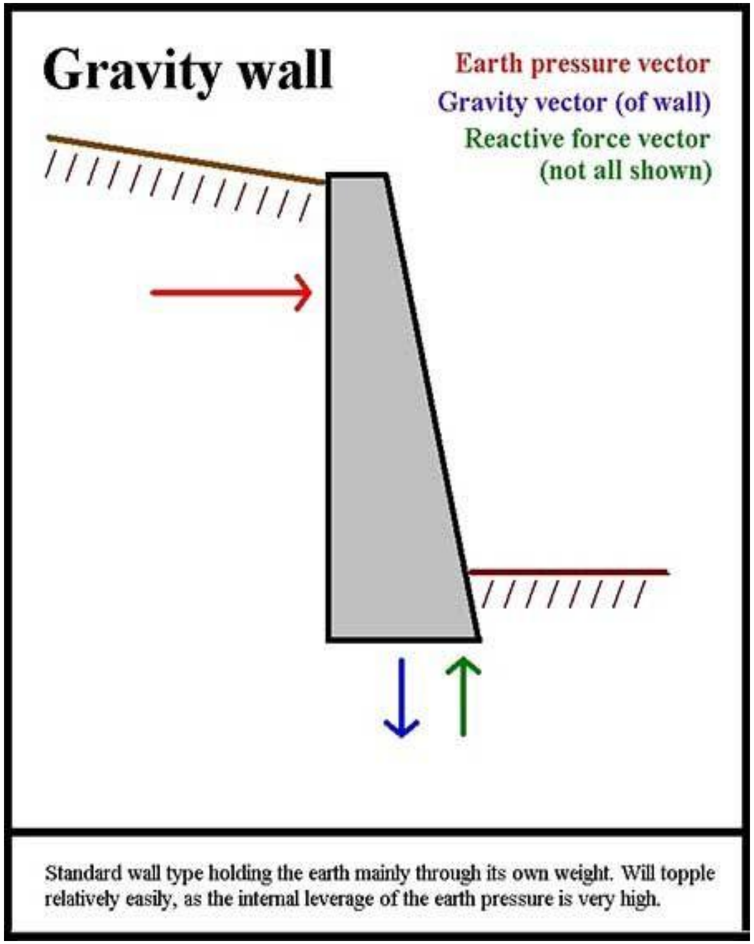
- Arch dams, gravity dams and arch-gravity dams



Retaining Walls

- **Retaining walls** are walls made of concrete or masonry to retain soil**.**

- Protect soil from erosion, stabilise slops



Water tanks

- A **water tank** is a container to store and distribute water
- Can be an overhead water tank, underground sumps
- Can be constructed using steel, concrete or plastic
- Useful distributing water, irrigation, rain water harvesting

Silos

- **Silo** is a structure, typically cylindrical in shape in which grain, cement or other materials are stored

- Can be constructed from concrete, steel etc.

Pipelines

- **Pipeline** transport is the transportation of goods through a pipe.

- Fuel, water, sewage etc.

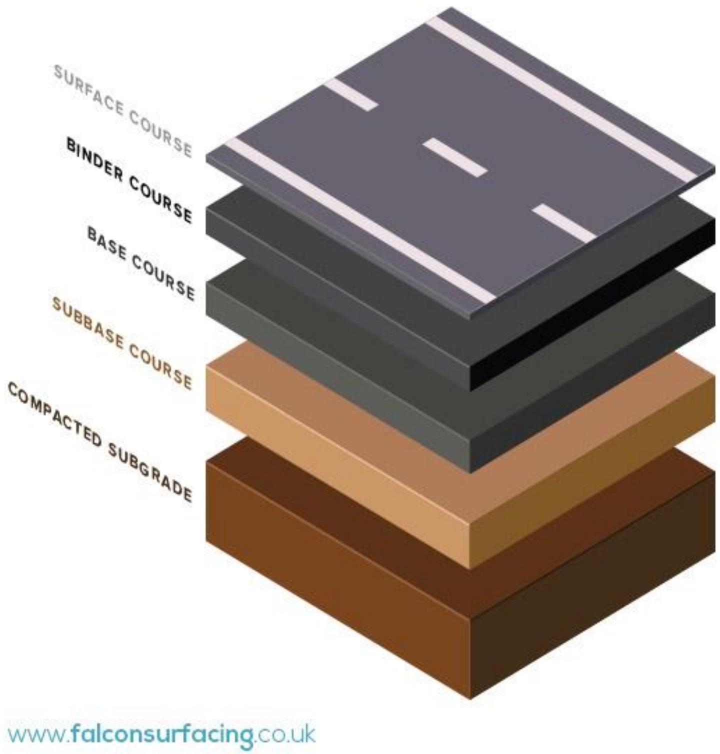
- Can be made of concrete, plastic, or steel

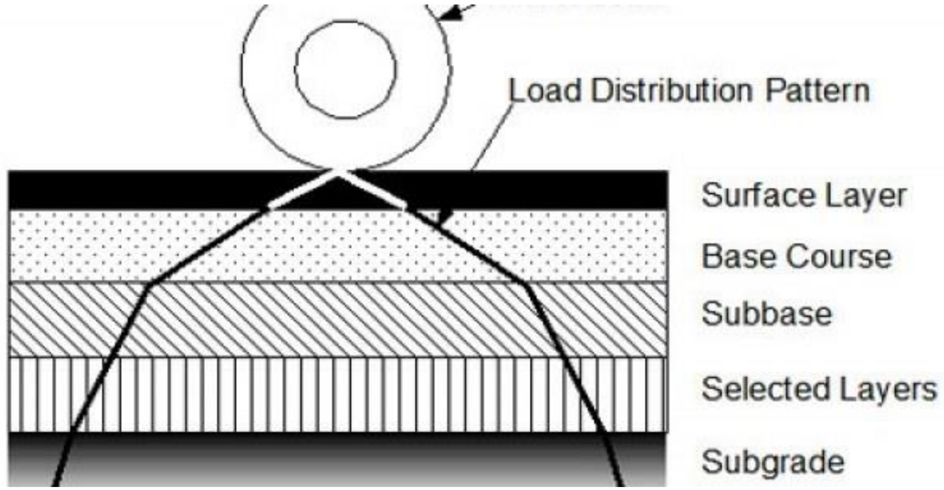
- Several advantages – large scale transportation of hazardous goods, cost effective, easy transportatiom

Roads

- Road is an identifiable pathway between two locations
- Allows easy movement of goods, people etc.
- Vital for economic development

Roads - Section





Roads - Classification

- Based on size – Single lane, double lane, four lane etc.

- Based on Nagpur road plan
  - National Highways
  - State Highways
  - Major district roads
  - Minor district roads
  - Village roads

- Based on road surface
  - Rigid pavement (Concrete pavement)
  - Flexible pavement (Asphalt pavement)

Runways

- **Runway** is a rectangular area of land in an airport prepared for the landing and take-off of aircraft.

- Runways may be a man-made surface (asphalt, concrete, or a mixture of both) or a natural surface.

- Airport types - Civilian airport, military airport

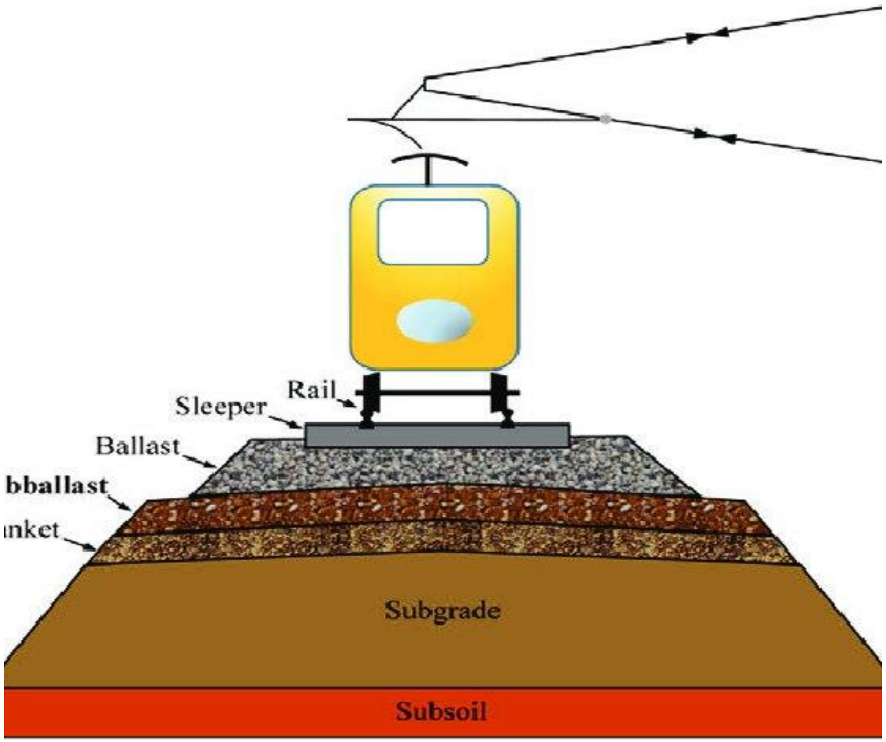
- The capacity of an airport is defined as the number of aircraft operations during a specified interval of time corresponding to a tolerable level of delay

- The selection of a site for an airport depends on – Economic factors, Commercial factors, Meteorological factors, Physical and Engineering factors.

Railways

- For the movement of trains
- Transport of goods and passenger over long distance
- Two rails are kept at a fixed distance over a sleeper
- The distance between two rails is called a gauge
  - Broad gauge (1676mm)
  - Meter gauge (1000mm)
  - Narrow gauge (762mm or 610mm)

Railways



Bridges

- A **bridge** is a structure built to cross an obstacle

Bridges

- Based on the material of construction
  - RCC Bridges
  - Steel Bridges
  - Wooden bridges

- Based on the function
  - Railway bridge
  - Road bridge
  - Pedestrian over-bridge
  - Aqueduct
  - Viaduct

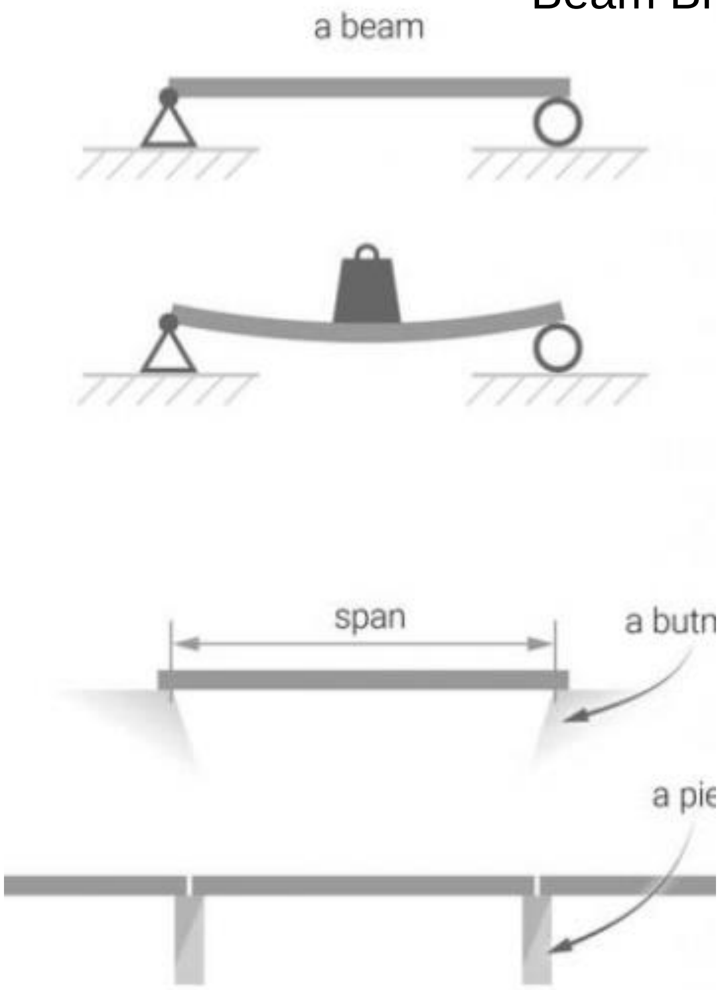
Bridges

- There are different types of bridges
  - Beam bridges
  - Truss bridges
  - Cantilever bridges
  - Arch bridges
  - Suspension bridges
  - Cable stayed bridges

- The site should be easily approachable, width of the river should be minimum, firm and stable banks, suitable foundation,

Beam Bridges

Beam Bridges

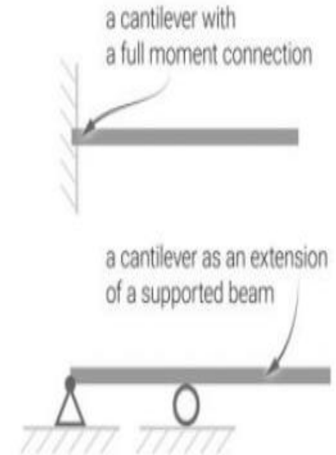


- Simplest bridge, easy to build, inexpensive

- Limited span, transportation underneath can be difficult

Cantilever Bridges

- Support is required only on one side of each cantilever



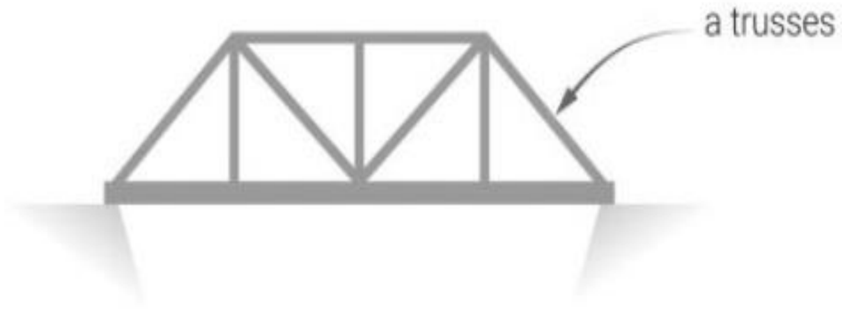
- Cantilever bridges do not require false work
  - Temporary structure for support during construction
- Longer spans, easy navigation

- Very expensive and requires high levels of maintenance
- May not be suitable in extreme weather conditions

Cantilever Bridges

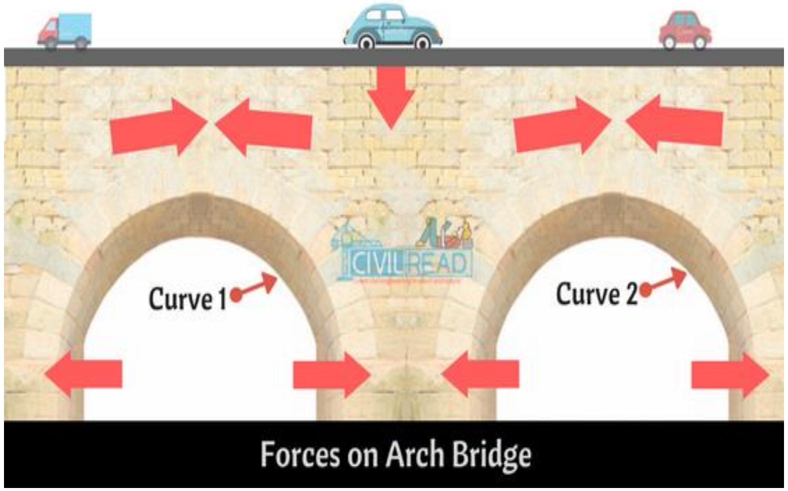
Truss Bridges

- The loads are shared by a network of trusses (interconnecting triangles)
- Extremely strong
- Deck can be on top or bottom
- High maintenance levels, expensive



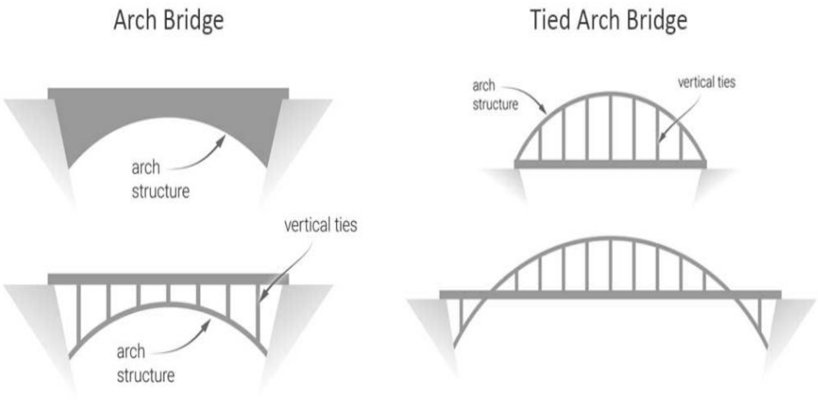
Arch bridges

- The weight of the bridge is thrust into the abutments at either side



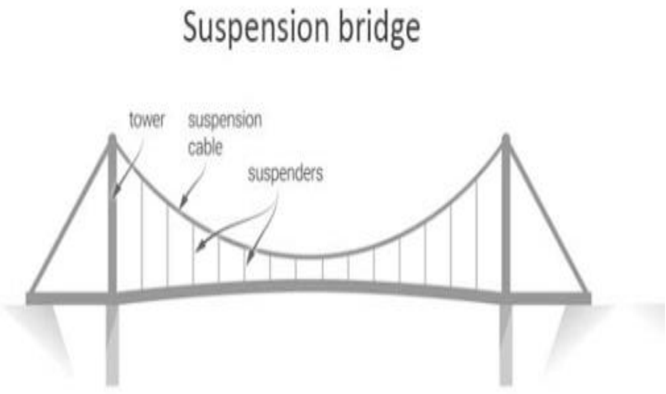
- Very strong, can be constructed from locally available materials

- Small spans for economy



Suspension Bridges

- This type of bridges are constructed by suspending the deck slab using suspension cables.



- The roadway is hanged using steel cables which are connected to two towers and secured by anchors on both ends of the bridge

- Strong and can span long distances such as across rivers.

- Expensive and complex to build.

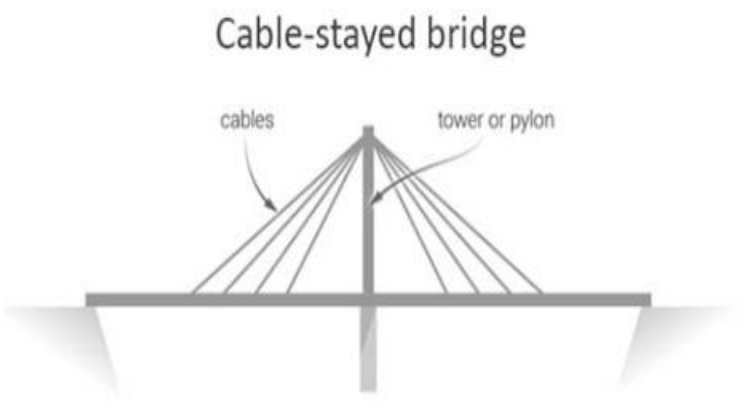
Cable-Stayed bridge

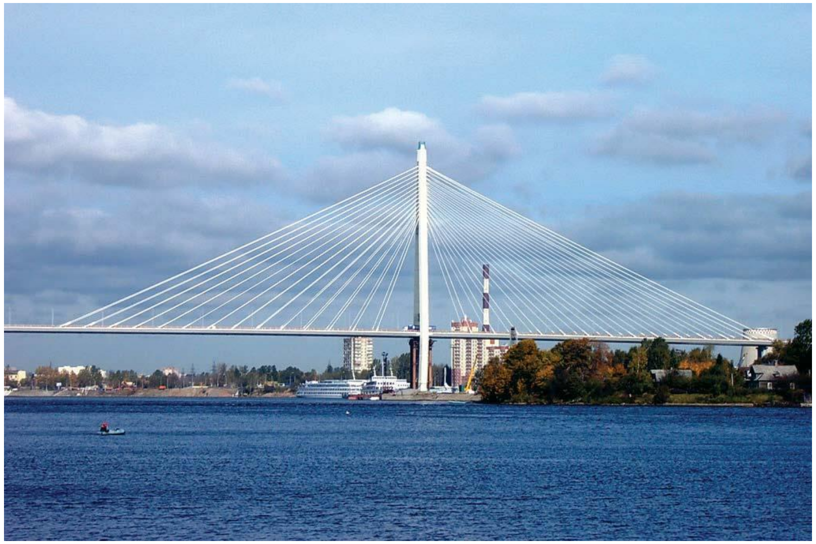
- In this type of bridge, the cables are directly connected to the roadway at different points radially, and towers alone bear the compression forces

- It is more economical when compared with the suspension bridge

- Longer spans are possible

- High levels of maintenance required





Bridge

- Lets watch a video of a bridge failure
- Learning from failures is important

Classification of Buildings

- We discussed the classification based on NBC norms
- Load bearing vs. framed structure
- Based on materials of construction – RCC, Steel, wood, composite
- Based on fire resistance – Type 1, Type 2, Type 3 and Type 4

Thank You!

- Any doubts..???

Introduction to Basic Civil Engineering

Lecture 5 – Building Rules and Regulations

Sreejith Krishnan, *PhD*

Recap

- In the previous lecture, we looked into –
  - The different type of structures other than buildings
  - Towers, dams, retaining wall, bridges etc.
  - Different classifications and functions
  - Fire resistant buildings

National Building Code

- It is the premier building code of India
- Published by the Bureau of Indian Standards
- Provides the regulation and guidelines for the construction activities across the country
  - Adopted by Government agencies, PWD and private companies
- Administrative regulations, development control rules, general building requirements
  - Fire safety, structural design, construction materials etc.
- Violation of the NBC norms can lead to heavy penalties, cancellation of building permits, or even demolition of the structure

KMBR and KPBR

- Kerala Municipal Building Rules (1999) and Kerala Panchayat Building Rules (2011) regulates the construction activities in Kerala

- Kerala Building Rules (1984) was used prior to the enactment of these rules

- KMBR for municipalities and corporations, KPBR for Panchayats

- Objective of KMBR and KPBR
  - Planned development of an area
  - Safety and well being of the occupants and public

KMBR and KPBR

- A person planning a building construction has to submit an application along with the site plan, ground plan, elevation and sections on the building to the secretary of the respective Panchayat/Municipality/Corporation for approval
- Applicant also has to prove the ownership of the land
- Secretary has to inspect the site and the building drawings to ensure that the construction will comply the regulations
  - Work permit is issued if everything is satisfactory
  - Necessary changes can be made if there are any violations
- Not required for government projects such as railways, highways etc.
- Not required for minor works such as repair, painting etc.
- Separate norms for the requirements of parking spaces, fire escape, open spaces etc. for different buildings based on the occupancy

CRZ

- Coastal zones are ecologically sensitive

- Human activities like construction, waste disposal fishing etc. has resulted in the degradation of the coastal ecosystem
  - Role of mangroves in Tsunami

- Coastal Regulatory Zones have been implemented in the Environmental Protection Act 1986
  - Objective is sustainable development and conservation of Coastal ecosystems

  - Local community (for e.g. fishermen) to play an important role in the conservation process

CRZ – Classifications

- CRZ-1: These are ecologically sensitive areas these are essential in maintaining the ecosystem of the coast. They lie between low and high tide line. Exploration of natural gas and extraction of salt are permitted

- 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.

- CRZ-3: Rural and urban localities which fall outside the 1 and 2. Only certain activities related to agriculture even some public facilities are allowed in this zone

- CRZ-4: This lies in the aquatic area up to territorial limits. Fishing and allied activities are permitted in this zone. No Solid waste should be let off in this zone.

CRZ

Coastal Regulation Zone Notification, 2011

Index

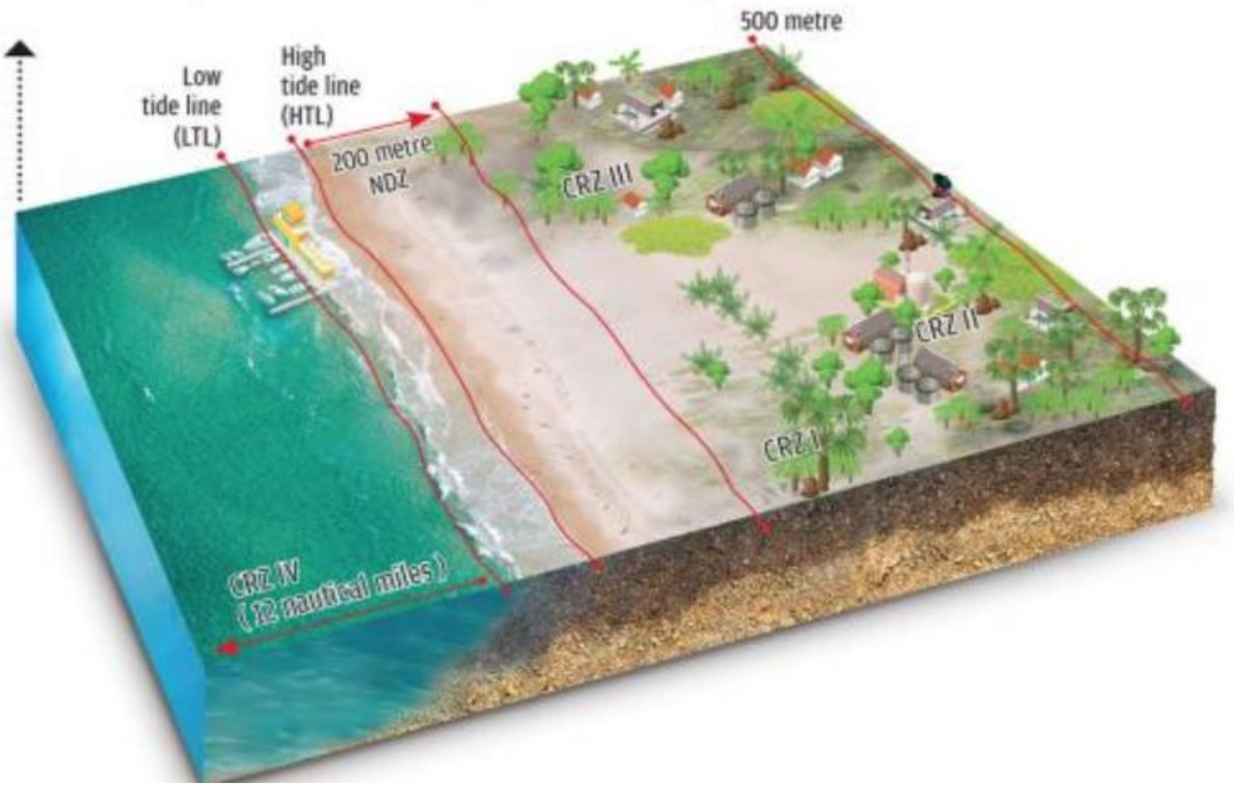
CRZ I: Eco-sensitive and intertidal areas

CRZ II: Areas which have been developed up to or close to the shore

CRZ III: Areas that are relatively undisturbed and do not fall under CRZ-I or CRZ-II

CRZ IV: Area between Low Tide Line and 12 nautical miles into the sea/ tidal influenced waterbodies

NDZ: No development zone that extends up to 200 m from High Tide Line towards land in CRZ-III area



Selection of site

- We had a small discussion on this in previous lecture
- Extent of site investigation depends on the complexity of the work
  - Minor studies for small construction like houses
  - Detailed investigation for large structures such as bridges
- Helpful in economical and safe development of the site
- Small part of the total construction cost but can potentially save huge amount at later stages

Factors considered for site selection

- Level of the land
- A plot with normal water table level
  - Can affect the quality of water
  - Can affect the foundation design
- Shape of the plot – should facilitate easy construction
- Quality of the soil – To check the bearing capacity of the soil for designing the foundations
- Easy access to amenities, located away from polluting areas

Requirements from a residential building

- Strength and Stability – Should withstand the different loads coming on to the structure
- Serviceability – Structural members should not deflect too much
- Comfort and Convenience
- Prevent dampness in the structure
- Safety against fires – Resist fire as much as possible

Requirements from a residential building

- Day lighting – Sufficient day light should be available with the help of windows

- Heat and sound insulation –
  - Should be able to maintain a constant temperature irrespective of the outside temperature variations
  - Should be able to reduce the outside noise as much as possible
  - Can be achieved using AAC blocks, thicker walls etc.

- Durability – Should last for a long time

Requirements from a residential building

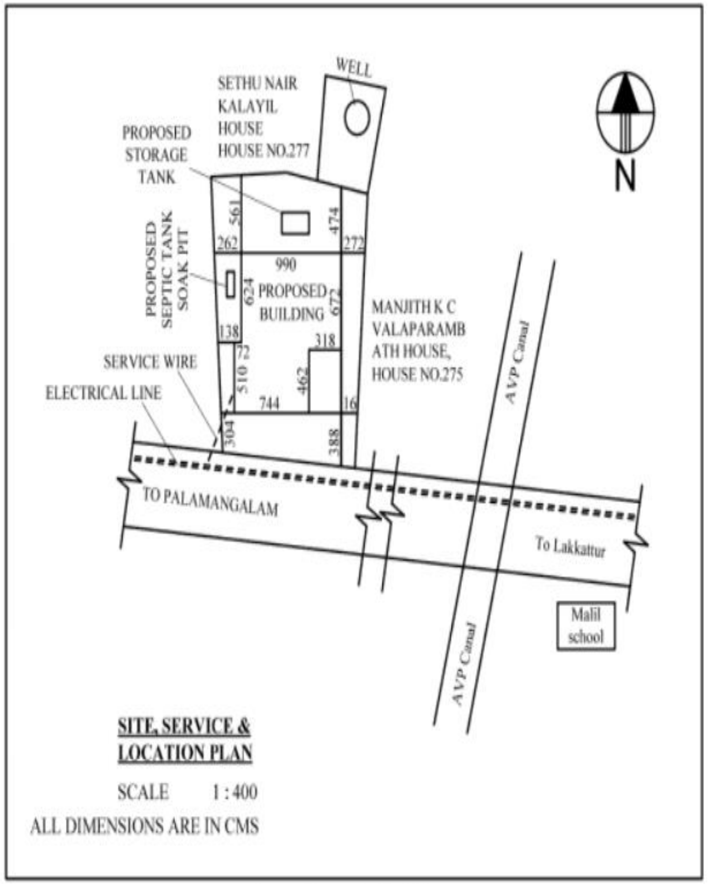
- Doors and windows placement – Should be placed to ensure sufficient sunlight
- Aesthetics – The elevation of the building should be pleasing
- Privacy – Sufficient privacy has be to available
- Placement and grouping of the rooms –
  - Kitchen in the east side, bedrooms in south/south-west direction for air circulation
  - Dining hall to be placed next to kitchen, living room near verandah etc.
- Spaciousness –
  - Plan for maximum utilisation of available space

Requirements from a residential building

- Circulation – Simple and straightforward path should be provided between room for easy circulation
  - Don't provide entry to a room from another room
  - Ideal placement of furniture for easy circulation
- Sanitation –
  - Well designed drainage facilities to remove waste from kitchen, bathroom etc.
- Flexibility
  - Some flexibility should be available for future modifications

Site Plan of the building

- Site plan is a detailed sketch of the plot with all the required details
- Should be prepared according to the building rules
- Should contain
  - Boundary of the plot and its details
  - Position of the site from neighbouring roads
  - Details of the road with name etc.
  - Existing structures in the plot
  - North direction should be marked
  - Proposed layout of the planned building
  - Other details – agricultural land, any subdivisions of the plot, requests by the authority
- Minimum scale of 1:400 on paper of size 24cm * 33 cm



Site plan of a building

Orientation of the building

- The method of fixing the direction of the plan of building so as to derive the maximum benefits from the nature elements – sun, wind and rain

- Well oriented building can also help to provide privacy and dust free environment

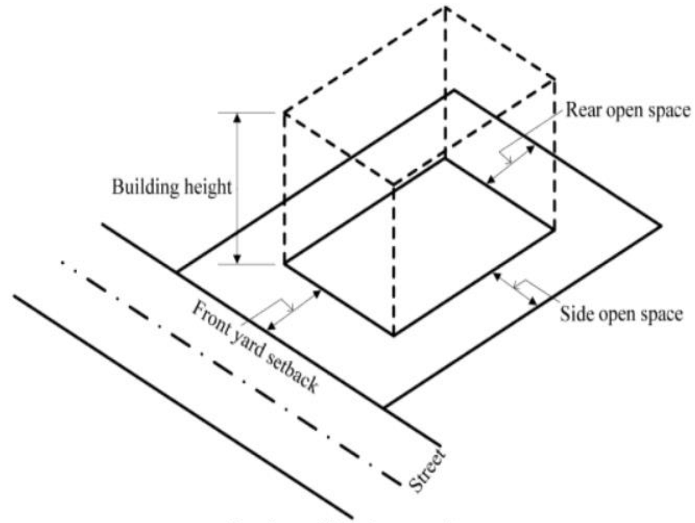
- Orientation of the building has to be first decided after the plot for construction has been identified

Factors affecting orientation

- Relative path of the sun
  - Building tends to absorb the sun rays during the day time and release the heat during the night time
  - Longer walls on the north and south side, shorter walls on the west and east side
  - Shading can be provided in by planting trees etc.
- Prevailing wind conditions
  - Windows of bedrooms provided perpendicular to the prevailing wind conditions for coolness
- Rainfall
- Site conditions

Open Space

- Open space needed around a residential building is dependent on the air and light requirements
- For public buildings, other factors must also be considered
- Open spaces are also known as setbacks
- Every building with a road in the front should definitely have a front open space



Exterior and interior open air spaces

Front Setback, m	Road Width, m
1.5	<7.5
3	7.5 to 18
4.5	18 to 30
6	>30

Rear Open Space

- Average width of 3m, but no less than 1.8m
- For back to back plots, it has to be constant 3m
- For buildings up to 7m high, rear space can be reduced to 1.5m
- Rear open space shall have to be provided along the back wall
- For corner plots less than $300m^2$ in area, the rear open space should be min 2.4m

Room Sizes - Bedroom

- The room size can depend on lots of factors – purpose, flexibility of the usage, finances involved etc.

- The height of a room designed for human occupation shall not be less than 2.75 m
- Bedrooms – Should have min. 9.5m^2 net area, also used for storing materials
- Minimum width is 2.9m, one wall external for ventilation
- Rectangle preferred, air circulation is important so should be located on the side of prevailing wind

Room Sizes -

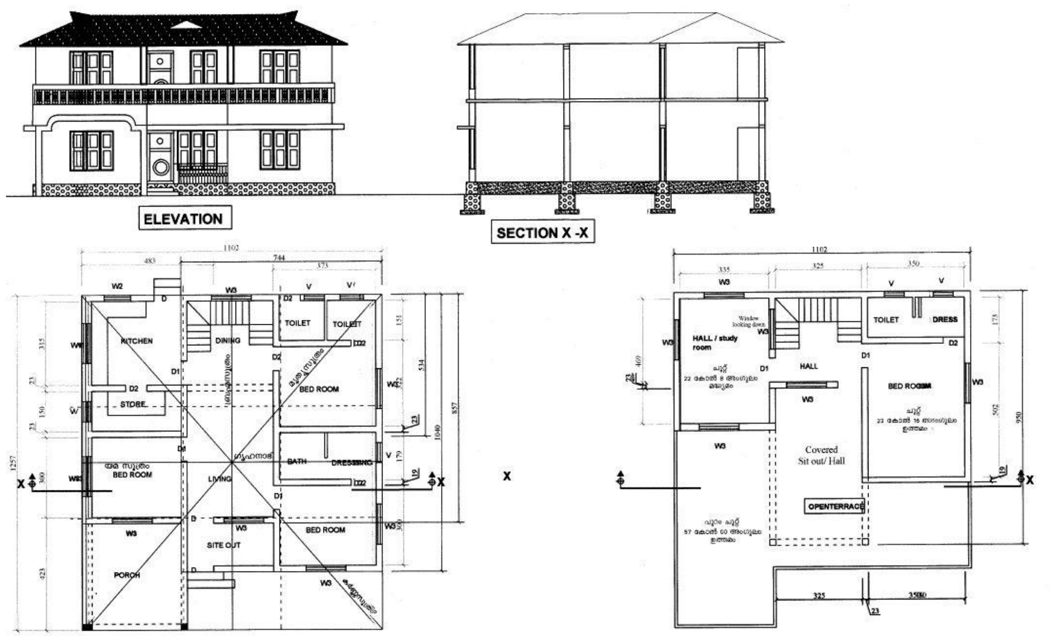
- Kitchen – Oriented towards east or north-east for maximum sunlight
- Should be of appropriate size – not too big and not too small
- Can be combined with a dining room
- Min 5 m^2 area, with a width of 1.8m

Room sizes

- Bathroom – Bathing and washing cloths
- Sufficient space for the activities
- Area should not be less than $1.8m^2$, with a minimum width of 1.2m
- Floor area of a water closed shall be $1.1m^2$

Residential plan

- It is planned drawing of the proposed construction in the paper
- Graphical representation of a building projected on to the paper
  - Scale of 1:100 on paper, should show all the details like windows, doors, stairs etc.



Residential plan

- Floor plans of all the floors, indicating size of all the rooms and members
- Show the use an occupancy of the different rooms
- Should show exactly all essential services – bathroom, kitchen etc.
- At least one elevation
- At least one section through staircase
- Show the arrangement of structural members such as beams, columns etc.
- North should be clearly marked
- Terrace plan to show the drainage and shape of the roof

Building Terms

- Plinth area/ built up area – measured at floor level of basement or individual floors including wall thickness
  - Should exclude plinth offsets

- So this is the entire area occupied by the outer walls

- Floor area – Plinth area – area of the walls

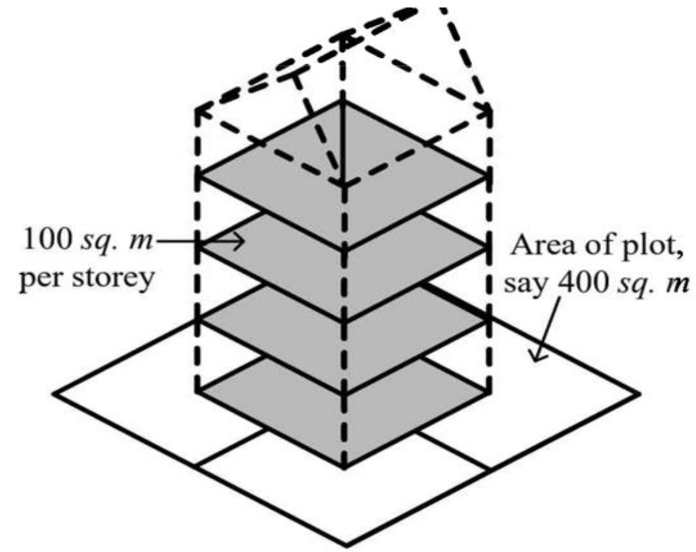
- Carpet area – floor area of the usable rooms at any floor levels

- Verandah, corridor, passageways, staircase, kitchen, lavatory not included

Building Terms

- KMBR states that 20% of the floor area shall be reduced to calculate the carpet area

- Floor area ratio – is the ratio of total built up area or the total floor area to the total area of the plot
  - Maximum allowed value is 3
  - Ranges from 1 to 2 for residential building



An example of FAR equal to 1

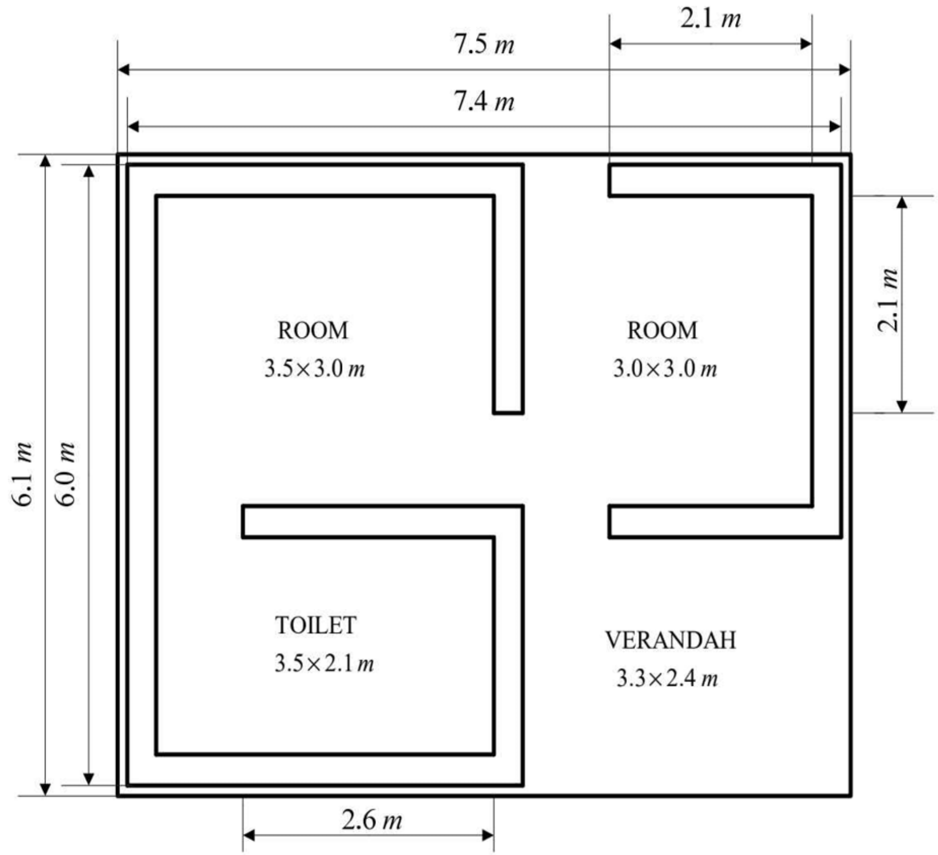
$$FAR = \frac{\text{Total covered area (plinth) on all floors}}{\text{Area of the plot}}$$

Problems

- Calculate plinth area, floor area, and carpet area of the following plan

- Walls area 30 cm thick

- Assume door as 0.9m * 2.1m



Plan of building

Thank You

- Any doubts???

Introduction to Basic Civil Engineering

Module 2- Building Materials

Civil Engineering Materials

- Cement
- Concrete
- Bricks
- Timber
- Asphalt
- Stone
- Mud
- Metal
- Ceramics
- Glass
- Stone
- Paintings and coatings

The life of materials

- Availability
- Extraction or/and production
- Usability – workability
- Predictability
- Strength
- Durability
- Disposability

Availability

Extraction/Production

Usability

Predictability in Laboratory

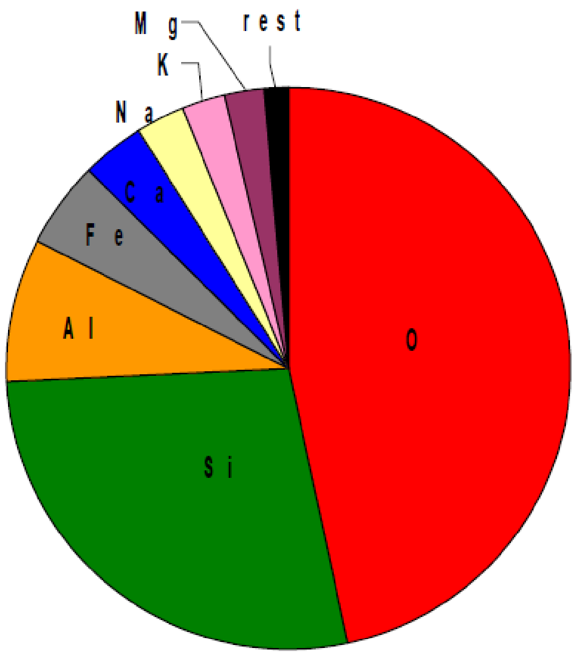
Predictability in Field

Strength

Durability

Disposability

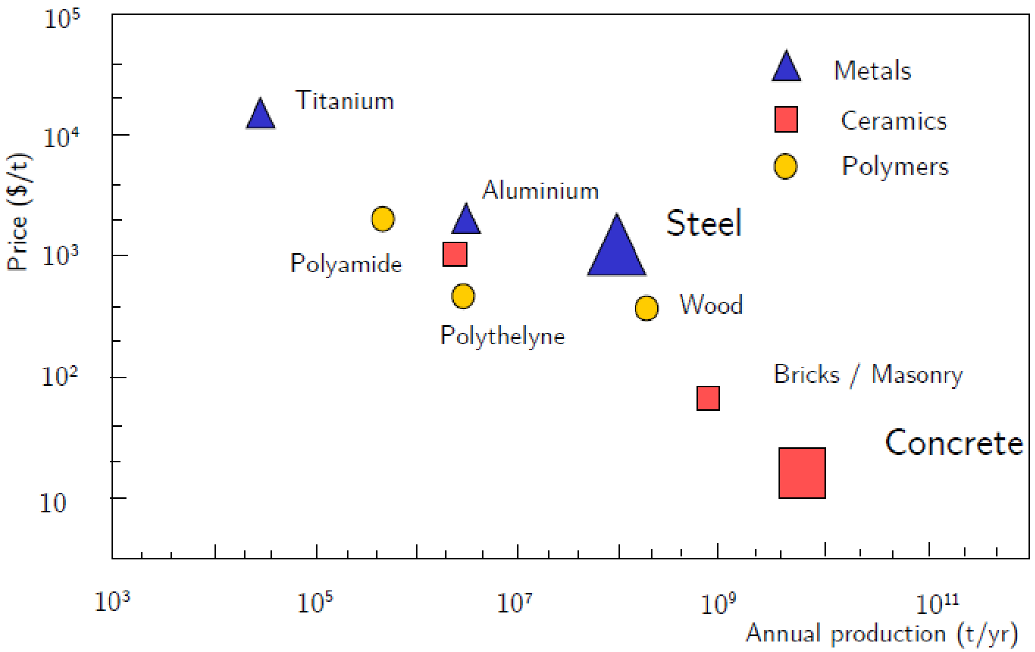
Let’s understand materials



Earth's crust

Source of all the materials

What materials do we use now?



Source: *INTRODUCTION à LA SCIENCE DES MATÉRIAUX, Kurz,Mercier, Zambelli,. PPUR , 2002*

Defects and Flaws

- All materials have flaws
  - Cracks
  - Crystal defects
  - Substitutions
  - Non-uniformities

- Flaws make important contribution to properties
  - True material properties make limited contribution

Some interesting facts

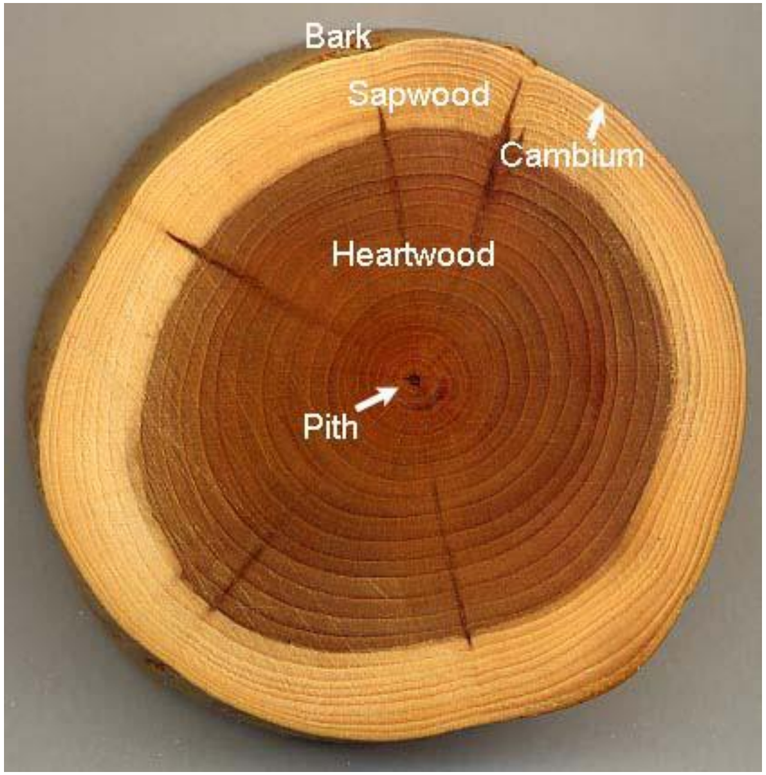
- Cement and concrete are not new materials... they have existed for thousands of years!

Some interesting facts

- Fired clay bricks are the most long lasting construction material

Some interesting facts

- Delignifed cellulose fibres can have strengths from 500 MPa to 2000 MPa

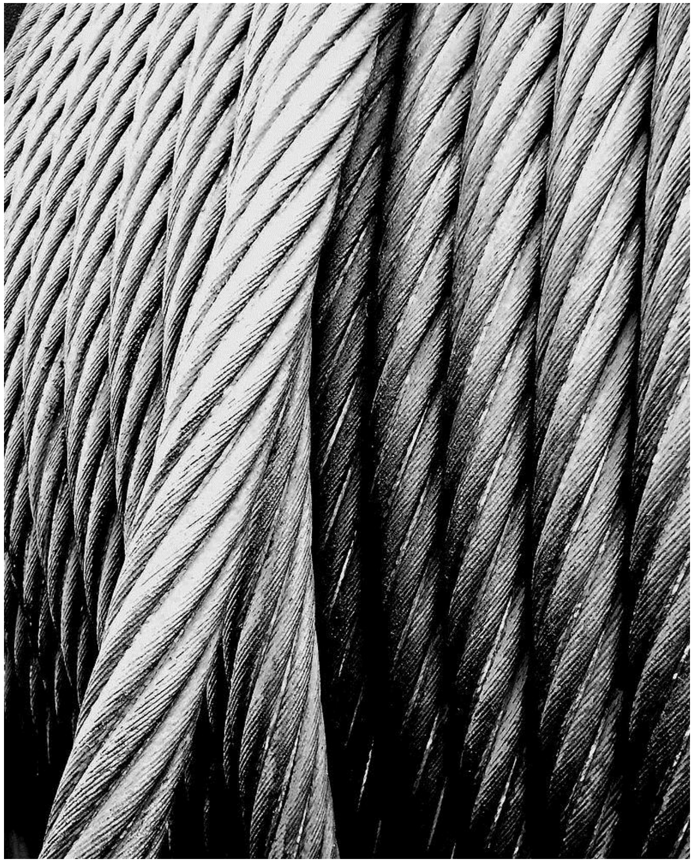


Some interesting facts

- Bitumen is one of the few massively used organic construction materials
- Obtained from petroleum!!!!

Some interesting facts

- Pure metals are too soft to use in construction
  - Contamination is important!
  - Alloys like steels



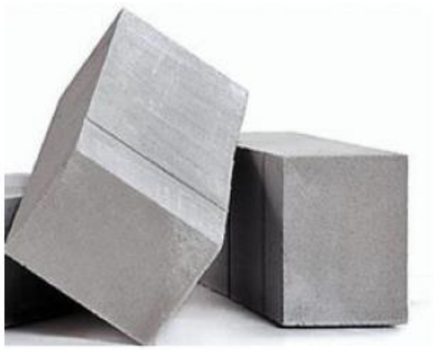
Bricks

Red clay brick

Hollow clay brick

Fly ash brick

Hollow concrete block



AAC block

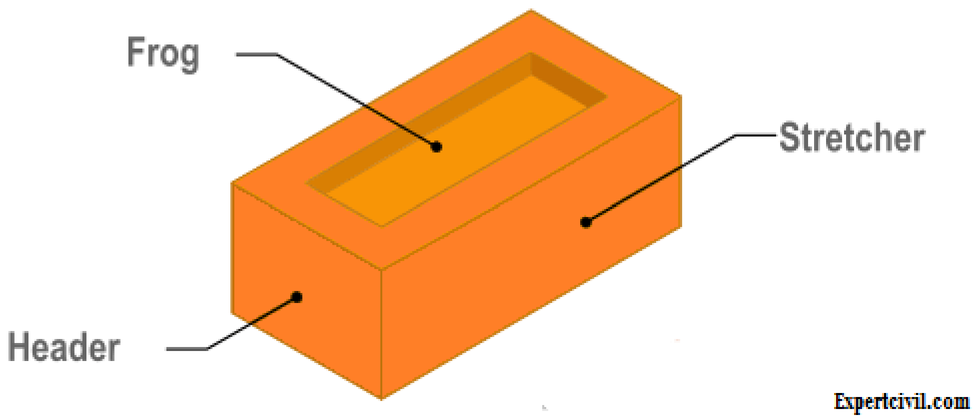
CLC block

Characteristics of bricks

- Strength
- Hardness
- Impact resistance
- Weight
- Bond
- Insulation: sound and heat
- Water absorption and permeability
- Colour
- Texture
- Shape and size

Clay bricks

- Clay is the most important material used to make bricks
  - Size of modular brick: 19x9x9 cm
  - Additional 1 cm for mortar
  - Field bricks are usually 9”x4.5”x3”
  - Bricks contain a 10x4x1 cm frog as a shear key
  - Prepared by firing at high temperature



Composition of brick

- Silica: 50% - 60%
  - Gives durability and stability
- Alumina 20% - 30%
  - Makes clay plastic, increases refractory nature
- Lime 10%
  - Helps in melting of silica, reduces drying shrinkage
  - Excess lime can cause brick to lose shape

Composition of brick

- Magnesia < 1%
  - Makes brick yellow
  - Softens clay

- Ferric oxide < 7%
  - Gives red colour: oxygen condition
  - Improved durability
  - Gives strength

- Alkalis < 10%
  - Help in fluxing
  - Cause efflorescence

Brick manufacturing

- Unsoiling – removal of top soil for clay mining
- Digging – extraction and spreading of clay on a level land
- Cleaning – removal of impurities/lumps/stones/pebbles
- Weathering – softening of clay by exposing to atmosphere
- Blending – mixing of other ingredients
- Tempering or pugging - Water in the required quantity is added and the whole mass is mixed so as to form a mass of uniform character.
- Moulding – shaping the clay mix to required shape
- Drying – drying the bricks in atmosphere
- Burning – dried bricks are placed in kiln and fired

Brick Manufacturing

Brick Manufacturing

Classes of bricks: First class

- Thoroughly burnt – deep red in colour
- Smooth, rectangular, free of flaws
- Uniform texture
- No lumps of lime
- Cannot be scratched
- Metallic ringing sound
- 12-15% water absorption
- Strength > 10 MPa

Classes of bricks: Second class

- Small cracks and distortions permitted
- 16-20% water absorption
- Strength > 7.0 MPa

Classes of bricks: Third class

- Under-burnt
- Soft and light coloured
- Dull sound
- Used for temporary structures

Classes of bricks: Fourth class

- Over-burnt
- Badly distorted
- Brittle
- Used for mettle work in floors, foundation and roads

Strength classes of bricks

Table 1 Classes of Common Burnt Clay Bricks
(*Clause* 4.1)

Class Designation	Average Compressive Strength not Less Than N/mm²	(kgf/cm²) (approx)
35	35·0	(350)
30	30·0	(300)
25	25·0	(250)
20	20·0	(200)
17·5	17·5	(175)
15	15·0	(150)
12·5	12·5	(125)
10	10·0	(100)
7·5	7·5	(75)
5	5·0	(50)
3·5	3·5	(35)

Tests of bricks

- Crushing strength
- Absorption
- Shape and size
- Field Tests

Crushing Strength

- Bricks are placed in a compressive strength testing machine and crushed
- Frog is filled with mortar, stored in a damp jute bag for 24 hours, followed by immersion in water for 24 hours
- Load applied uniformly over the brick
- The failure load noted to calculate the compressive strength
- Average value of 5 bricks is reported

Absorption

- Brick specimen are weighed dry
- Then they are immersed in water for a period of 24 hours.
- The specimen are taken out and wiped with cloth. The weight of each specimen in wet condition is determined.
- The difference in weight indicate the water absorbed
- Should not be more than 20%

Shape and Size

- Bricks should be of standard size and edges should be truly rectangular with sharp edges

- 20 bricks placed along length, breadth and height

- Following tolerance levels are allowed
  - Length wise: 3680 to 3920 mm
  - Width wise: 1740 to 1860 mm
  - Height wise: 1740 to 1860 m

Field Tests/ Desirable Bricks Properties

- Uniformity in shape – A good brick should have rectangular plane surface and uniform in size.

- Uniformity in colour **-** A good brick will be having uniform colour throughout.

- Structure - A few bricks may be broken in the field and their cross-section observed. The section should be homogeneous, compact and free from defects such as holes and lumps.

Field Tests/ Desirable Bricks Properties

- Sound Test - If two bricks are struck with each other they should produce clear ringing sound

- Hardness Test: For this a simple field test is scratch the brick with a nail. If no impression is marked on the surface, the brick is sufficiently hard.

- Toughness Test – Drop the brick from 1m height. It should not crack

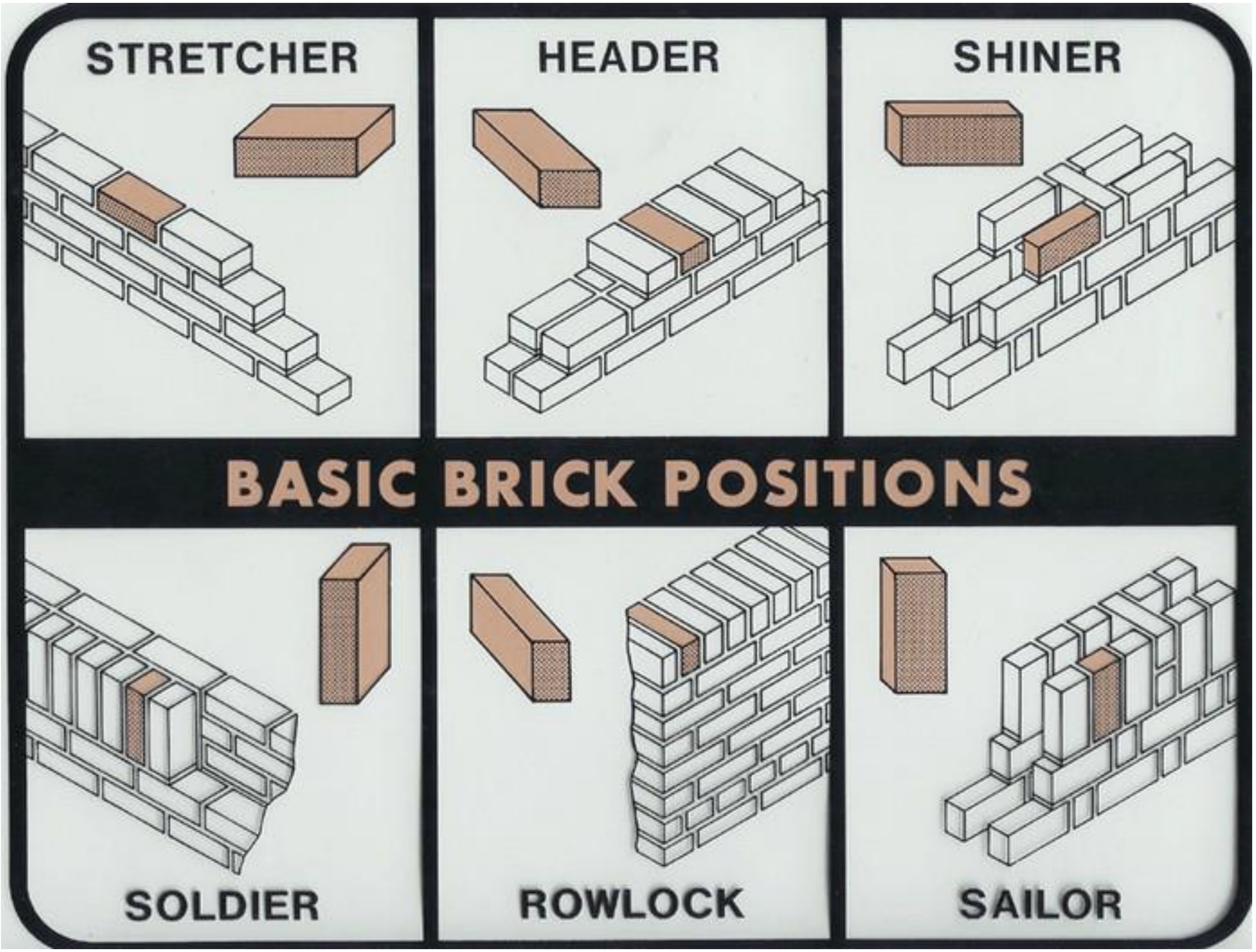
Field Test - Efflorescence

- Place the brick specimen in a glass dish containing water to a depth of 25 mm in a well ventilated room.

- After all the water is absorbed or evaporated again add water for a depth of 25 mm.

- After second evaporation observe the bricks for white/grey patches.

Position of bricks



Thank You!

- Any doubts..???

Introduction to Basic Civil Engineering

Module 2- Stones and Cement

Stones

- One of the most commonly used building material during early ages
- Obtained from rocks in the earths crust
- Usually, a combination of minerals such as quartz, calcite, etc.

Use of stones

- Construction of foundation, walls, arches, abutments etc.
- For making stone masonry
- Coarse aggregate in concrete
- Ballast in railways, preparation of base course and sub base course in roads
- Flooring materials
- Roofing materials
- Industrial application such as production of cement

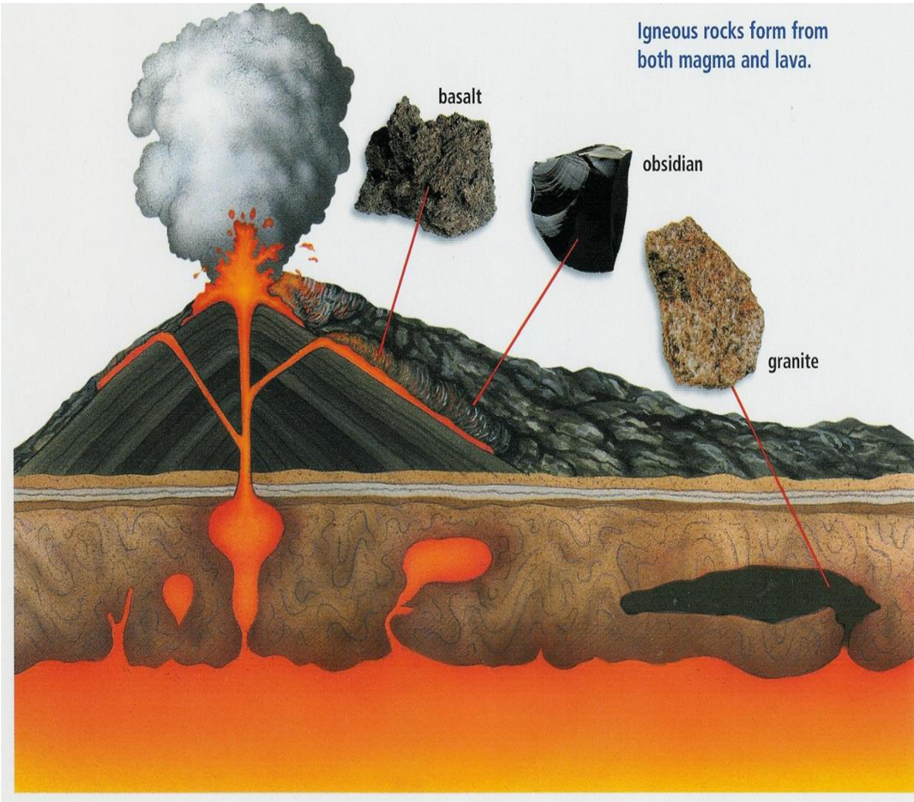
Stones - Classification

Based on origin –

- Igneous rocks - formed by the cooling of magma are called igneous rocks.
    - Strong and durable

- The portion of lava which comes outside the surface cools quickly and forms a rock of non-crystalline nature called as trap or basalt

- The rest which remains inside the earth undergoes cooling at a slow rate and results in the formation of a rock of crystalline variety known as granite.



Stones - Classification

- Sedimentary Rocks - formed by the weathering action on the original rock and subsequent transportation by air, river, glacier and sea and deposition at a different localities

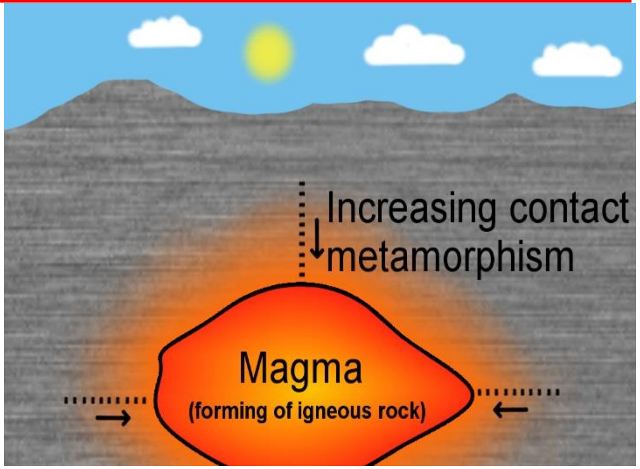
- The deposits gets consolidated by the pressure and heat forming rocks
  - Uniform, fine grained and compact
  - Stratified in appearance

- Eg. limestone, sand stones etc.

- Further classified into
  - Residual deposit, sedimentary deposit, chemical deposit and organic deposits

Stones - Classification

- Metamorphic stones - rocks are formed by the change in character of the pre-existing rocks
  - High pressure and temperature, chemical agents



- Eg. Limestone to Marble, sandstone to quartzite, granite to gneiss

Stones - Classification

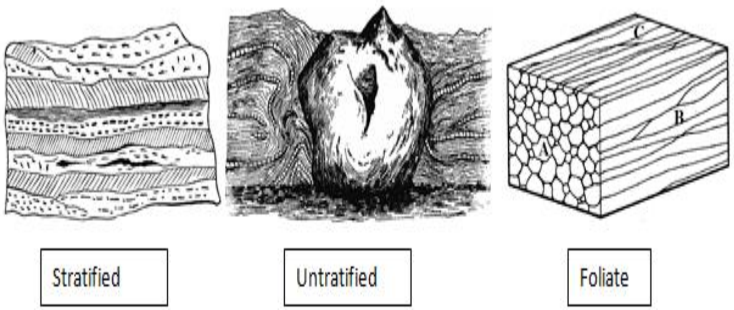
Based on chemical composition

- Siliceous rocks – Silica is the major mineral
  - Hard and durable
  - Not easily affected by weathering
  - Granite, Sandstones etc

- Argillaceous rocks – Clays are the main mineral
  - Can be dense, compact
  - Can be soft and brittle
  - Laterites, slate etc.

- Calcareous rocks – Calcium carbonate is the predominant mineral
  - Durability will depend on the atmosphere
  - Limestone, marble, dolomite

Stones - Classification



Based on the structure of the rock

- Stratified rocks - possess planes of stratification or cleavage
- Can be easily split along the layers of stratification

- Unstratified rocks – No layers or stratifications.
- Structure may be crystalline granular or compact granular
- Cannot be split into thin slabs
- Granite,

- Foliated rocks – typically seen in metamorphic rocks were grains are oriented along a particular direction due to heat and pressure
- These rocks have a tendency to be split up in a definite direction only

Identify

Dressing of stones

- A place where exposed surfaces of good quality natural rocks are abundantly available is known as ‘quarry’

- The process of taking out stones from the natural bed is known as ‘quarrying

- The stones after being quarried are to be cut into suitable sizes and with suitable surfaces which is called dressing of stones
  - To make the transport from the quarry easy and economical.
  - To suit the requirements of stone masonry.
  - To get the desired appearance for the stonework

Characteristics of a good stone

- Crushing strength – Should have sufficient strength to withstand loads.
- Hardness – Should be sufficiently hard, especially for flooring and pavement applications.
- Appearance – important from an architectural point of view. Colour is dependent on the type of mineral present.
- Resistance to fire – clay stones are resistant to fire but softer
- Texture - good building stone should have a compact fine crystalline structure, free from cavities, cracks or patches of soft or loose material.

Characteristics of a good stone

- Durability -It denotes the period in years for which a stone may stand practically unaltered after being used in construction.

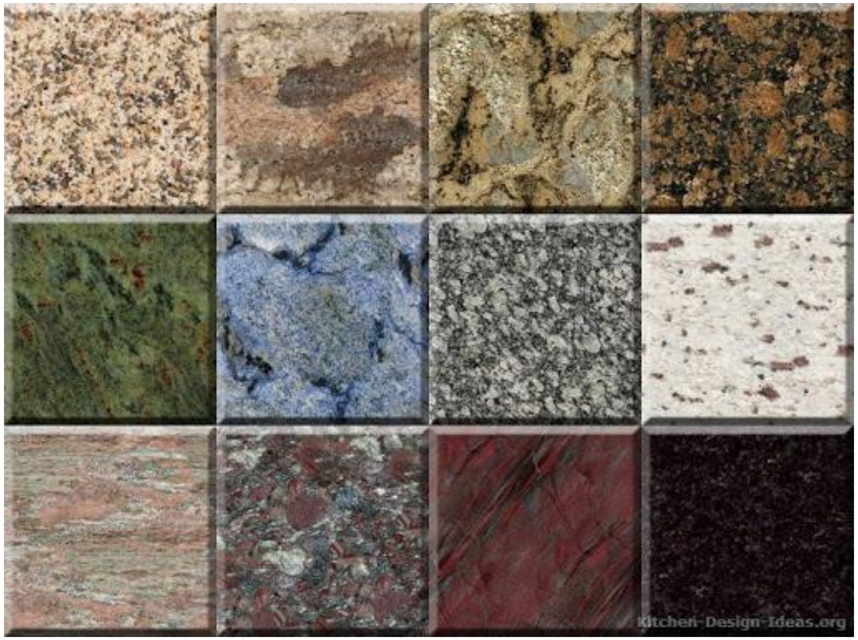
- *Water absorption:* Moisture reduces the strength of the rocks and as such rocks that contain or absorb great amounts of moisture show lower strength values. For a good stone, percentage absorption by weight after 24 hours should not exceed 0.60

- *Weathering:* A good building stone should possess better weathering qualities. It should be capable of withstanding adverse effects of various atmospheric and external agencies such as rain, frost, wind, etc.

- Ease of dressing - Should be capable of being dressed easily. Important from the economic point of view

Common Stones in India

- *Granite:* Granite is an igneous rock and is hard and durable. 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



Common Stones in India

- *Limestone:* They are sedimentary rocks composed mainly of calcium carbonate. They show great variation in their properties and, hence, all types are not useful as building stones.

- Useful for paving and flooring

- Useful for the production of cement

- Can be used for road construction etc.

Common Stones in India

- *Marble:* These are metamorphic rocks and have been formed from limestone under high temperatures. Marbles vary greatly in colour, structure and texture and most of them are suitable both as an ornamental stone and as a construction material.

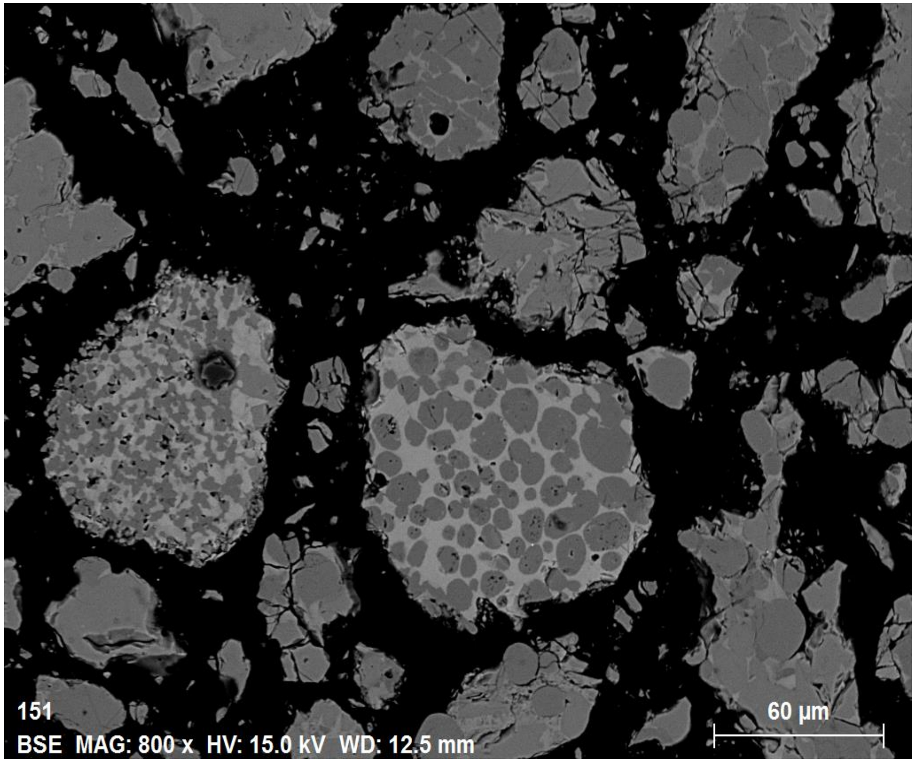
- *Laterite:* It is a sedimentary rock composed mainly of oxides of iron and aluminium. Laterites are of dull red or brown colour and their important property is that they are quite soft and plastic when cut from the natural bed rock but become hard on exposure.

Common Stones in India

- Other kind of stones are sand stone, basalt, kankar, gneiss, etc.

Cement

- In construction, cements are usually fine powders (100nm to 300μm) that harden on reacting with water



Cements

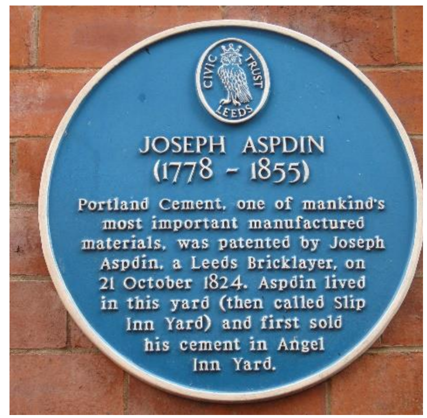
- There are many types of cements, e.g.:
  - Portland cements,
  - Calcium aluminate cements (High alumina cements),
  - Calcium sulpho-aluminate cements
  - Blended cements, etc.

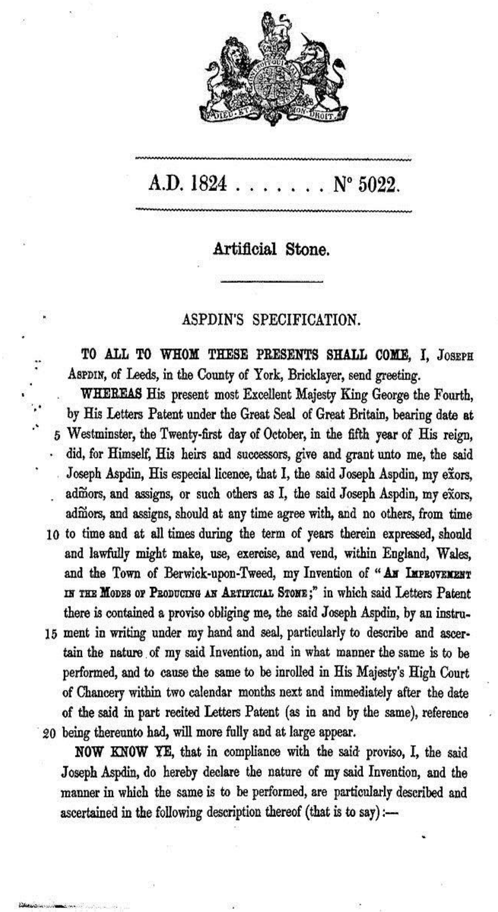
Portland Cement

- The most commonly used cement is Ordinary Portland Cement or simply OPC

- OPC is so called as it bears similarity to the Portland Stone found in England

- Joseph Aspdin, a British brick-layer got a patent to Portland cements in 1824





A.D. 1824 . . . . N° 5022.

Artificial Stone.

ASPDIN'S SPECIFICATION.

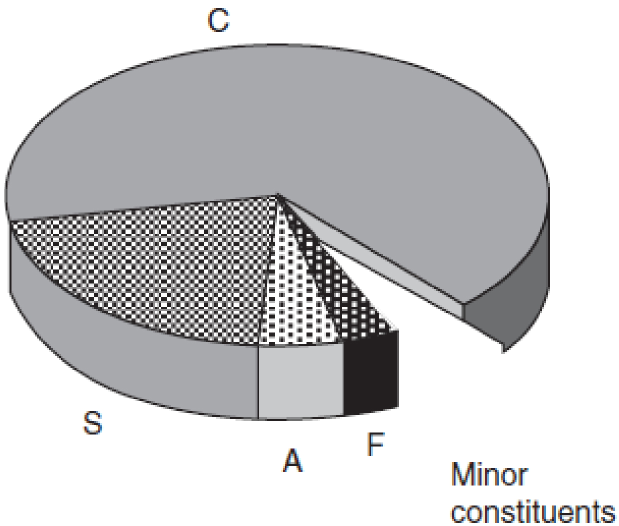
TO ALL TO WHOM THESE PRESENTS SHALL COME, I, JOSEPH ASPDIN, of Leeds, in the County of York, Bricklayer, send greeting.

WHEREAS His present most Excellent Majesty King George the Fourth, by His Letters Patent under the Great Seal of Great Britain, bearing date at Westminster, the Twenty-first day of October, in the fifth year of His reign, did, for Himself, His heirs and successors, give and grant unto me, the said Joseph Aspdin, His especial licence, that I, the said Joseph Aspdin, my exors, admors, and assigns, or such others as I, the said Joseph Aspdin, my exors, admors, and assigns, should at any time agree with, and no others, from time to time and at all times during the term of years therein expressed, should and lawfully might make, use, exercise, and vend, within England, Wales, and the Town of Berwick-upon-Tweed, my Invention of "AN IMPROVEMENT IN THE MODES OF PRODUCING AN ARTIFICIAL STONE;" in which said Letters Patent there is contained a proviso obliging me, the said Joseph Aspdin, by an instrument in writing under my hand and seal, particularly to describe and ascertain the nature of my said Invention, and in what manner the same is to be performed, and to cause the same to be inrolled in His Majesty's High Court of Chancery within two calendar months next and immediately after the date of the said in part recited Letters Patent (as in and by the same), reference being thereunto had, will more fully and at large appear.

NOW KNOW YE, that in compliance with the said proviso, I, the said Joseph Aspdin, do hereby declare the nature of my said Invention, and the manner in which the same is to be performed, are particularly described and ascertained in the following description thereof (that is to say):—

Cement Composition

Main constituents	Cement chemist's shorthand	%
SiO_2	S	21.1
Al_2O_3	A	5.6
Fe_2O_3	F	3.0
CaO	C	65.5
		95.2

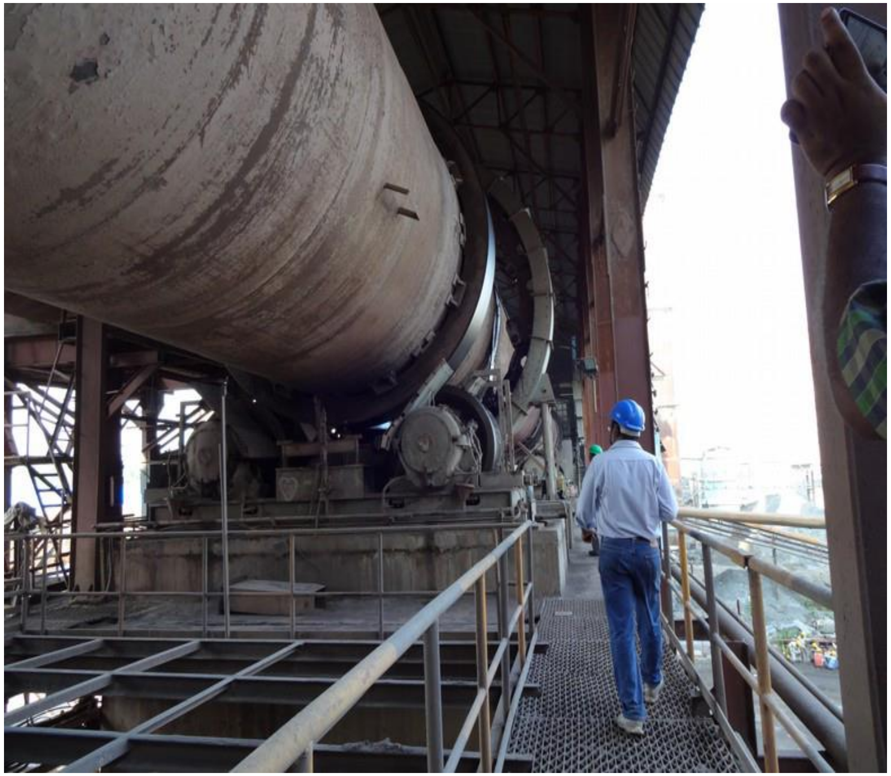


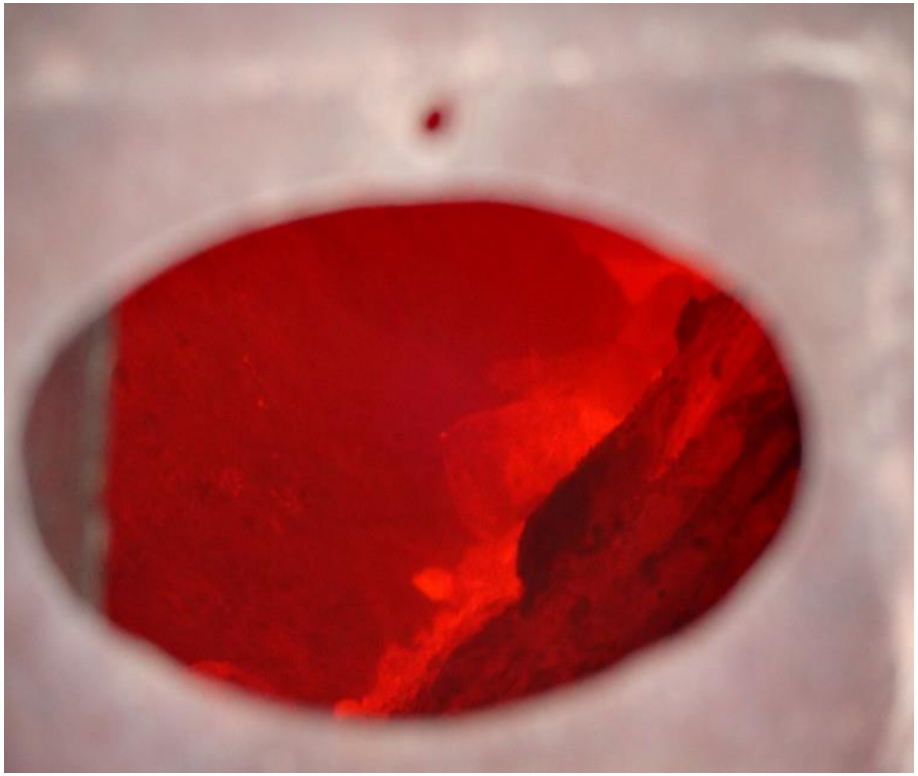
Minor constituents	%
Mn_2O_3	0.05
P_2O_5	0.15
TiO_2	0.30
MgO	1.50
SO_3(S)	1.20
Loss on ignition	0.50
K_2O	0.72
Na_2O	0.18
Fluorine	0.04
Chloride	0.02
Trace elements	0.01
	4.67

Cement Production

- By heating a well homogenised mixture of clay and limestone in a rotary kiln up to 1450° C
- Limestone
  - Production of $CaO + CO_2$
- Clay
  - Production of $SiO_2 + Al_2O_3 + Fe_2O_3$

Cement Production





Cement production

- Clinker is formed in the rotary kiln
  - Ground with gypsum to regulate the setting time of cement

Cement Composition

Major phases in Portland Cement

- 3CaO.SiO2 – Alite – C_3S (45-65%)
- 2CaO.SiO2 – Belite – C_2S (10 – 30%)
- 3CaO.Al2O3 – Aluminate – C_3A (5-12%)
- 4CaO.Al2O3.Fe2O3 – Ferrite - C_4AF (6 – 12%)

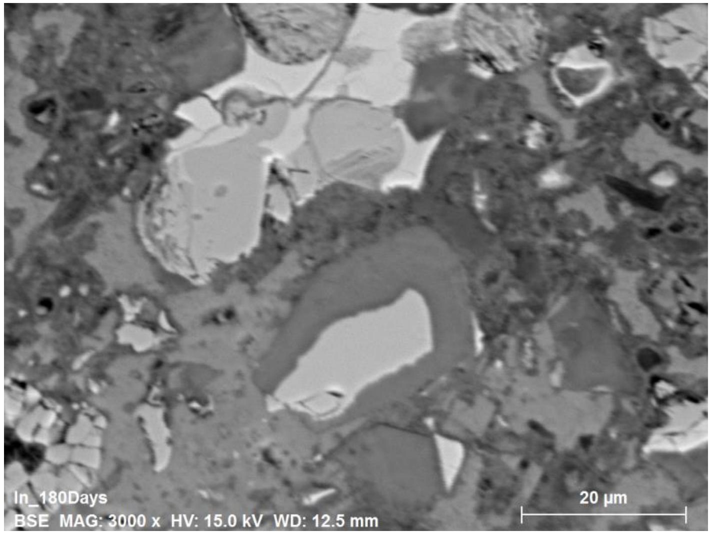
Cement chemistry notations are used

Alite and belite are the main strength providers

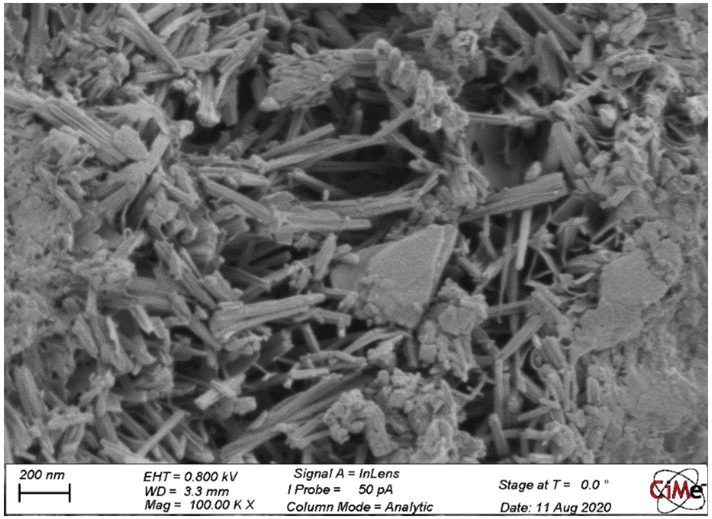
We add 5% gypsum to prevent very fast reaction of cement

Why does cement harden?

- Alite and belite react with water to form amorphous calcium silicate hydrate gel
  - $C_3S + H \rightarrow C\text{-}S\text{-}H + CH$
  - $C_2S + H \rightarrow C\text{-}S\text{-}H + CH$



- C-S-H is the binding “glue” of concrete

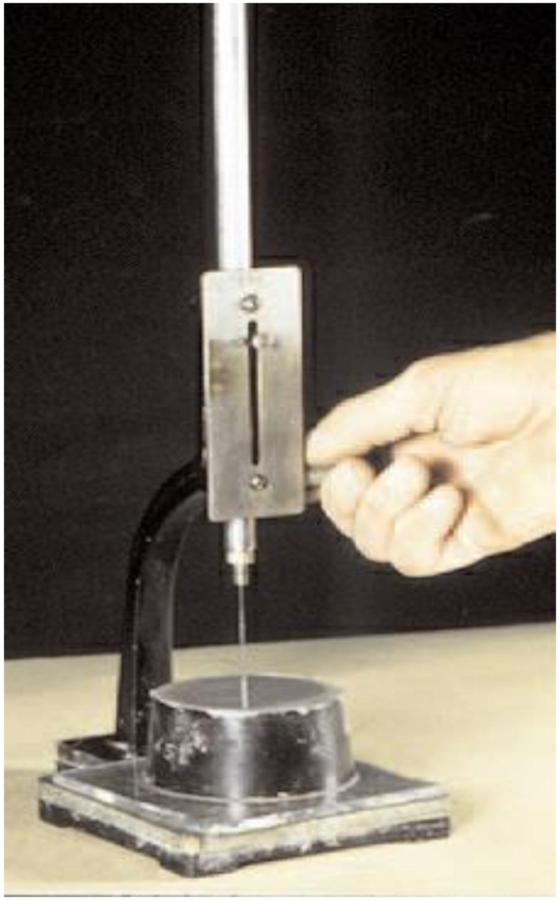


Setting Times

- Initial setting time – the time that elapses from the moment water is added until the paste ceases to be fluid and plastic
  - Minimum 30 minutes suggested in the code
  - Typically more than 3 hours

- Final setting time – the time that elapses from the moment water is added until the cement paste achieved a certain degree of hardness

- A certain given penetration into fresh paste using a standard needle – IS 4031 (Part 5)



Strength

- Strength measured on mortar (1:3) cubes (7.07 cm on side – IS4031 (Part 6)
- Demoulded after 24 hours
- Tested at 3, 7 and 28 days

Grades of Cement – BIS Specifications

33 Grade cement

- 16 MPa in 72 hours, 22 MPa in 168 hours,33 MPa in 672 hours

43 Grade cement

- 23 MPa in 72 hours, 33 MPa in 168 hours, 43 MPa in 672 hours

53 Grade cement

- 27 MPa in 72 hours, 37 MPa in 168 hours, 53 MPa in 672 hours

Qualities of Cement

- Fineness – should not be too fine or too coarse
- Setting time – must conform to specifications
- Soundness – ability of a hardened **cement** paste to retain its volume after setting without delayed destructive expansion
  - This destructive expansion is caused by excessive amounts of free lime (CaO) or magnesia (MgO)
- Strength development – should achieve the specified compressive strength

Storage of Cement

- Cement needs to be carefully stored
- Absorbs moisture from atmosphere
- Stacked and covered using waterproof sheets
- Do not store more than 1.5 to 2 years

Types of cement

- Ordinary portland cement – discussed previously

- Rapid hardening cement: The rapid hardening property is imparted to the cement primarily by burning at a higher temperature and secondly by finer grinding of the particles
    - Gains strength rapidly compared to OPC, very high early strengths
    - It can be used when the construction has to be carried out fast
    - Emergency repair and maintenance

- Low heat cement: It is a type of Portland cement which sets and hardens with the evolution of very low heat of hydration
    - It contains low percentage of tricalcium aluminate, of about 5 per cent, and higher percentage of dicalcium silicate, of about 45 per cent.

    - Ideal for construction of mass structures

Types of cement

- *Quick setting cement:* It is produced by adding a small percentage of aluminium sulphate and by finely grinding the cement
  - It contains very little or no retarding substances like gypsum. The setting action of the cement starts within 5 minutes after addition of water and it becomes hard in less than 30 minutes.

- *Portland Pozzolanic cement –* Produced by replacing a part of cement with pozzolanic materials such as fly ash or calcined clay
  - Lower heat of hydration compared to OPC
  - More durable in conditions high sulphates and chlorides

Self-Reading

- High alumina cements
- Sulphate resisting cements
- Portland slag cements
- Hydrophobic cements
- Expanding cements

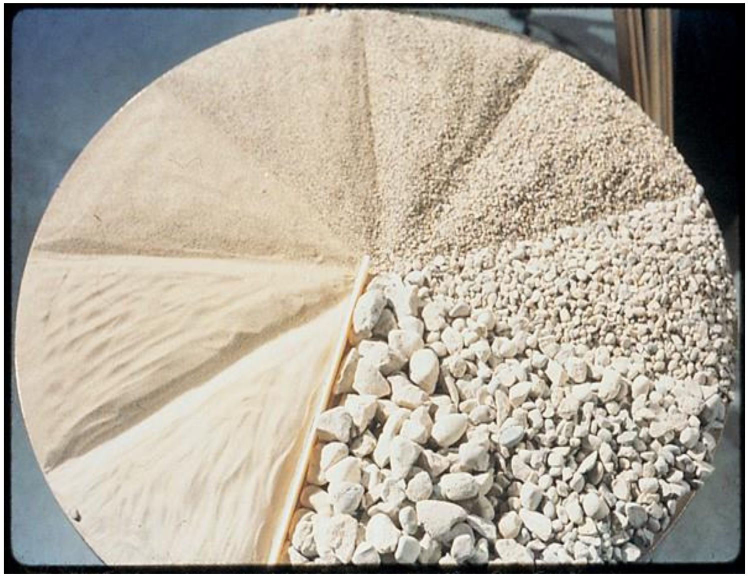
Thank you

- Any doubts????

Introduction to Basic Civil Engineering
Module 2- Sand, Mortar and Concrete

Sand

- Sand is an important building material
- Sand particles consist of small grains of silica (SiO_2)
- Formed by the weathering of rocks
- Major ingredient in concrete, mortar etc.



Sand

- Based on the natural sources from which sand is obtained, it is classified as follows:
    - Pit sand
    - River sand
    - Sea sand

- *Pit Sand* - obtained by forming pits in soils. It is excavated from a depth of about 1-2 m from the ground level

- This sand is found as deposits in soil and it consists of sharp angular grains, which are free from salts.

- Pit sand must be made free from clay and other organic materials before it can be used in mortar.

- Extremely good for construction

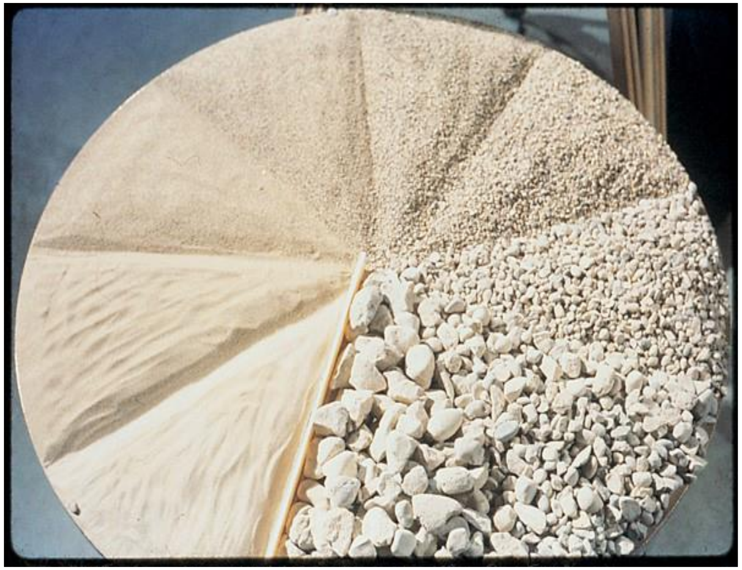
Sand

- River Sand - It is obtained from the banks or beds of rivers and it consists of fine rounded grains.
    - Usually white in colour
    - General purpose sand
    - Good for construction activities

- Sea Sand – Obtained from sea shores
    - Not ideal for engineering purposes
    - Why?

Sand Classification

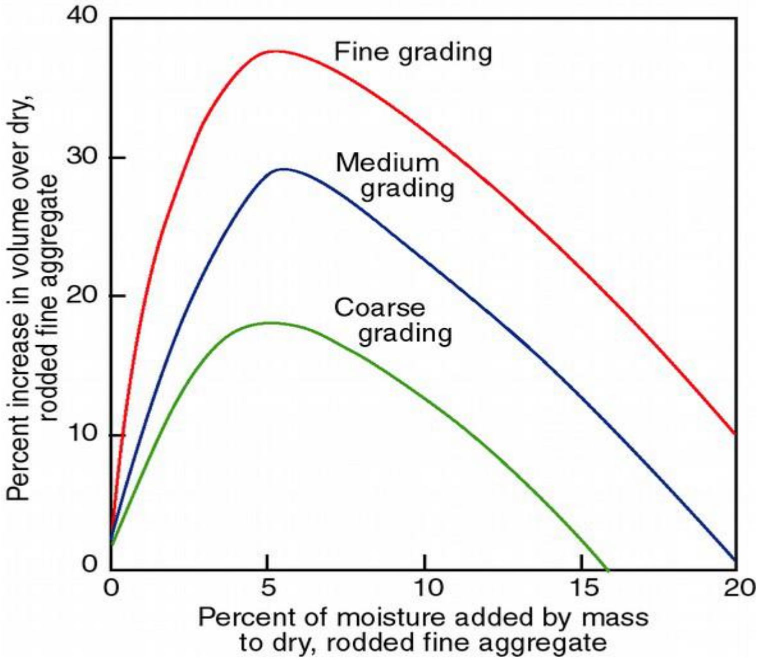
Based on the grain size distribution, sand is classified as fine, coarse and gravelly.



- *Fine sand:* The sand passing through a sieve with clear openings of 1.5875 mm is known as fine sand.
  - Fine sand is mainly used for plastering.
- *Coarse sand:* The sand passing through a sieve with clear openings of 3.175 mm is known as coarse sand.
  - It is generally used for masonry work.
- *Gravelly sand:* The sand passing through a sieve with clear openings of 7.62 mm is known as gravelly sand.
  - It is generally used for concrete work.

BULKING OF SAND

- The increase in the volume of sand due to the presence of moisture is known as bulking of sand.
- Moisture forms a film of water around the sand particles
- Finer sand are more affected by bulking
- Volume increase up to 40% at 5-8% moisture content
- Practical Implications???



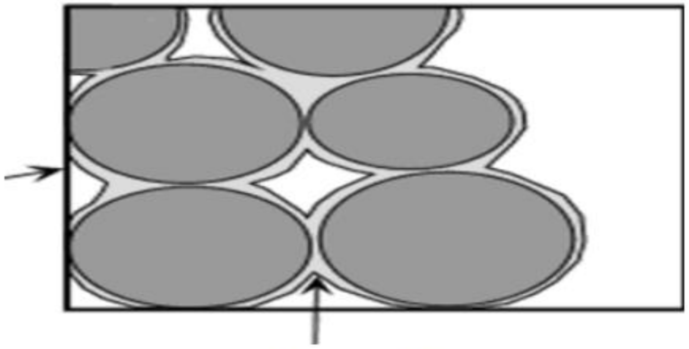


fig 1. Thin water firm

BULKING OF SAND

Ideal Sand

- It should be clean and coarse
- It should be free from any organic or vegetable matter; 3-4% clay is permitted
- It should be chemically inert.
- It should contain sharp, angular, coarse and durable grains
- It should not contain salts which attract moisture from the atmosphere.
- It should be well graded, i.e., it should contain particles of various sizes in suitable proportions.
- It should be strong and durable. It should be clean and free from coatings of clay and silt.

Functions of sand

- *Strength:* It helps in the adjustment of the strength of mortar or concrete by variation of its proportion with cement or lime. It also increases the resistance of mortar against crushing.

- *Bulk:* It acts as an adulterant. Hence, the bulk or volume of mortar is increased which results in reduction of cost.

- *Setting:* In the case of fat lime, carbon dioxide (CO_2) is absorbed through the voids of sand and setting of fat lime occurs effectively.

- *Shrinkage:* It prevents excessive shrinkage of mortar in the course of drying and, hence, the cracking of mortar during setting is avoided.

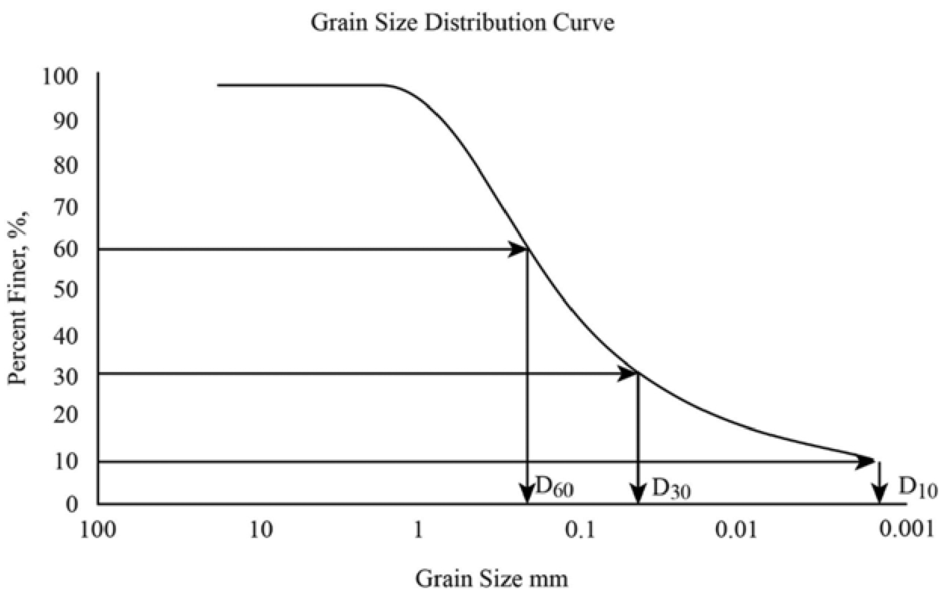
- *Surface area:* It subdivides the paste of the binding material into a thin film and, thus, more surface area is offered for its spreading and adhering.

Grading of Aggregates

- Grading is the particle size distribution of the aggregate as determined by sieve analysis
- Sieves with square openings are used
- Sizes of the squares are defined in standards

Grading of Aggregates

- Several standards exist
- IS383 gives:
  - 7 sieve sizes for fine aggregates – 10mm to 150µm
  - 9 sieve sizes for coarse aggregates from 2.36mm to 80mm



IS383 – F.A. Grading limits

Percent passing for

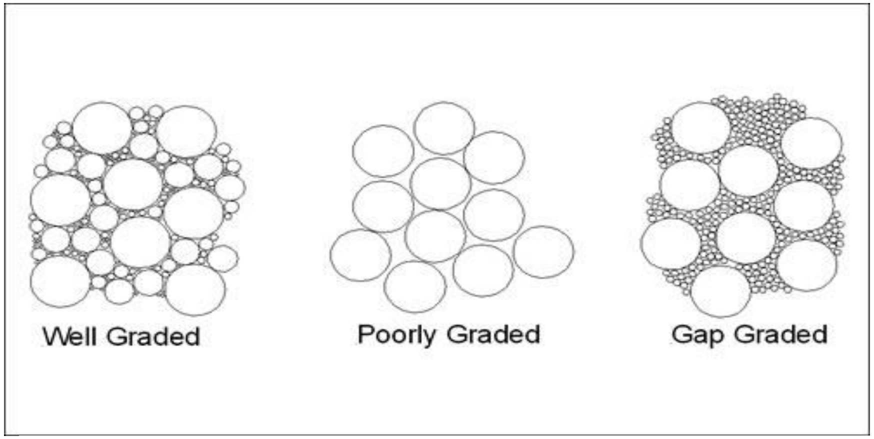
Sieve Size	Zone - I	Zone - II	Zone - III	Zone - IV
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	90-100
1.18 mm	30-70	55-90	75-100	90-100
0.6 mm	15-34	35-59	60-79	80-100
0.3 mm	5-20	8-30	12-40	15-50
0.15 mm	0-10	0-10	0-10	0-15

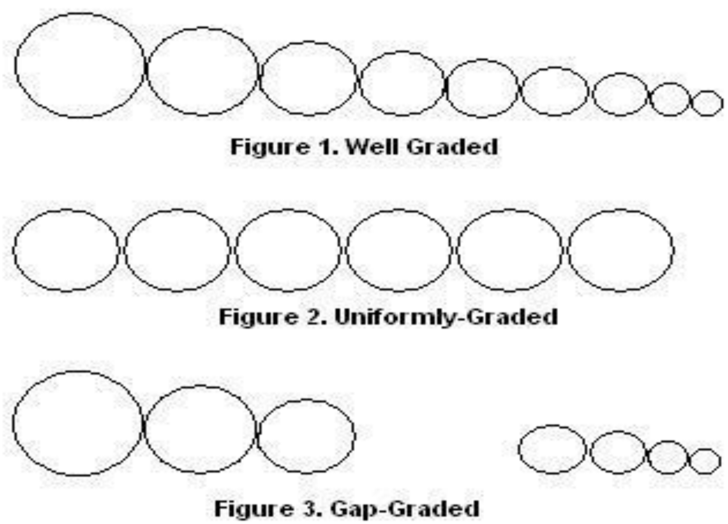
Grading of Aggregates

- Grading is expressed as percentage of material passing each sieve
- Grading affects:
  - Aggregate and cement proportions
  - Water requirements
  - Workability
  - Economy
  - Shrinkage
  - Durability
  - Grading should be uniform

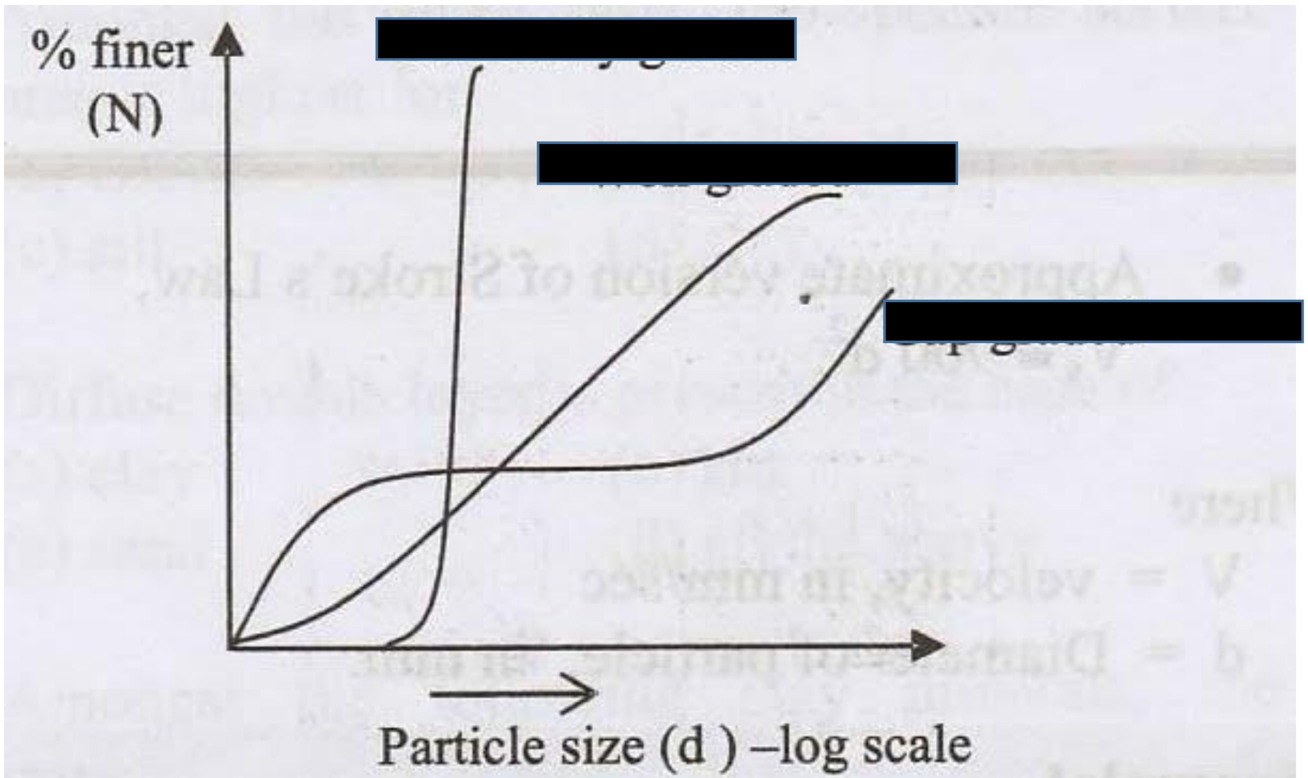
Different gradations of Sand

- *Well Graded* – Contains particles of wide size ranges
  - Ideal for preparation of concrete
  - Well packed structure since fine particles will fill the space between the coarse aggregates
- *Uniformly graded:* Small variation in particle sizes
  - Ineffective packing. Results in large voids
  - Uneconomical
- *Gap graded:* Some particles sizes are missing
  - Stiff and low workability in concrete





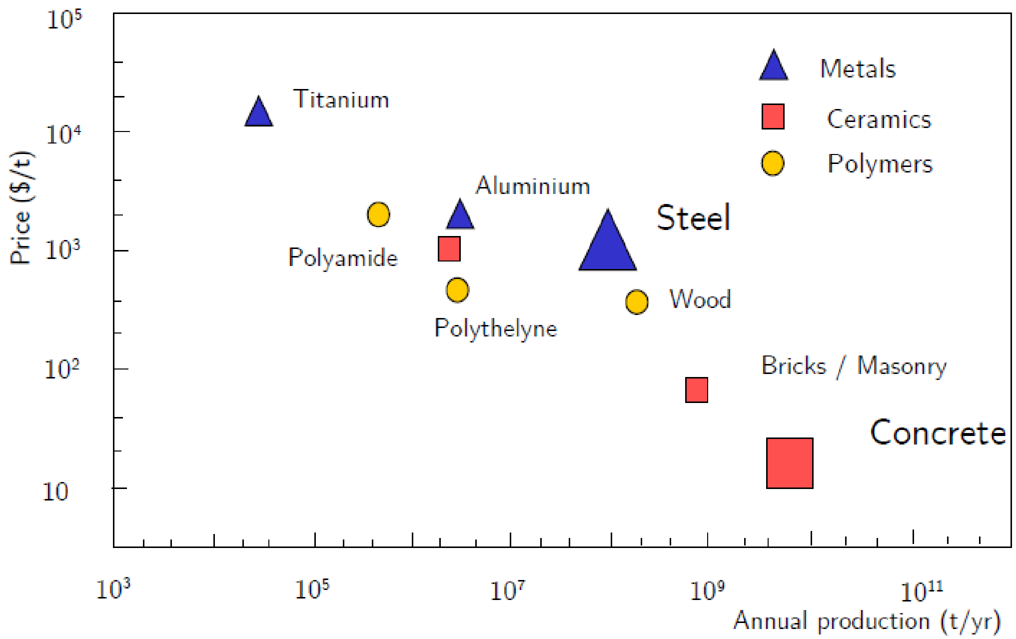
Different gradations of Sand



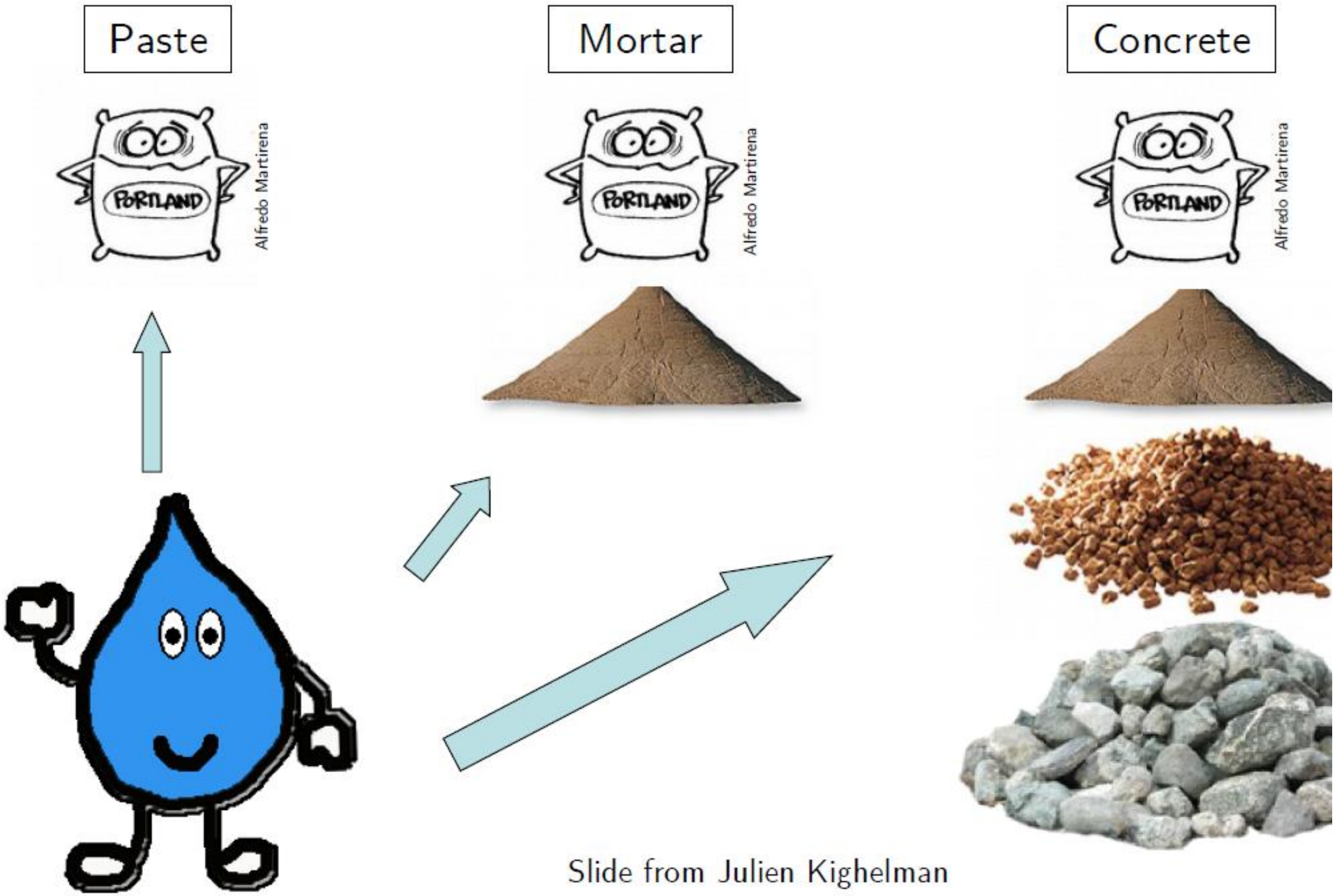
Alternatives

Concrete

- Concrete is the most used construction material in the world



What is concrete?



Slide from Julien Kighelman

Why Concrete?

- Concrete is a widely used material because
  - It is cheap
  - It can be made with locally available materials
  - It can be transported to the site or made on site with whatever resources are available
  - It is a viscous mix that can take any form
  - Concrete is a strong and usually a durable material
  - However, it shows brittle failure and has a low tensile strength
  - Comparison with steel and timber – Strength development

Components of concrete

- Cement
- Water
- Aggregates – fine (<4.75mm) and coarse (>4.75mm)
- Chemical admixtures, e.g. Super plasticizers, retarders, accelerators, etc.
- Mineral additions, e.g. fly ash, slag, rice husk ash, etc.

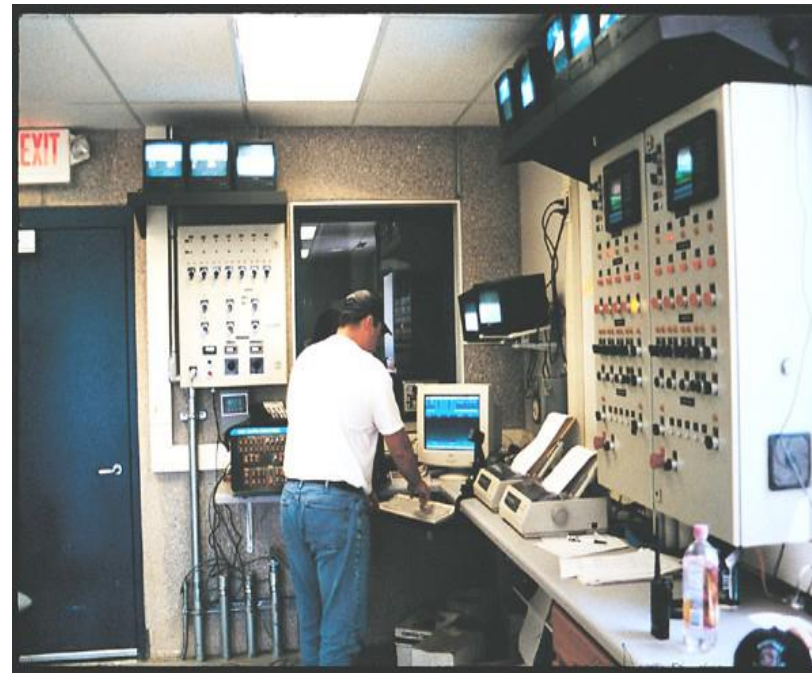
Aggregates

- Aggregates should be graded to minimise voids
  - Fine aggregates fill spaces between coarse aggregates
- Aggregates are usually the strongest and the cheapest solid component of plain concrete, so there is an interest in increasing their fraction
- However, the zone around the aggregates can be weak and can reduce strength

Batching

- The proportioning of the components is called batching
- Batching practices vary throughout the world
- Batching can be based on volume or on weight
- Volumetric batching is less accurate

Concrete Production

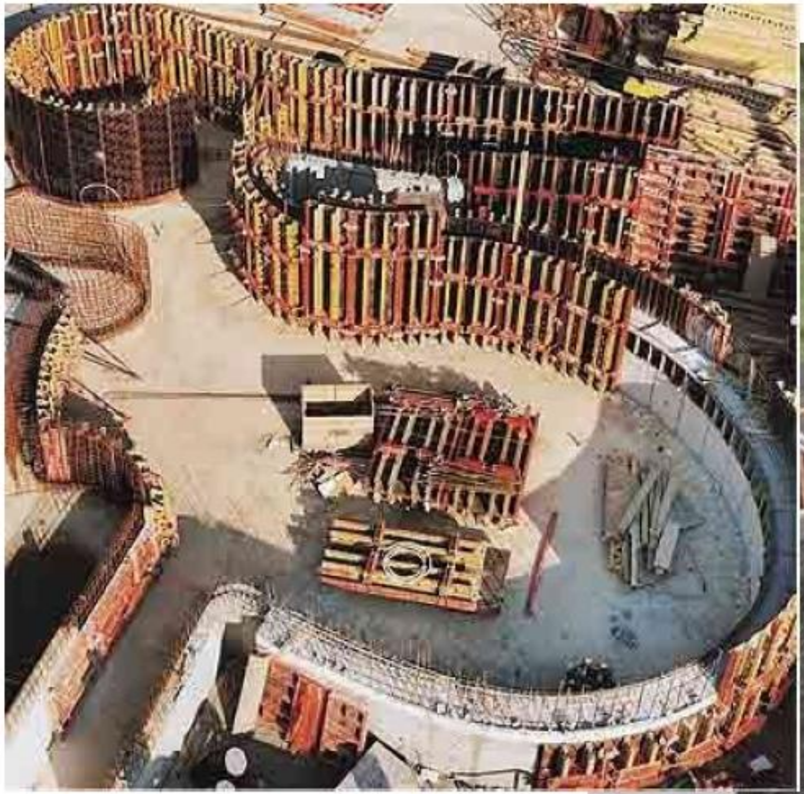


Concrete Transportation

Source: cariolawheelbarrow.com

Concrete Transportation

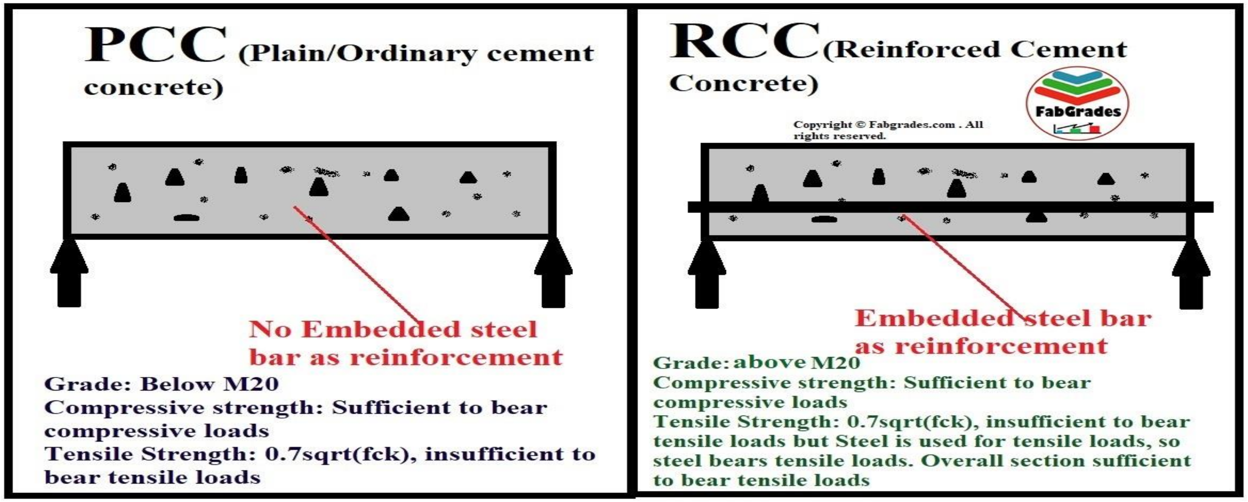
Formwork



Types of Concrete

- Plain cement concrete – without reinforcement
  - Low tensile strength
  - Brittle failure
  - We need to use reinforcement

- Reinforced Cement Concrete – plain concrete plus rebar



Grades of Concrete

- The concrete mixes are designated as M10, M15, M20, M25, M30, M35 and M40.
- The number denotes the ultimate strength of concrete mix in MPa at the end of 28 days.
- Another term is characteristic strength or f_{ck}
- Minimum grade for RCC is M20

Type of work	*Recommended mix*	*Applications*
Ordinary concrete	M 10, M 15, M 20	Mass concrete like heavy wall.
Standard concrete	M 25, M 30, M 35, M 40, M 45, M 50, M 55	Thinner sections.
High strength concrete	M 60, M 65, M 70, M 75, M 80.	Pre-stressed concrete.

1) Proportioning Concrete

- Arbitrary Proportioning – Some standard ratios of cement:FA:CA are given based on the experience

Proportion of concrete mix	Maximum size of aggregate	Nature of work
1:1:2	12–20 mm	Heavily loaded RCC columns and RCC arches of long span
1:2:2	12–20 mm	Small precast members of concrete, such as poles for fencing telegraphs, long piles, watertight constructions and heavily stressed members of the structures.
1:1½ :3	20 mm	Water-retaining structures, piles, precast products, etc.
1:2:3	20 mm	Water tanks, concrete deposited under water, bridge construction and sewers
1:2½:3½	25 mm	Footpaths and roadworks
1:2:4	40 mm	For all general RCC works in building, such as stair, beam, column, weather shed, slab and lintel, machine foundation subjected to vibration and RCC piles.
1:3:6	50 mm	Mass concrete works in culverts, retaining walls, etc.
1:4:8 or 1:5:10 or 1:6:12	60 mm	Mass concrete work for heavy walls, foundation, footings, etc.

1.Proportioning Concrete : Batching

- The proportioning of the components is called batching
- Batching practices vary throughout the world
- Batching can be based on volume or on weight
- Volumetric batching is less accurate

2.Mixing

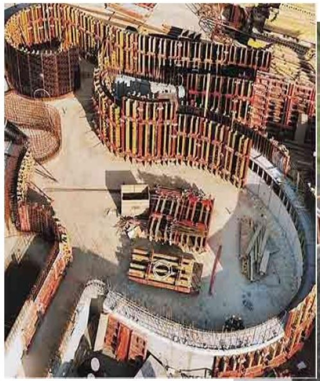
- Hand Mixing
- Machine Mixing

3.Transportation of Concrete

- Mixed concrete has to be taken to the location as soon as possible
- Special concrete can be designed that can be pumped
- Should not lose uniformity, homogeneity, etc.
- Should not undergo segregation

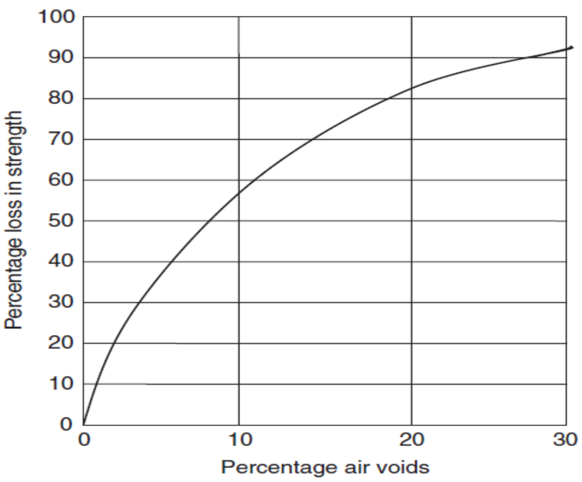
4. Placing concrete

- Well cleaned, adequately supported, oiled formwork has to be placed in the correct position
- Concrete must be laid continuously
- Should not be poured from a height more than 1m
- Concrete should not undergo segregation
- Formwork should not be displaced



5. Compacting Concrete

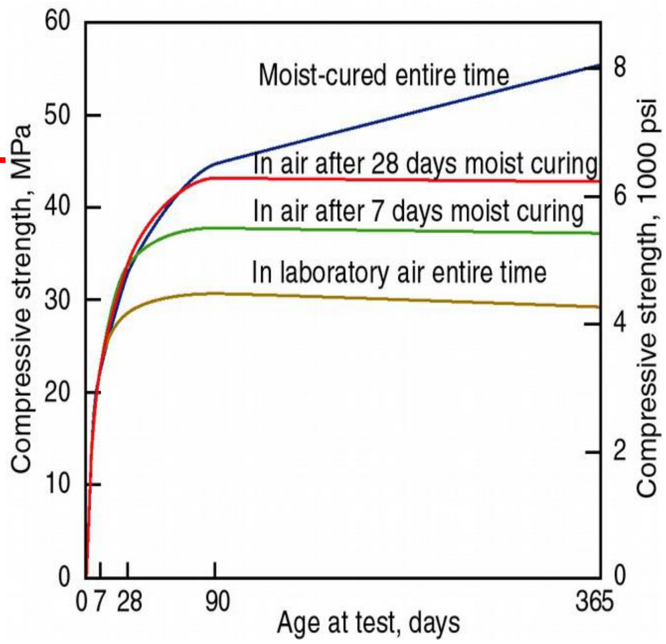
- Compaction of concrete is the method adopted for expelling the entrapped air from the concrete.
- If the air is not removed fully, the concrete loses strength considerably.
- Hand compaction or machine compaction possible
- Helps in providing finishing to concrete
- Care should be taken to not over compact

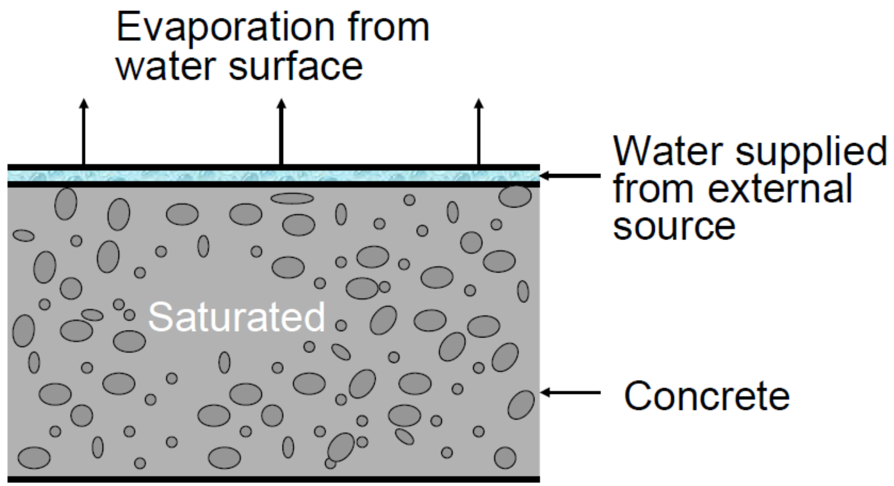


5. Compacting Concrete

6. Curing

- Curing requires adequate
  - Moisture
  - Temperature
  - Time
- Proper curing will improve
  - Strength
  - Abrasion resistance
  - Water tightness
  - Durability
  - Volume-stability





6.Curing

Spraying, fogging, ponding

Saturated wet covering

Ponding on concrete slab

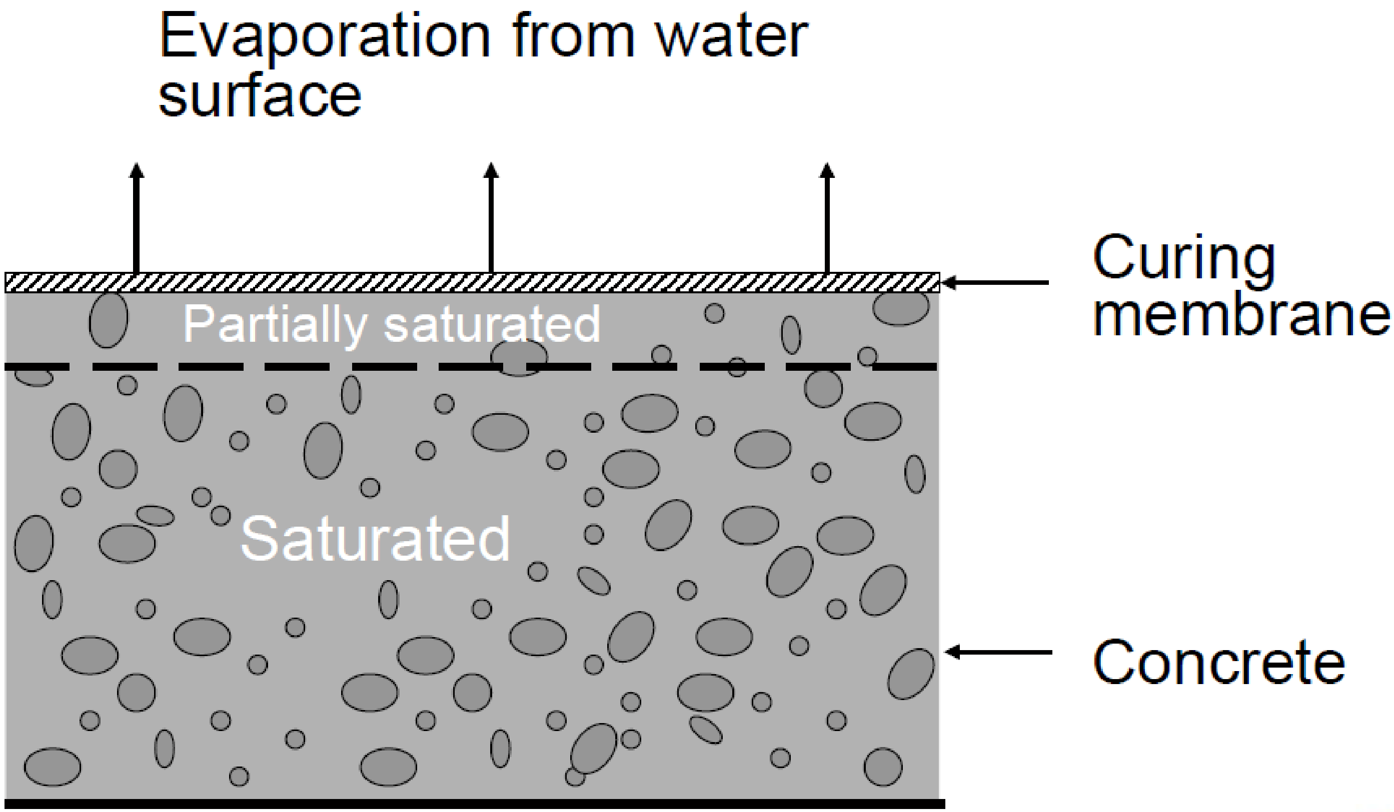
6.Curing

Plastic sheets

6.Curing - Chemicals

Curing compounds

6.Curing - Membrane



Classification of Concrete

- PCC
- RCC
- Fibre Reinforced Concrete
- Self-Compacting Concrete
- Precast Concrete
- Prestressed Concrete
- Light weight concrete

Thank you

- Any doubts???

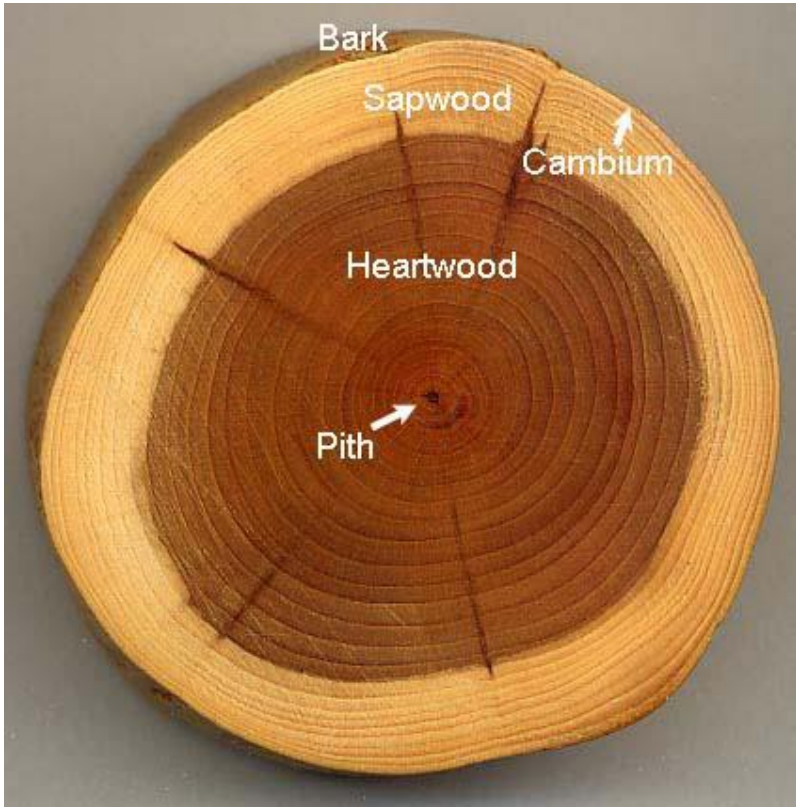
Introduction to Basic Civil Engineering

Lecture 2 – Steel and Timber

Sreejith Krishnan, *PhD*

Timber

- Timber denotes wood which is suitable for building or carpentry and for various engineering and other purposes



Classification of Timber

- Based on mode of growth
  - Exogenous – Grows outwards
    - Further divided to coniferous and deciduous
    - Coniferous trees have cone shape leaves and fruits. Yields softwood. Eg. Cedar, Pine
    - Deciduous trees have broad leaves which regularly falls and get replaced. Yields hardwood. Eg. Teak, Mahagony and oak
    - Useful for structural applications
  - Endogenous – Grows inwards
    - Not suitable for construction
    - Eg. Bamboo, Sugar cane

Classification of Timber

Classification based on modulus of elasticity – *Young's modulus* is determined by conducting ***bending test***. On this basis timber is classified as follows.

a) ***Group A***, $E = 12.5\ kN/mm^2$

b) ***Group B***, $E = 9.8\ kN/mm^2$ to $12.5\ kN/mm^2$

c) ***Group C***, $E = 5.6\ kN/mm^2$ to $9.8\ kN/mm^2$.

Classification based on durability – Durability tests are conducted by the forest research establishment. They bury test specimen of size $600 \times 50 \times 50\ mm$ in the ground to half their length and observe their conditions regularly over several years. Then timbers are classified as follows.

a) ***High durability*** – If average life is more than 10 years.

b) ***Moderate durability***– Average life between 5 to 10 years.

c) ***Low durability*** – Average life less than 5 years.

Classification of Timber

Classification based on availability – The ***IS***: ***339-1963*** has grouped timber into the following three grades based on availability.

a) ***X*** – Most common ; 1415 m^3 or more per year

b) ***Y*** – Common ; 355 m^3 to 1415 m^3 per year

c) ***Z*** – Less common ; less than 355 m^3 per year.

Properties of timber

- *Appearance:* A freshly cut surface of timber should exhibit a hard and shining appearance.
- *Colour:* The colour of the timber should be preferably dark. A light colour indicates low strength.
- *Hardness:* A good timber should be hard, i.e., it should offer resistance when it is being penetrated by another body. The chemical present in heartwood and the density of wood imparts hardness to timber.
- *Durability:* A good timber should be durable. It should be capable of resisting the action of fungi, insects, chemicals, physical agencies and mechanical agencies.
- *Strength:* A good timber should be strong for working as a structural member such as joist, beams and rafter. It should be capable of taking loads slowly or suddenly.
- *Structure:* The structure should be uniform and the medullary rays should be hard and compact. The annual rings should be regular and should be closely located.

Properties of timber

- *Mechanical wear:* A good timber should not deteriorate easily due to mechanical wear or abrasion. This property is essential for places where timber would be subjected to traffic, like wooden floors and pavements.
- *Toughness:* A good timber should be tough. It should be capable of offering resistance to shocks due to vibrations.
- *Elasticity:* This is the property by which the timber returns to the original shape when load causing deformation is removed. This property is essential when timber is used for bows, carriage shaft, etc.
- Fire resistance: Timber is a bad conductor of heat. A dense wood offers good resistance to fire and it requires sufficient heat to cause a flame.
- *Defects:* A good timber should be free from serious defects such as dead knots, flaws and shakes

Seasoning of wood

- Wood is dried by exposure to air to reduce moisture from 30-35% to 12-15%
- Kiln-drying can be carried out at higher temperatures (>80°C) to reduce water to 3.5%
- Other methods such as salt, chemical, boiling seasoning are also used
- Wood shrinks during seasoning
  - Circumferential shrinkage more than radial
  - Can lead to cracking

Use of wood in construction

- Wood can be used for most structural and functional elements of structures
- Can used for building formwork and scaffolding
- Can be used for making ply wood, etc.
- Framework of windows and doors
- Flooring
- Roof members

Advantages of Wood

- Easy to manipulate, shape and transport
- Can be planed, sawed and jointed using simple carpenters tools
- Easily available and transportable
- It is light weight but strong at the same time
- Wood is easily available and cheap
- It provides good insulation
- Is generally weather-resistant and ductile
- Can last hundreds of years if properly seasoned
- Easy to conduct repairs
- Maybe ideal for construction near marine conditions

Disadvantages of Wood

- It is not fire resistant
- Likely to decay if not preserved properly
- Can swell and shrink due to atmospheric moisture
- Requires regular maintenance
- Can crack or warp if not maintained properly

Steel

- Steel is an iron alloy
- It contains iron mixed with 0.2% to 2.1% carbon
- Manganese, chromium, vanadium and tungsten also used
- Steel has been known for thousands of years, earliest known is 4,000 years old from Anatolia
- Wootz steel has been used in India from around 300 B.C.

Steel

- Carbon increases the hardness of iron
- Carbon and other elements prevent dislocations from sliding and harden iron
- Hardness, ductility and tensile strength of steel can be controlled by varying the amount of alloying elements
- There are many types and grades of steel

Uses of steel

- Steel can be used for various purposes in building works.
  - As structural material in trusses, beams, etc.
  - As non-structural material for grills, doors, windows, etc.
  - In steel pipes, tanks, etc.
  - In sanitary and sewer fittings, rainwater goods, etc.
  - Corrugated sheets.
  - As reinforcement for concrete.

Mild steel

- Mild and low carbon steel
  - 0.05% to 0.15% carbon
  - Cheap and malleable
  - Neither brittle nor ductile
  - Density ~7.85 g/cm3
  - Young's modulus: 210 Gpa
  - Used in structures

Higher carbon steels

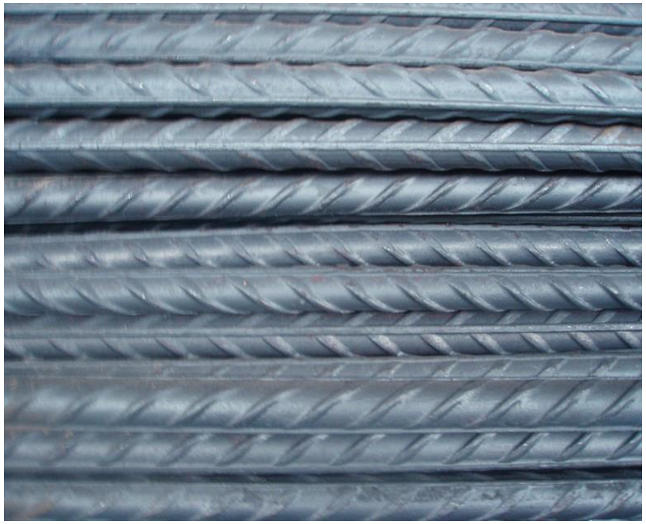
- Medium carbon steel
  - 0.3-0.59% carbon content
  - Balances ductility and strength
  - Used for forging, large parts and automotive
  - components
- High carbon steel
  - 0.6-0.99% carbon
  - Very strong, used for springs and high strength wires

Other Steel types

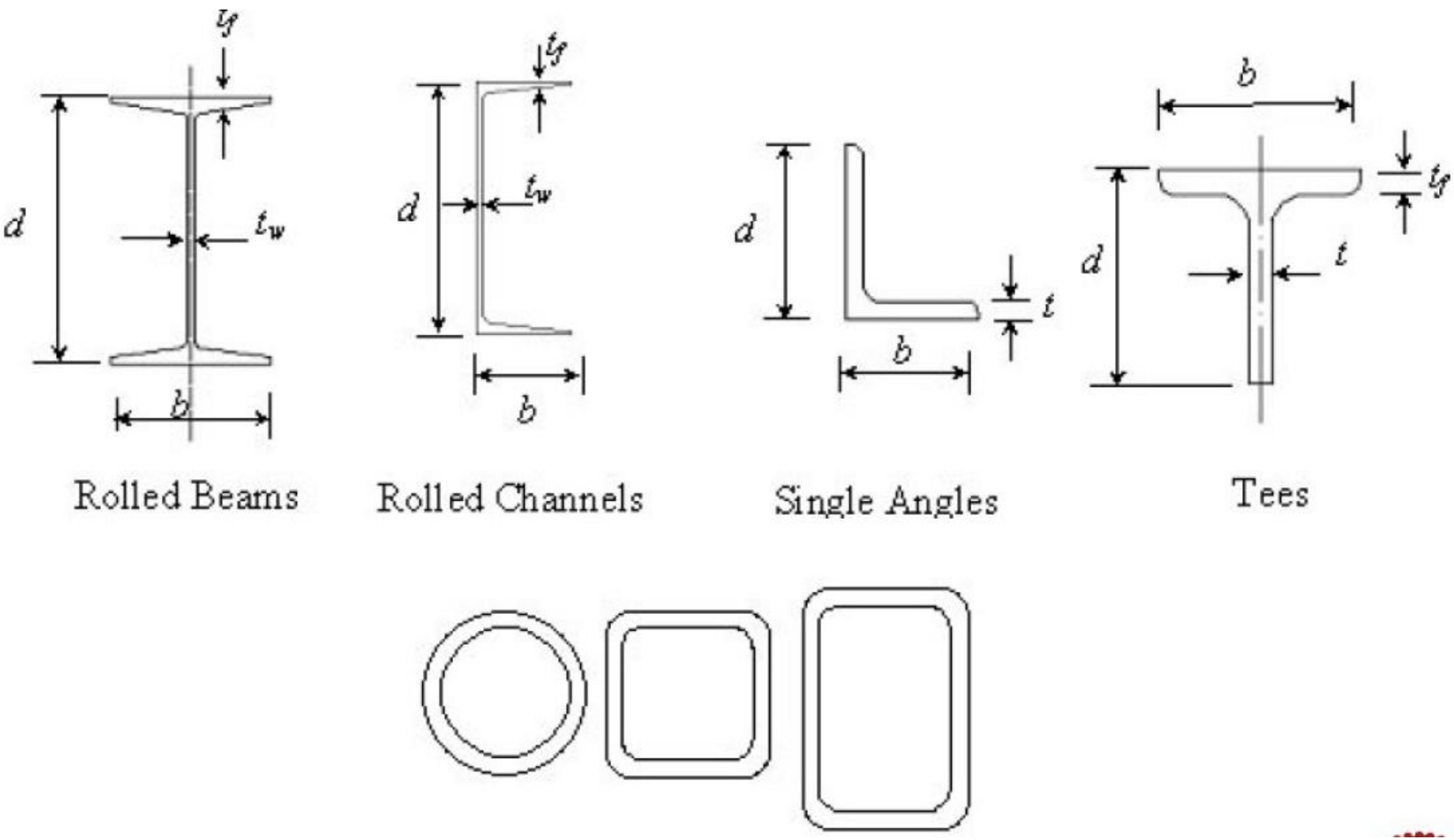
- High-strength low-alloy steels
  - 0.05-0.25% carbon
  - Up to 2% manganese
  - Small amounts of chromium, nickel, molybdenum, copper, nitrogen, vanadium, niobium, titanium and zirconium
- Stainless steel
  - Minimum 10.5% chromium by mass up to 26%
  - Passivation offered by oxidation of chromium

Other steel types

- High-yield steel
  - Usually cold-rolled twisted bars
  - Deformations improve bond with concrete
  - Higher yield-stress than mild-steel (415-500 MPa)
  - More brittle than mild-steel



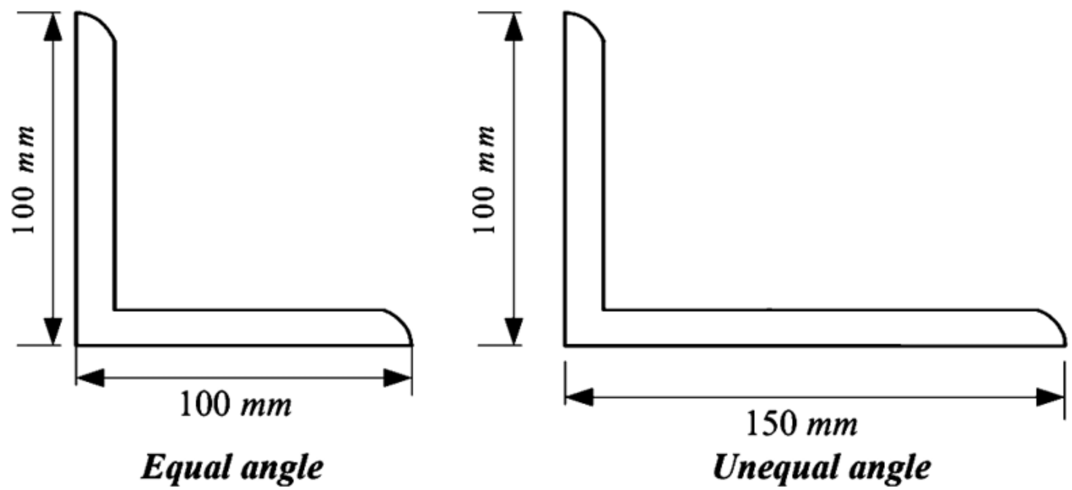
Forms of steels



Forms of Steel

- Angle sections

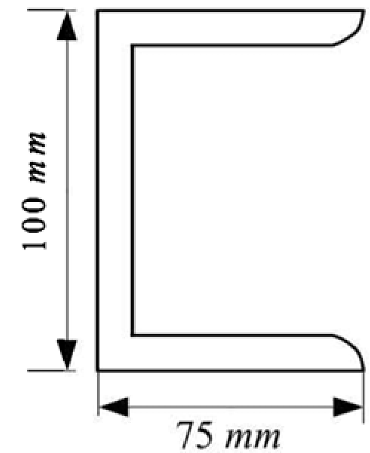
Angle section – Angle section consists of two legs, which can be of equal or unequal size or length. Accordingly they are specified as *ISA* (*Indian Standard Angle*) equal or unequal angles. These are available in sizes varying from 20 × 20 × 3 *mm* to 200 × 200 × 25 *mm*. *Indian Standard bulb angle* is another type of angle with bulged portion at the end of the leg.



Forms of Steel

- Channel Section

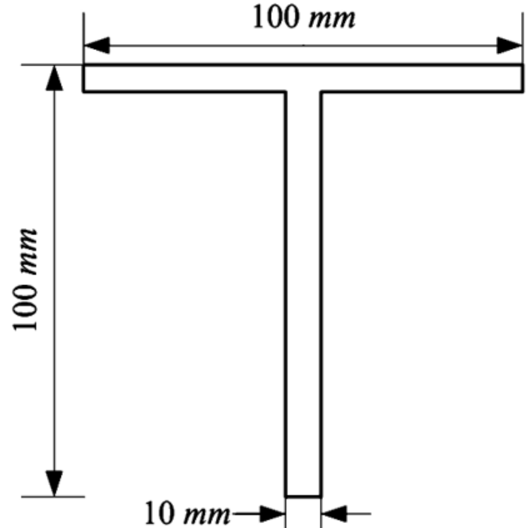
Channel section – Channel section consists of a web with two equal flanges. Channel section is designated by the height of web and width of flange. These are available in sizes varying from 100 *mm* × 45 *mm* to 400 *mm* × 100 *mm*. BIS designates channel as *ISJC – Indian Standard Junior Channel*, *ISLC – Indian Standard Light Channel*, *ISMC–Indian Standard Medium Channel*, *ISSC*– Indian *Standard Special Channel*, etc.



Channel section

Forms of Steel

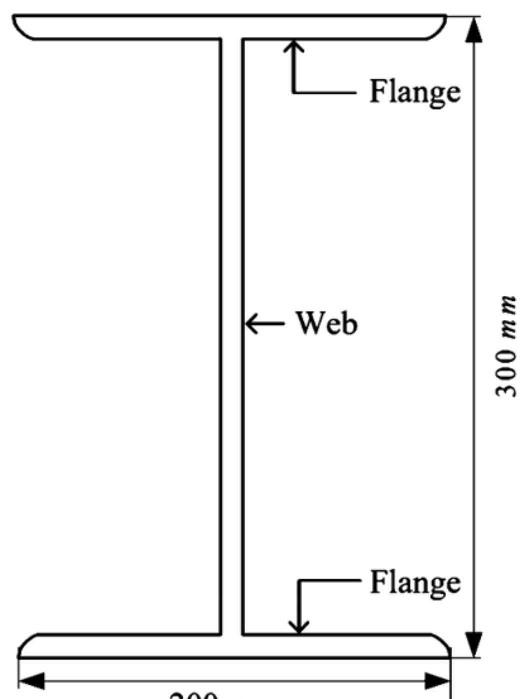
T – sections – The shape of this section is like that of letter **T** and it consists of flange and web. It is designated by overall dimensions and thickness. The specifications are *ISNT – Indian Standard Normal Tee*, *ISHT – Indian Standard Heavy Tee*, *ISWC – Indian Standard Wide Tee*, *ISST - Indian Standard Short Tee*, *ISMT - Indian Standard Medium weight Tee*, etc. T-sections are widely used as member of the steel roof trusses and to form built-up sections. These sections are available in sizes varying from 20 $mm \times$ 20 $mm \times 3$ mm to 150 $mm \times 150$ $mm \times 10$ mm. The figure shows a T-section of size 100 $mm \times$ 100 $mm \times 10$ mm. Special T-sections with unequal sides, bulbs at bottom edge of web, etc., are also available.



T- section

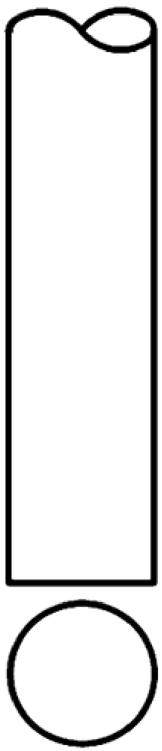
Forms of Steel

I - section – It consists of two flanges connected by a web, are also known as ***Rolled Steel Joists*** (***RSJ***). It is designated by overall depth, width of flange and weight per *metre* length. Available sizes are 75 *mm* × 50 *mm* to 600 *mm* × 210 *mm* of varying thickness. The designated sections are *ISJB – Indian Standard Junior Beam*, *ISLB – Indian Standard Light Beam*, *ISMB - Indian Standard Medium Beam*, *ISWB - Indian Standard Wide flange Beam*, *ISHB - Indian Standard Heavy Beam*, etc. These are used as beams, lintels, columns, members of steel framework, grillage foundations, built up columns for carrying lateral loads, etc. The economy in material is achieved by concentrating the material in two flanges where bending stresses are maximum. Rolled steel I-section is the most ideal section of a beam, wherein the flange resists major portion of the bending moment while the web resists major portion of shear.

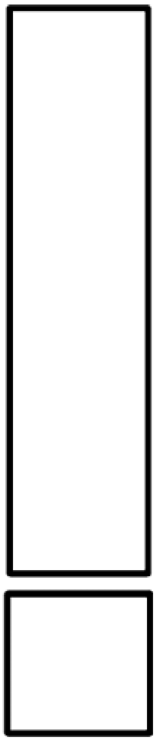


I- section

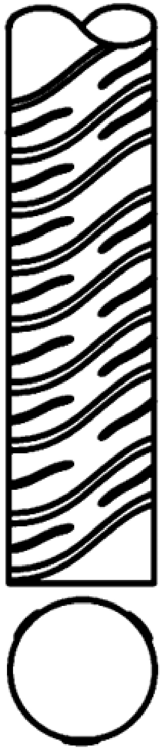
Forms of steel



Round bars



Square bar



Ribbed HYSD bar

Thank You

Introduction to Basic Civil Engineering

Other building materials

Sreejith Krishnan, *PhD*

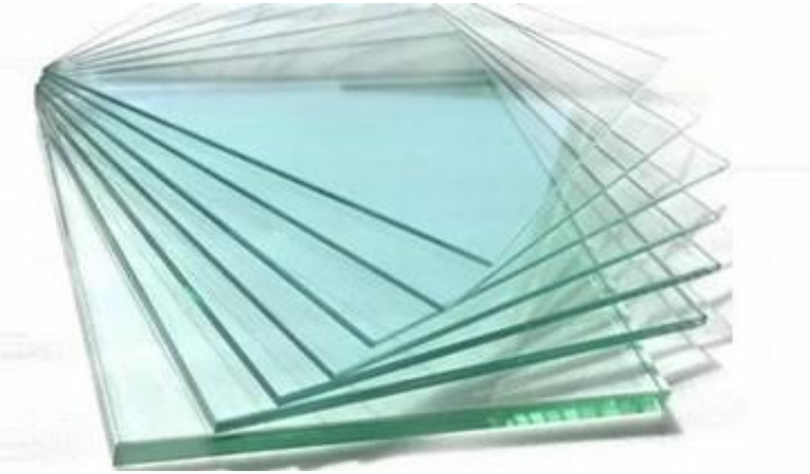
Ceramics

- A **ceramic** is any of the various hard, brittle, heat-resistant and corrosion-resistant materials made by shaping and then firing a nonmetallic mineral, such as clay, at a high temperature.

- Common examples are earthenware, porcelain, and brick.

Ceramics

- High tensile strength in theory
  - Presence of flaws and cracks
- High compressive and shear strength
- Uncertain transverse strength



Glass

- **Glass** is a non-crystalline, often transparent amorphous solid, that has widespread practical, technological, and decorative use.

Glass

- It may also be considered as a solidified super-cooled solution of various metallic silicates having infinite viscosity.
- It is a mixture of metallic silicates, one of which is usually that of an alkali material
- It is difficult to assign a particular composition to glass
  - SiO_2 is the main phase
  - Sodium or potassium carbonate is added to ensure lowering of silica melting point.
  - Easier workability

Glass – Properties

- It absorbs, refracts or transmits light.
- It can take up a high polish.
- t has no definite crystalline structure.
- t has no sharp melting point.
- It is affected by alkalis.
- It is an excellent electrical insulator.
- It is available in beautiful colours.
- Can be cleaned easily
- Some glasses have excellent chemical resistance
- Can be welded by fusion

Uses of glass

- Glass can be used for window panels.
- Glass blocks can be used for partitions up to 6 m for insulation.
- Sheet glass can be used for glazing.
- Structural glass can be used for insulation, panel walls, wall facings, enclosures, etc.
- Potash lead glasses are used for making electric bulbs.
- Tinted glass can be used for decorative glassworks.
- Fibre glass reinforced plastics can be used to construct furniture, lampshades and bathroom fittings.

Types of glass

- Soda lime glass - also known as soda ash glass, soda glass, commercial glass or soft glass which is obtained from the fusion of a mixture of silica, lime, soda and alumina.

- It is the most common type of glass produced in the world.

- It is widely used for glazing of doors, windows, and for making ordinary glassware such as glass bottles, containers, etc.

Types of glass

- Potash lime glass - It is also known as hard glass or Bohemian glass.

- Potash lime glass is similar to soda lime glass, except that soda is replaced by potash.

- Potash lime glass has a high melting point and hence can withstand high thermal stresses.

- Hard glass has good resistance towards acids and alkalis as compared to soda lime glass. It is used for making laboratory apparatus and combustion tubes.

Types of glass

- Potash lead glass: It is also known as flint glass or lead glass. It is obtained from the fusion of a mixture of silica, lead, and potash, in which the content of lead is around 18-40%.

- Due to the presence of lead oxide, this glass has more transparent and shiny look.

- Lead increases the stability of the glass, and thus it is less brittle as compared to other glasses.

- Potash lead glass is used for high-quality glassware, cut glass, bulbs, lenses and prisms.

- Lead is also known to block x-rays and gamma radiations, thus they are used in making shields for personnel working in the nuclear science industry.

Types of glass

- Borosilicate glass: also known as Pyrex glass. It is obtained from the fusion of silica, borax, lime, and feldspar.

- Due to the addition of boron, borosilicate glass has good resistance to thermal and electric shocks.

- They have excellent chemical resistant properties

- Laboratory glassware – burette and pippette

Types of glass

- Common glass - also known as bottle glass is prepared from cheap raw materials like sodium silicate, iron silicate and calcium silicate.

- Bottle glass is available in different colours like green, brown and yellow.

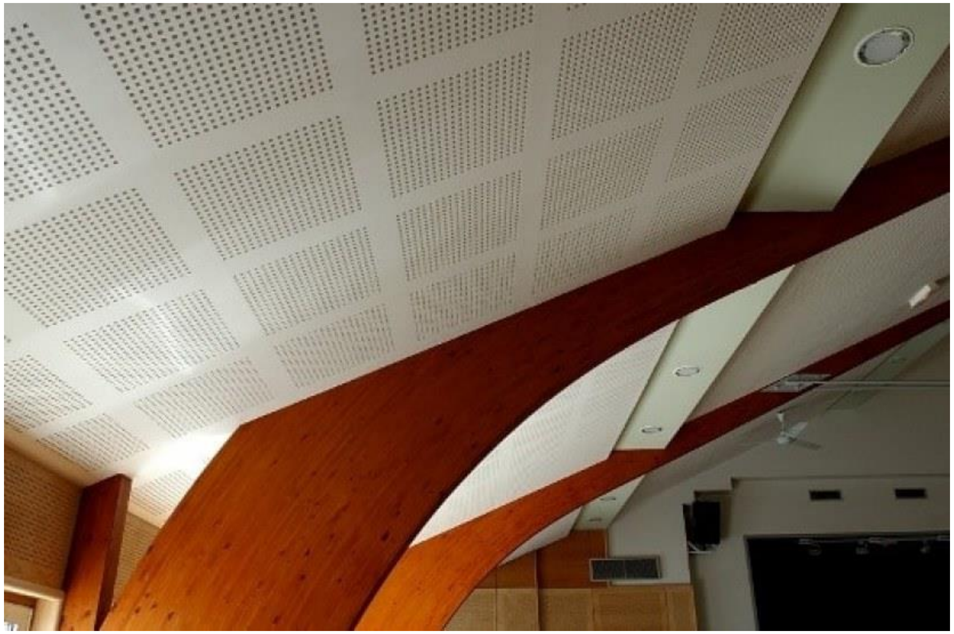
- They have moderate resistance to chemicals. Bottle glass allows less light to enter and thus prevents fading or degradation of products stored in it.

- Common glass is mainly used to manufacture household bottles, medicine bottles, glassware used for drinking, packaging of drugs, etc.

Acoustics insulating materials

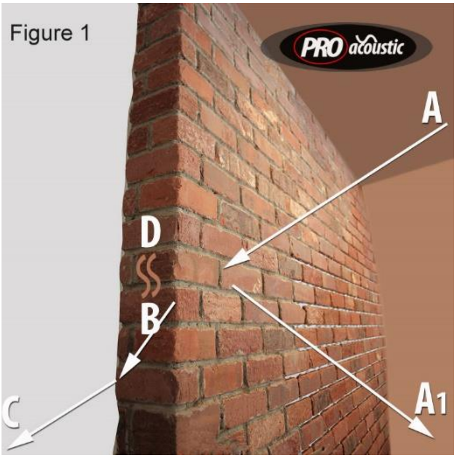
- Sound proofing – to prevent the transmission of sound from one section to another.

- Important in case of film studios, laboratories etc.



Acoustics insulating materials

- Non-porous rigid materials – like plastered solid brick masonry wall
  - Insulation depends on weight per unit area
  - Thickness of wall is important but there is a practical limit
  - Weight doubling leads to an additional sound insulation of 4 to 5 dB



Acoustics insulating materials

- Porous rigid materials – these materials provide higher sound insulation.
    - 10% higher sound insulation for the same weight
    - Eg. Cinder concrete

Acoustics insulating materials

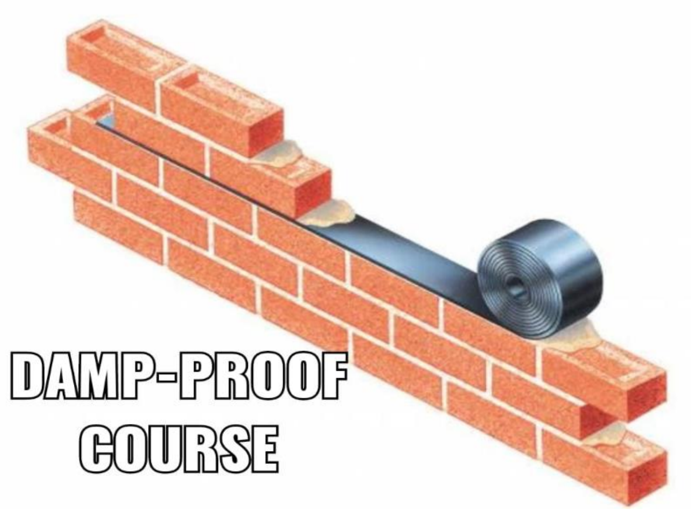
- Non-rigid flexible porous materials – materials such as glass wool, felt etc.

- Less sound insulation compared to rigid materials

- Can be used in combination with rigid materials

Waterproofing Materials

- Dampness is the ingress of moisture into the building
- Very undesirable since dampness is unhygienic, reduction in the strength, corrosion etc.
- Damp proof course is typically provided to prevent ingress of dampness into the building
- Continuously provided without any breaks



Damp proof course

Waterproofing Materials

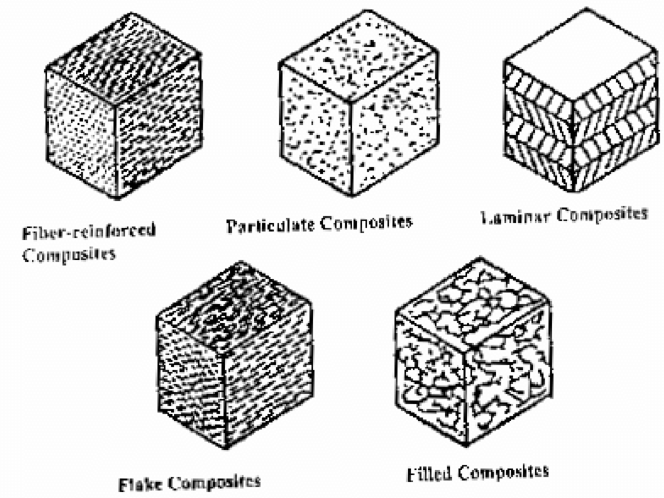
- Hot bitumen – A 3mm layer of bitumen can act as a damp proof course
- Mastic Asphalt – Semi rigid materials obtained by heating asphalt with sand and fillers. It is laid on mortar or concrete bed.
- Bituminous Felt – sheet liked material that can be rolled on the flat mortar surface
- Metal Sheet – Sheets of lead, Copper or aluminium
- Combination of sheet and felt
- Different chemical solutions
- Plastic sheets can be used for temporary damp proof course
- Concrete layer over plinth level can act as DPC

Composite Materials

- Composite materials are usually made using two or more phases tha are bonded together to obtain superior properties
  - Eg. Reinforced cement concrete

- Composites can be a combination of metal, ceramics or polymers

- Glass Fibre Reinforced Polymers – Fibreglass : glass fibres in epoxy
  - Glass is strong but brittle
  - Epoxy is flexible



Composite Materials

- Carbon Fibre Reinforced Polymer – carbon fibres are embedded in polymers

- Can be used for reinforcement, for making cycles, aeroplanes etc.

Plastic

- **Thermoplastics** are the plastics that, when heated, do not undergo chemical change in their composition and so can be molded again and again.

- **Thermosets**, or **thermosetting polymers**, can melt and take shape only once: after they have solidified, they stay solid.[12] If heated again, they do not melt; they decompose instead.

Thermoplastics

- PVC – Making water pipes, waste water pipes, window frames, flooring and roofing foils
  - Generally less expensive, light and durable

- Polypropylene – naturally strong and flexible, can stretch and deform without breaking.
  - Packaging industry, automotive industry

- Acrylic – hard and high impact strength.
  - Sanitary wares, sinks, sheeting, roof glass etc

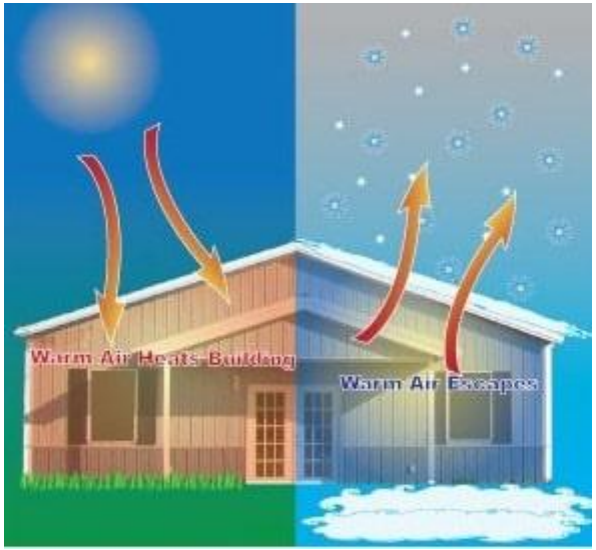
Thermosets

- Epoxy resins – Good resistance for heat and chemicals.
    - Generally used for repair work

- Bakelite or phenol formaldehyde – Are strong, dimensionally stable and resist heat
    - Electric Panels, Lavatory seats etc,.

Thermal insulators

- To control the rate of heat transmission in the building



- Slab or Block Insulation
  - The blocks are made of mineral wool, cork board, cellular glass, and cellular rubber or saw dust etc.
  - These are fixed to the walls and roofs to prevent heat loss and maintains required temperature.

Thermal insulators

- Blanket Insulation –
  - Blanket insulation materials are available in blanket shape or like paper rolls which are directly spread over the wall or ceilings.
  - They are flexible and having a thickness about 12 to 80mm.

- Bat Insulating Materials
  - These are also available as blanket rolls but bat insulating rolls are having more thickness than blanket type materials.
  - These are also spread over the walls or ceilings.

Thermal insulators

- Loose Fill Insulation
  - Stud space is provided in wall where windows and doors are to be provided. In that studding space of wall loose fill of some insulating materials is provided. The materials are rock wool, wood fiber wool, cellulose etc.

Thermal insulators

- Reflective materials – can be provided to reflect away sunlight
  - White or black?

- Special building materials – AAC blocks, CLC blocks etc,

Prefabricated Construction

- Precast concrete is a construction product produced by casting concrete in a reusable mold or "form" which is then cured in a controlled environment, transported to the construction site and lifted into place

- In contrast, standard concrete is poured into site-specific forms and cured on site.

Prefabricated Construction

- Cast in a yard.
- Members transported to the location and placed using cranes
- Better quality control, cheap, faster, etc.
- Handling and transportation is a challenge, high initial investment for setting up,

Self Study

- Gypsum

Thank you

Introduction to Basic Civil Engineering

Surveying

Sreejith Krishnan, *PhD*

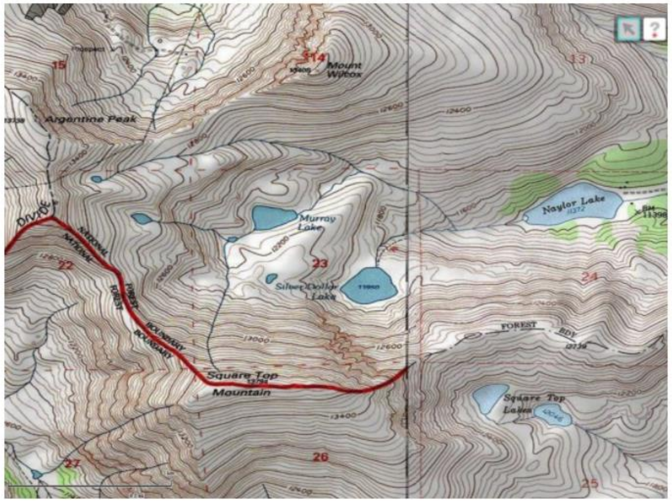
Surveying

- The art of making measurements of the relative positions of natural and man-made features on the Earth's surface, and the presentation of this information either graphically or numerically.

- The first surveying works date back to the antiquity, the Greek provided the first account of surveying techniques.

Objective of Surveying

- The aim of surveying is to prepare a map to show the relative positions of the objects on the surface of the earth.
- To collect field data.
- To prepare plan or map of the area surveyed.
- To analyse and calculate the field parameters for setting out operation of actual engineering works
- To set out the field parameters at the site for further engineering works.
- Can be over water as well



Importance of Surveying

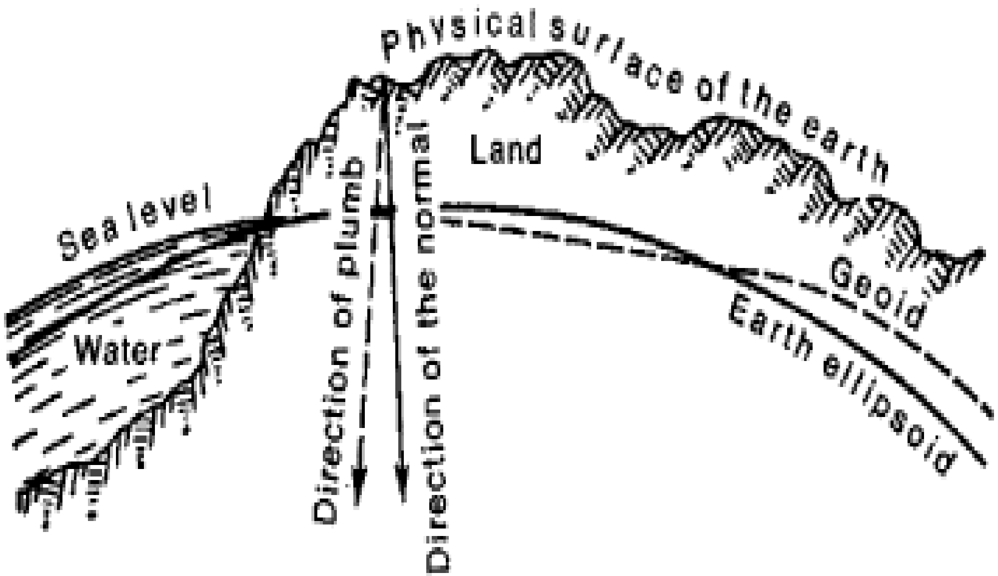
- Preparation of site plan
    - Help to decide alignments, best layouts etc.
    - Surveying is vital in understanding the economic aspects of project
- It helps to prepare topographical maps which show natural and manmade features
- It helps to prepare cadastral maps showing the boundaries of the properties and other land rights
- It helps to prepare an engineering map which shows the details of engineering works such as roads, railways, reservoirs etc.
- It helps to prepare a contour map to determine the steepness or gentleness of slopes

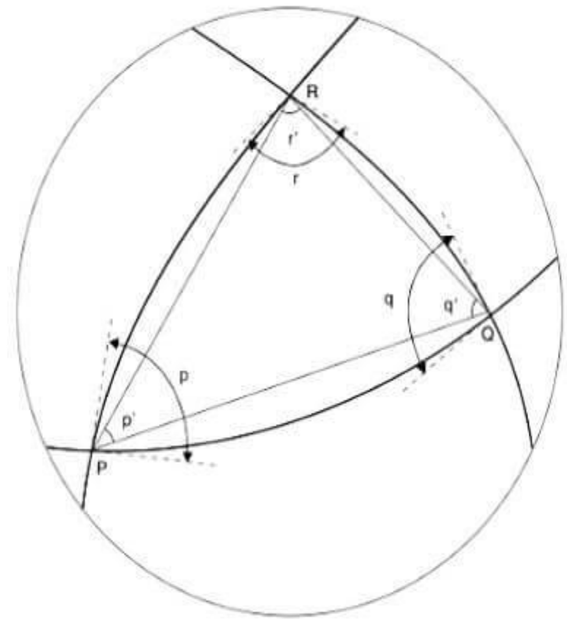
Classification of Surveys

- Plane surveying - Survey in which the mean surface of earth is regarded as plane surface and not curved as it really is
  - Engineering projects on large scale such as factories, bridges, dams, location and construction of canals, highways, railways, etc
  - For establishing boundaries.

- Geodetic surveying - Survey in which the shape (curvature) of the earth's surface is taken into account and a higher degree of precision is exercised in linear and angular measurements
  - A line connecting two points is regarded as an arc. The distance between two points is corrected for the curvature and is then plotted on the plan.
  - The angles between the intersecting lines are spherical angles.

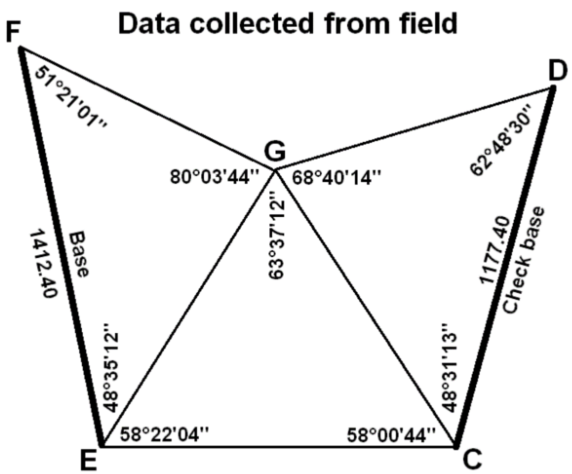
Classification of Surveys

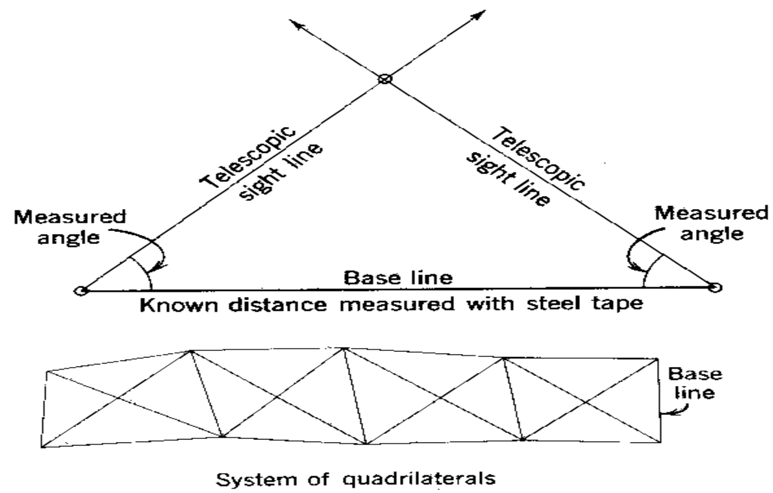




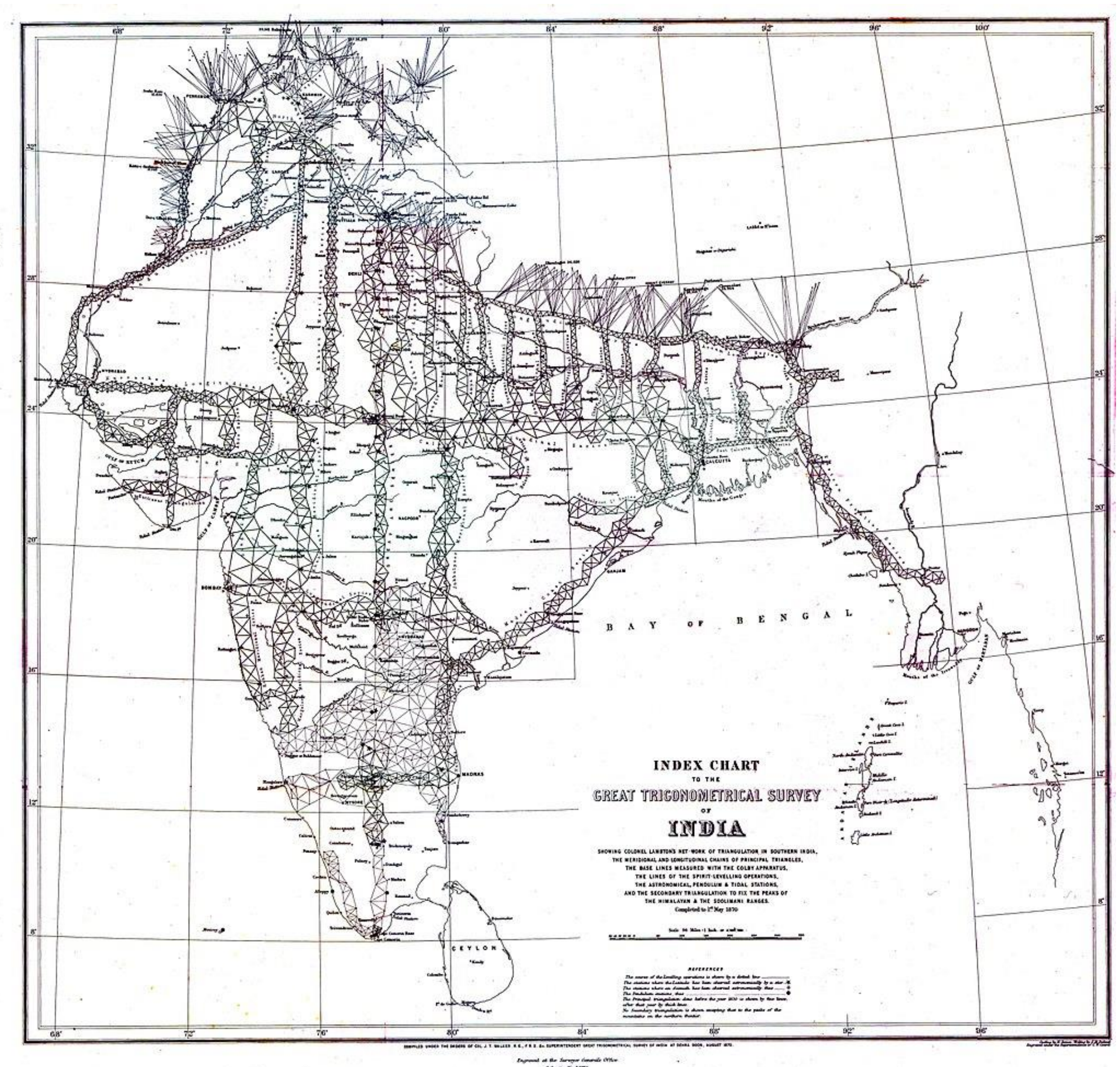
Classification – Based on Method

- Triangulation Survey - When the area to be surveyed is of considerable extent, triangulation is adopted.
  - The entire area is divided into a network of triangles.
  - Any one side of any of the triangles so formed, is selected and is measured precisely.
  - Such a line is called baseline.
  - All the angles in the network are measured with a transit.





Great Trigonometric Survey of India



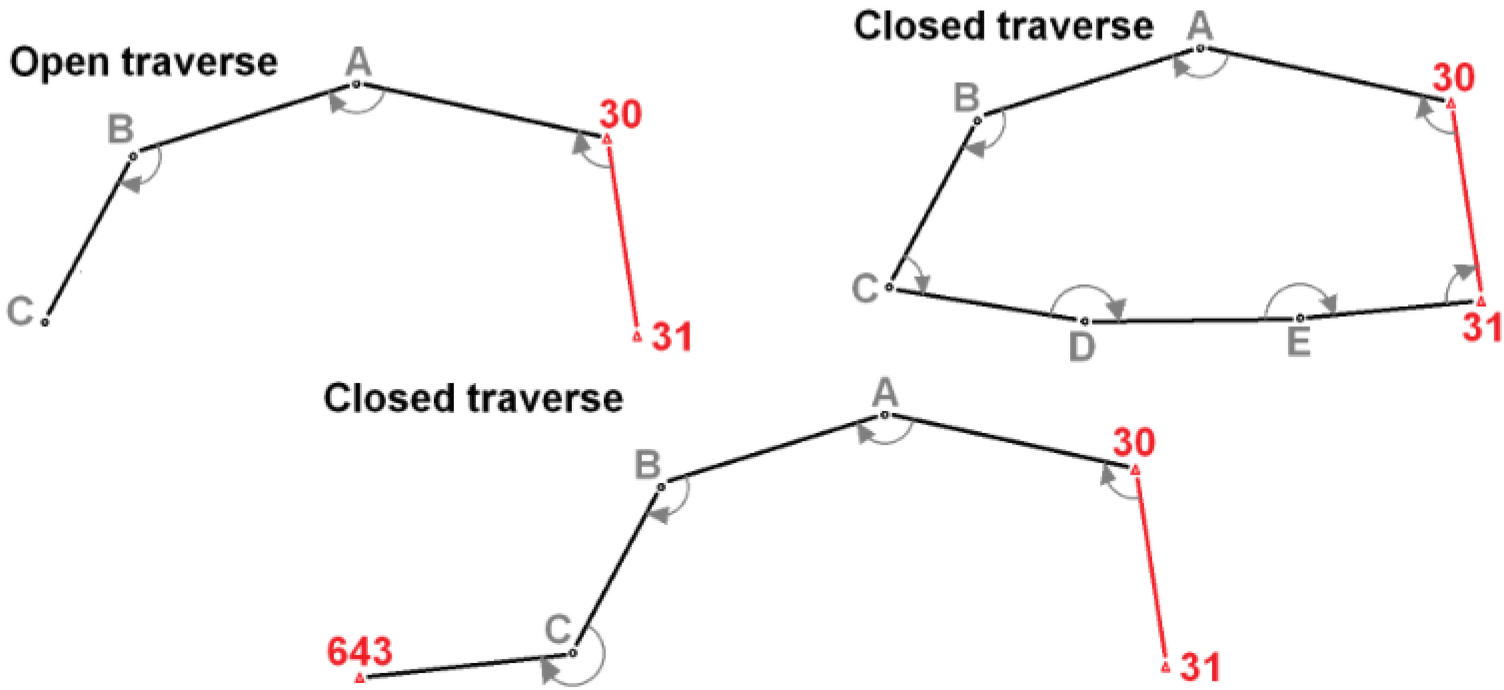
Classification – Based on Method

- Traversing - When the linear measurements are done with chain and tape and the directions or angles are measured with compass or transit respectively, the survey is called traversing.
  - **A traverse survey measures distances and angles (courses) between the points.**
  - These points can serve as control stations. Other, less precise measurements, can be taken from control stations then.

  - **Traversing is used usually for smaller areas or on areas with many obstacles.** The method is appropriate for land and property surveys as well.

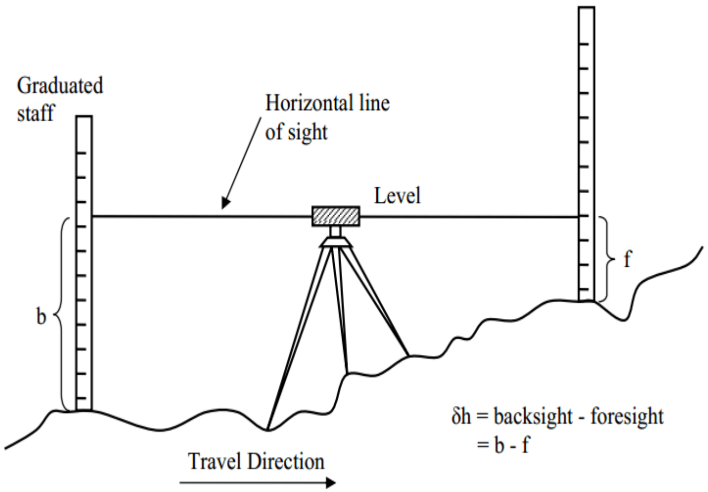
Classification – Based on Method

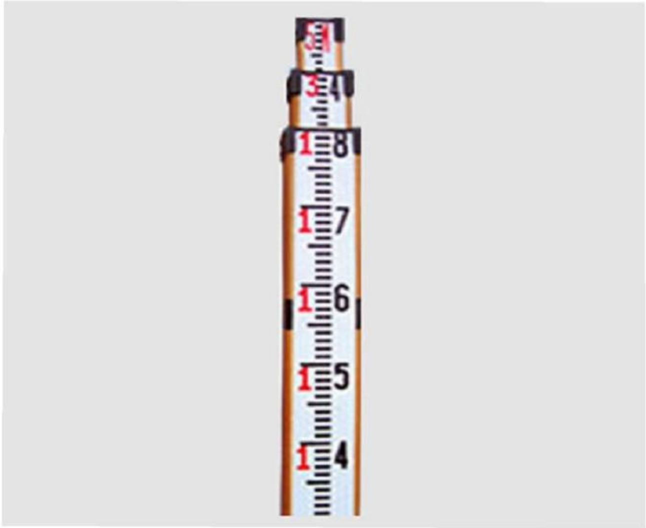
- Open traversing and closed traversing



Classification – Based on Method

- 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.
- In planning a constructional project, irrespective of its extent, i.e., from a small building to a dam, it is essential to know the depth of excavation for the foundations, trenches, fillings, etc.
- This can be achieved by collecting complete information regarding the relative heights of the ground by levelling.



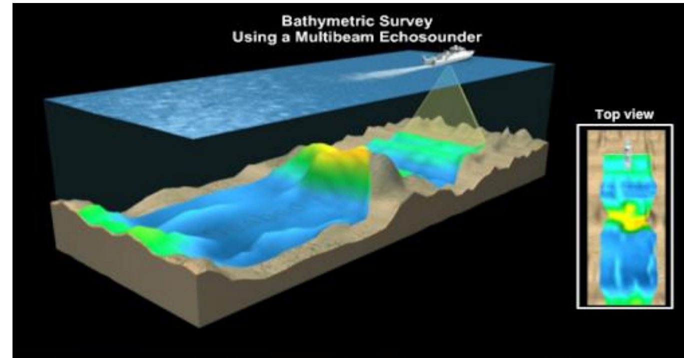


Classification – Based on Method

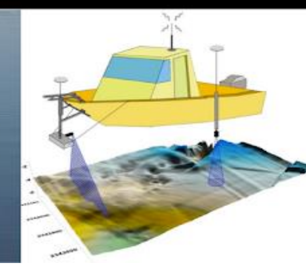
- Chain Surveying - When a plan is to be made for a very small open field, the field work may consist of linear measurements only.
  - All the measurements are done with a chain and tape.
  - However, chain survey is limited in its adaptability because of the obstacles to chain like trees and shrubs.
  - Also, it cannot be resorted to in densely built-up areas.
  - It is recommended for plans involving the development of buildings, roads, water supply and sewerage schemes.

Based on Nature of Field

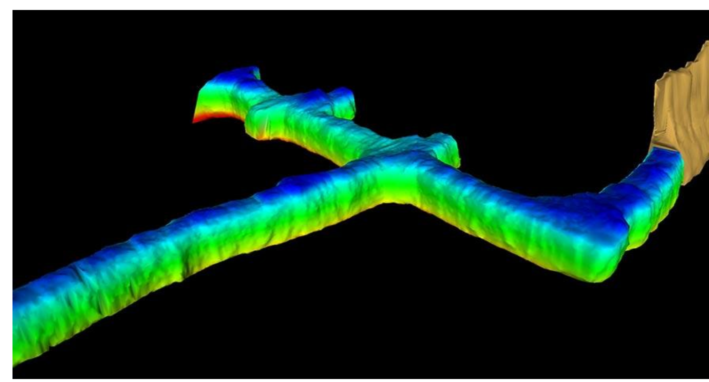
- Land Survey - It consists of re-running old land lines to determine their lengths and directions, subdividing the land into predetermined shapes and sizes and calculating their areas and setting monuments and locating their positions



- Marine Survey - It deals with the survey of water bodies like streams, lakes, coastal waters and consists in acquiring data to chart the shore lines of water bodies

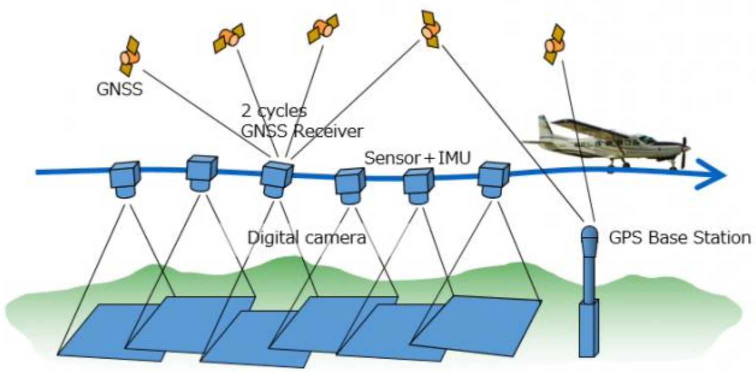


- Underground Survey - This is referred to as the preparation of underground plans, fixing the positions and directions of tunnels, shafts and drifts, etc.



Based on Nature of Field

- Aerial Survey - When the survey is carried out by taking photographs with a camera fitted in an aeroplane, it is called aerial or photogrammetric surveying. It is extremely useful for making large-scale maps of extensive constructional schemes with accuracy. Though expensive, this survey is recommended for the development of projects in places where ground survey will be slow and difficult



Based on Objective

- Geological Survey
- Engineering Survey
- Defence Survey
- Archaeological survey
- Mine survey

Based on instrument used

- Chain Surveying
- Compass Surveying
- Plain Table surveying
- Theodolite Surveying
- Total Station Surveying
- Aerial surveying

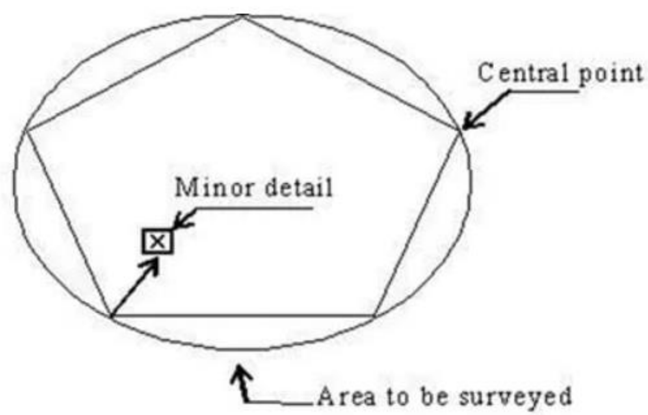
Principles of Surveying

- There are two basic principles of surveying. These find their inherent applications in all the stages of a project, i.e., from initial planning till its completion.
  - To work from whole to part.
  - To locate a point by at least two measurements.

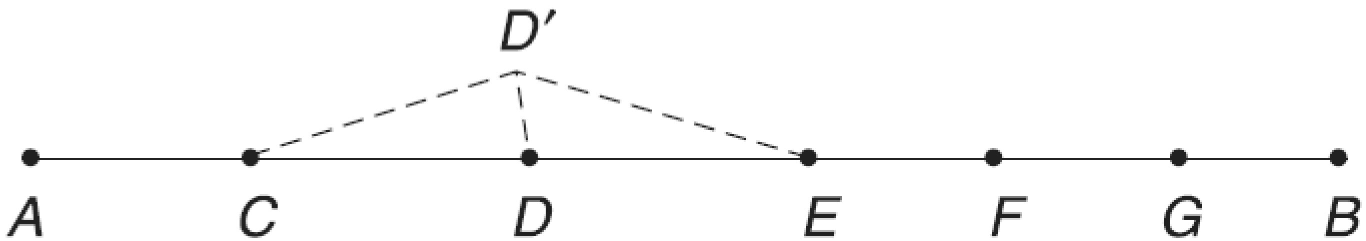
1. To work from whole to part

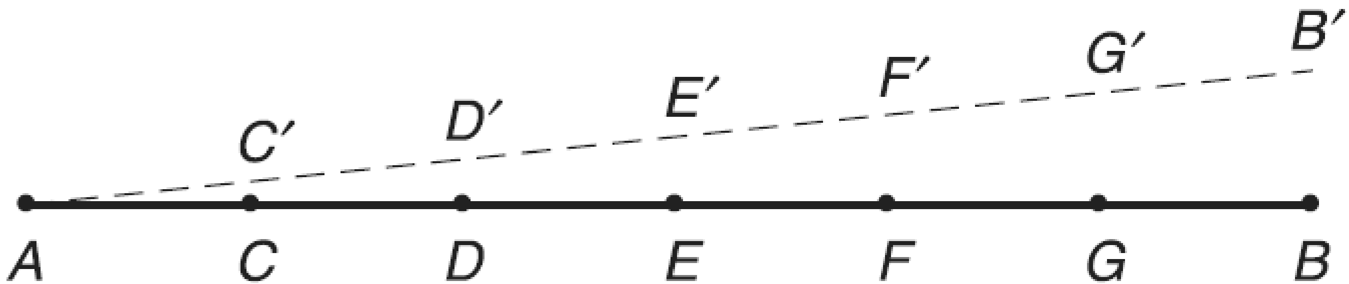
- The main idea of working from whole to part is to localise the errors and prevent their accumulation.

- On the contrary, if we work from part to whole, the errors accumulate and expand to a greater magnitude in the process of expansion of survey, and consequently, the survey becomes uncontrollable at the end.



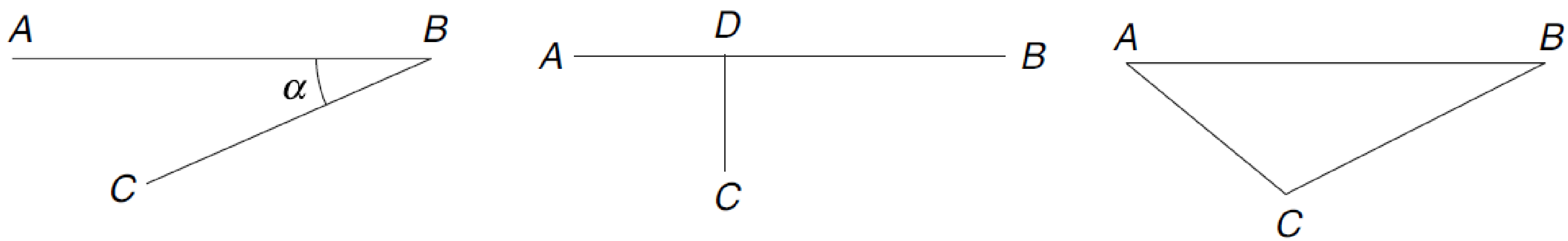
1. To work from whole to part

- 



To locate a point by at least two measurements

- Two control points (any two important features) are selected in the area and the distance between them is measured accurately. The line joining the control points is plotted to the scale on drawing sheet. Now the desired point can be plotted by making two suitable measurements from the given control points.



(a) (b) (c)

Thank you

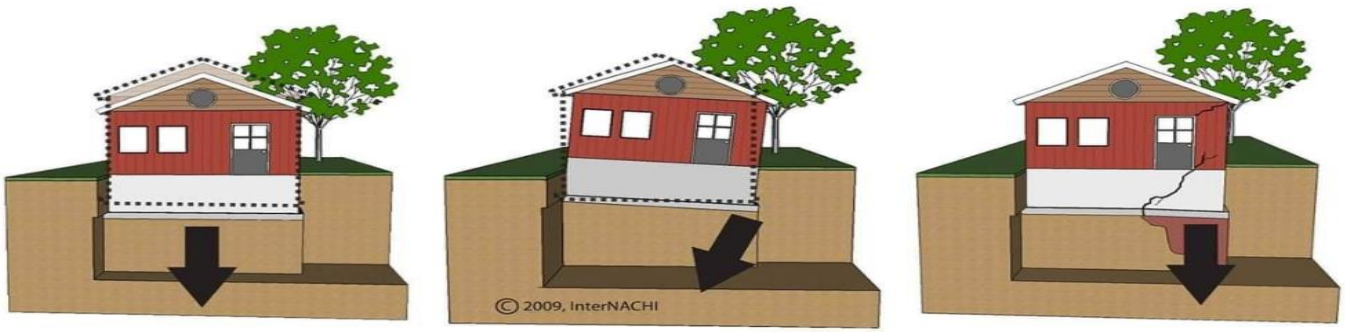
Introduction to Basic Civil Engineering

Module 3

Sreejith Krishnan, *PhD*

Bearing Capacity

- The bearing capacity of soil is the maximum load per unit area which the soil or material in foundation, may be rock or soil, will support without displacement.
- Since soil is usually much weaker than other common materials of construction, such as steel and concrete, a greater area or volume of soil is necessarily involved in order to satisfactorily carry a given loading



Uniform Settlement (No Cracks) | Tipping Settlement (Mostly Without Cracks) | Differential Settlement (With Cracks)

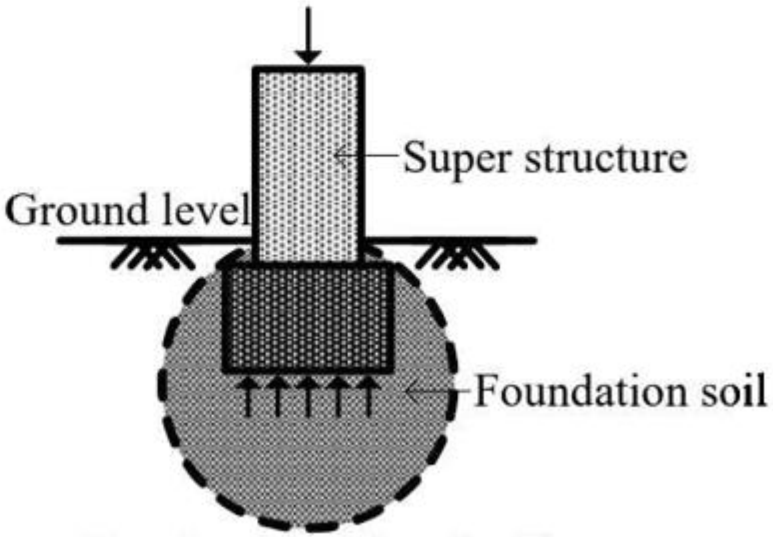
Bearing Capacity

- Ultimate bearing capacity or Gross bearing capacity: It is the least gross pressure which will cause shear failure of the supporting soil immediately below the footing.

- Net ultimate bearing capacity: It is the net pressure that can be applied to the footing by external loads that will just initiate failure in the underlying soil. It is equal to ultimate bearing capacity minus the stress due to the weight of the footing and any soil or surcharge directly above it.

Bearing Capacity

- Safe bearing capacity: It is the bearing capacity after applying the factor of safety (FS).

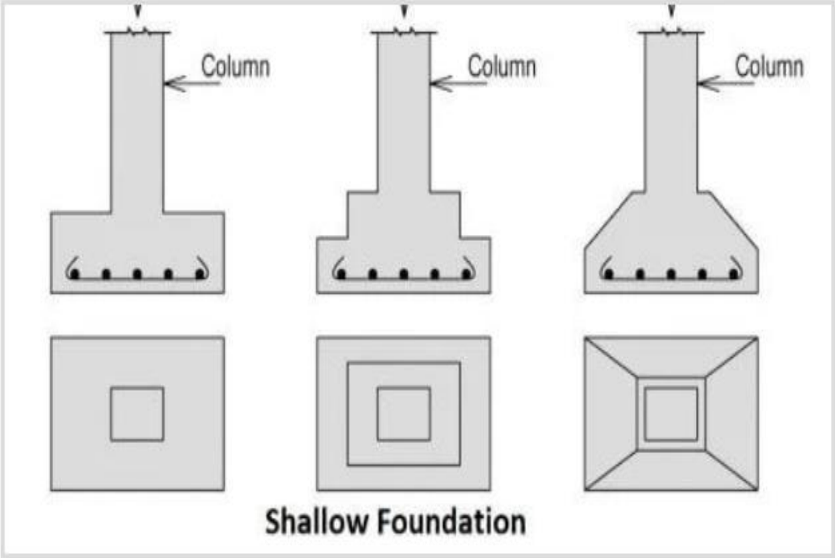


Foundation

- The part of the structure below the ground level.
- .To support the loads of the superstructure
- To give stability to the structure against various disturbing forces such as wind and rain.
- To prepare a level surface for concreting and masonry work
- Should go deep enough to be not affected by swelling and shrinkage
- Should distribute the loads evenly

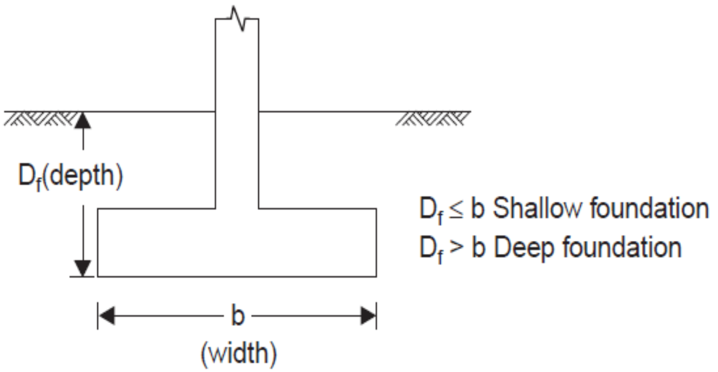
Foundation

- Can be of two types
  - Shallow Foundation
  - Deep Foundation



- Shallow Foundation - a foundation that transfers building loads to the earth very near to the surface

- The depth of the foundation is less than its width

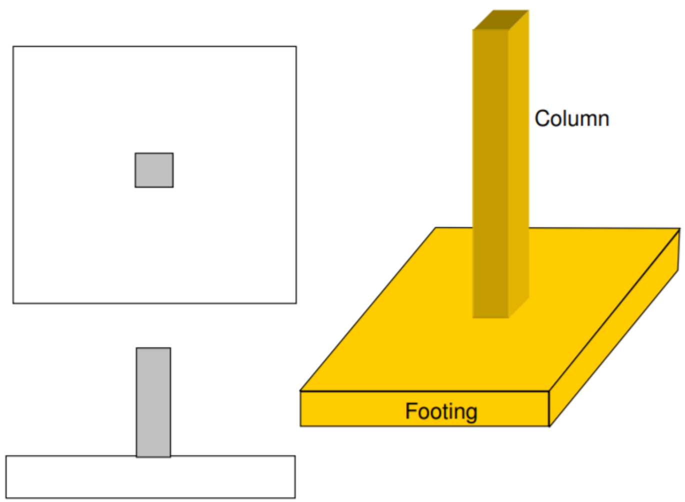


- When soil at shallow depth can support the loads of the structure

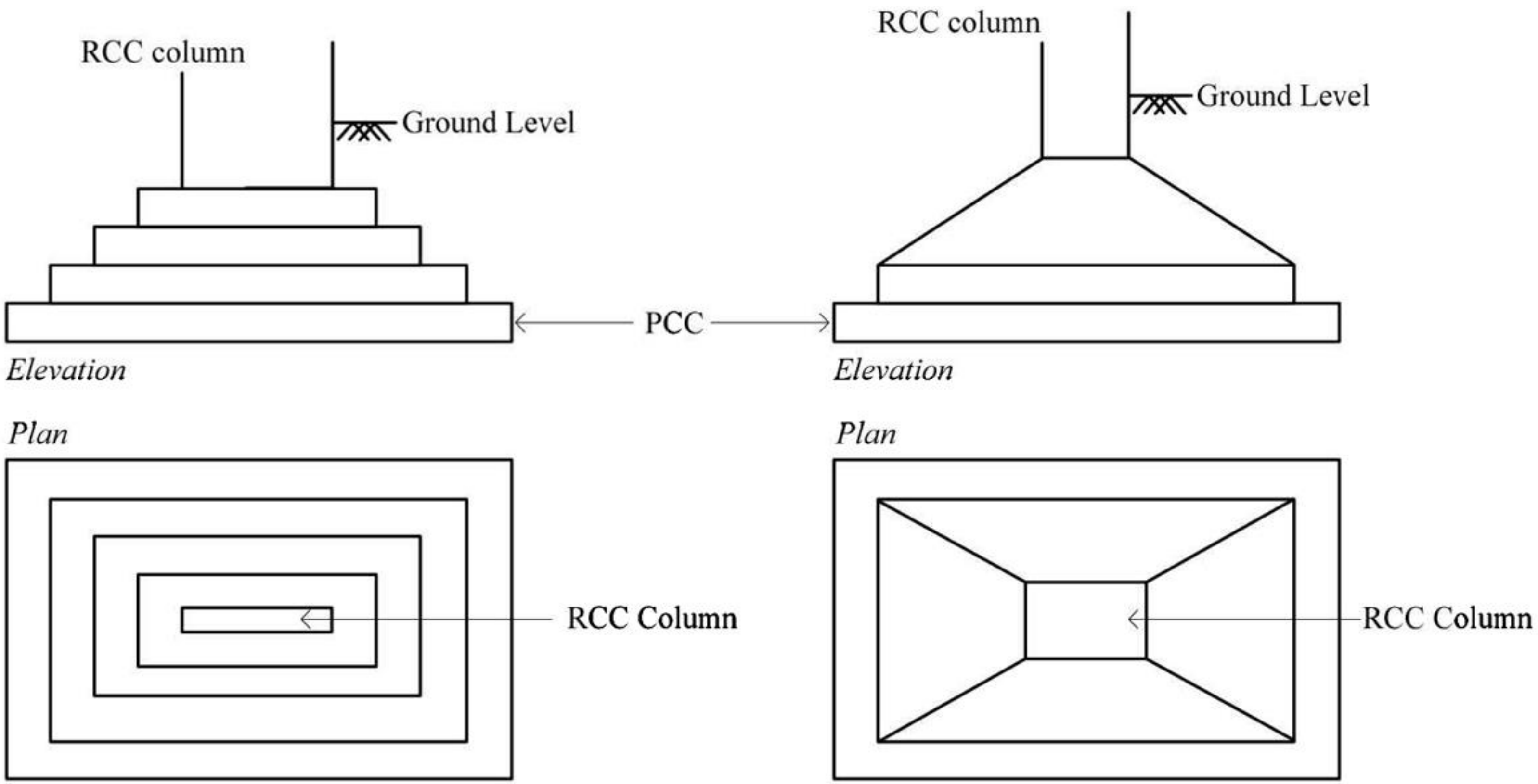
Types of shallow foundation

- Footings are structural elements, which transfer loads to the soil from columns, walls or lateral loads from earth retaining structures

- Isolated spread footings are provided under individual columns. These can be square, rectangular, or circular.



Isolated spread footings

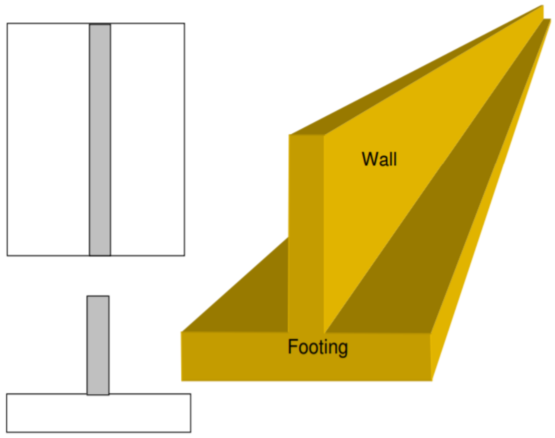


Stepped footing

Slopped footing

Types of shallow foundation

- Wall footing or strip footing is a continuous slab strip along the length of wall.

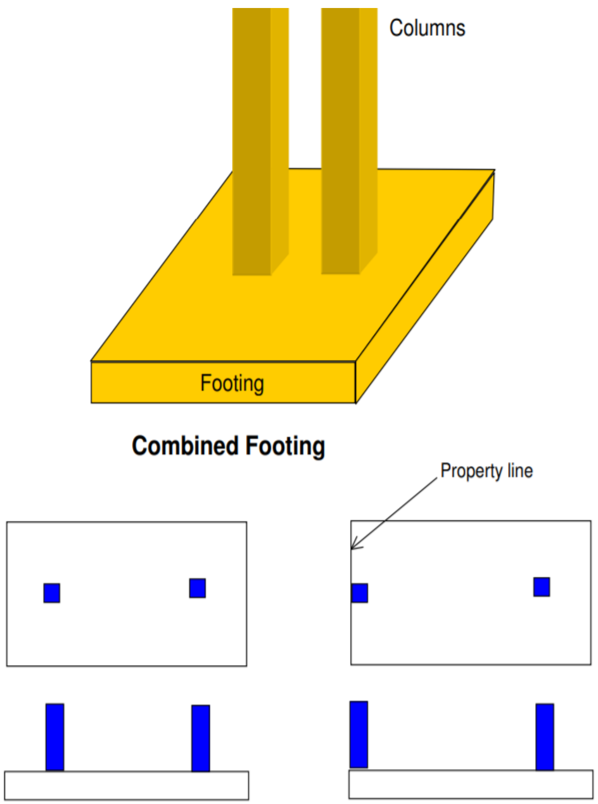


- Can also be provided for closely spaced columns

- Used for individual columns, walls and bridge piers where the bearing soil layer is within 3m (10 feet) from the ground surface.

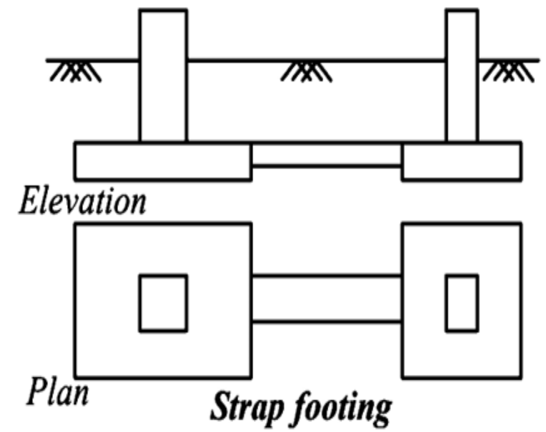
Types of shallow foundation

- Combined footings support two columns.
- Also called continuous footing if it supports more than 3 columns
- Can be economical
  - Single pit
  - No risk of soil collapse between the spread foundations
- These can be rectangular or trapezoidal plan.
  - Uniform vs non uniform loading



Types of shallow foundation

- Cantilever or strap footings: These are similar to combined footings, except that the footings under columns are built independently, and are joined by strap beam.



- It is used to help distribute the weight of either heavily or eccentrically loaded column footings to adjacent footings

- The strap beam restrains the tendency of the footing to overturn by connecting it to nearby footings

Types of shallow foundation

- Raft or Mat foundation: This is a large continuous footing supporting all the columns of the structure.

- The raft or mat foundation is a combined footing that covers the entire area beneath the structure and supports the columns.

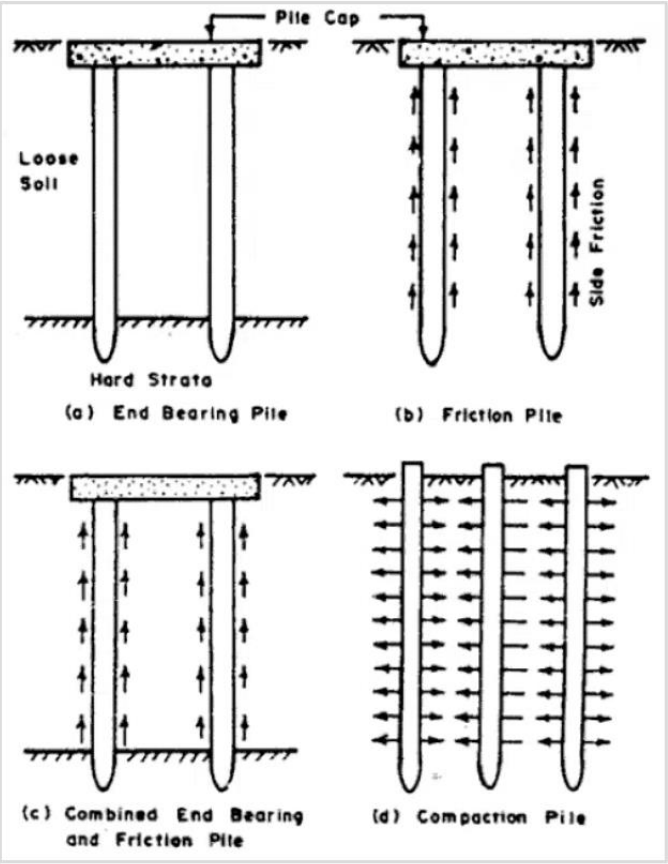
- This is used when soil conditions are poor but piles are not used.

- Usually, when hard soil is not available within 1.5–2.5 m, a raft foundation is adopted.

- Raft foundation is economical when one-half area of the structure is covered with individual footings and wall footings are provided.

Foundation

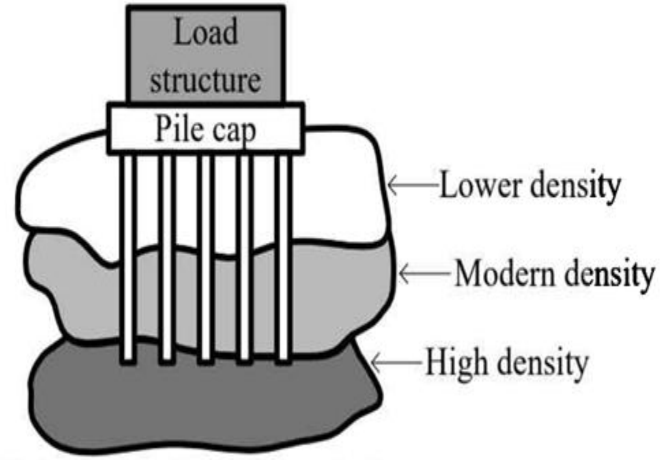
- Deep foundation – a foundation which transfers to the loads farther down the surface of the earth
- Pile foundation is an example
- Expensive but can take very high loads
- Can be up to 65m in depth



Deep Foundation

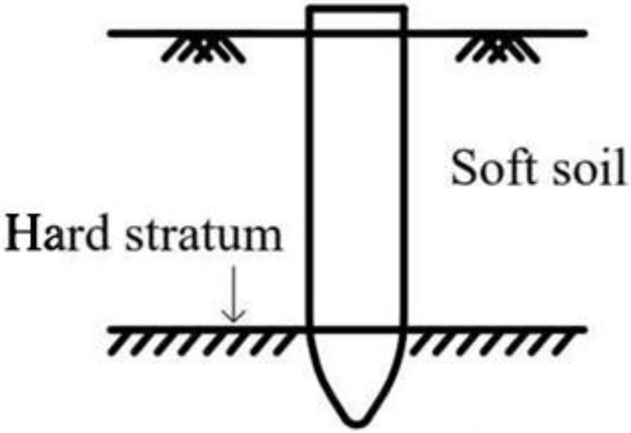
- Pile foundations are intended to transmit structural loads through zones of poor soil to a depth where the soil has the desired capacity to transmit the loads.

- Piles obtain lateral support from the soil in which they are embedded so that there is no concern with regard to buckling

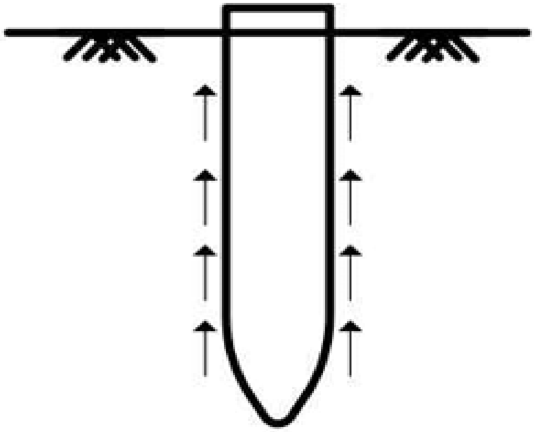


Principle of pile foundation

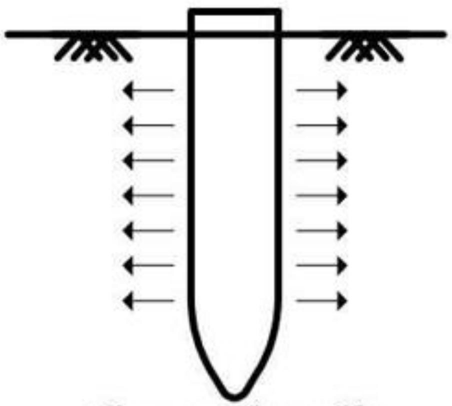
Different Pile Foundations



End bearing pile



Friction pile



Compaction pile

Other piles are also possible – Sheet pile, anchor pile

Different Pile Foundations

- Based on construction materials
  - Steel
  - RCC
  - Timber

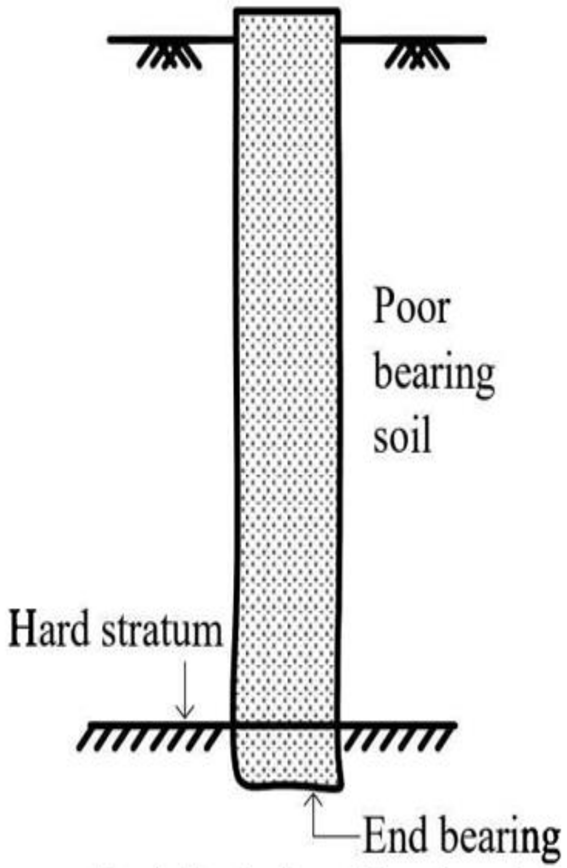
Pier Foundations

- A pier is a vertical column of a relatively larger cross-section than a pile. A pier is installed in an area by excavating a cylindrical hole of a large diameter to the desired depth and then backfilling it with concrete.

- A cast-in-situ pile greater than 0.6 m diameter is generally termed as a pier.

- Shallower in depth than pile foundation

- The difference between the pile foundation and pier foundation lies in the method of construction. Though pile foundations transfer the load through friction and bearing, pier foundations transfer the load only through the bearing.

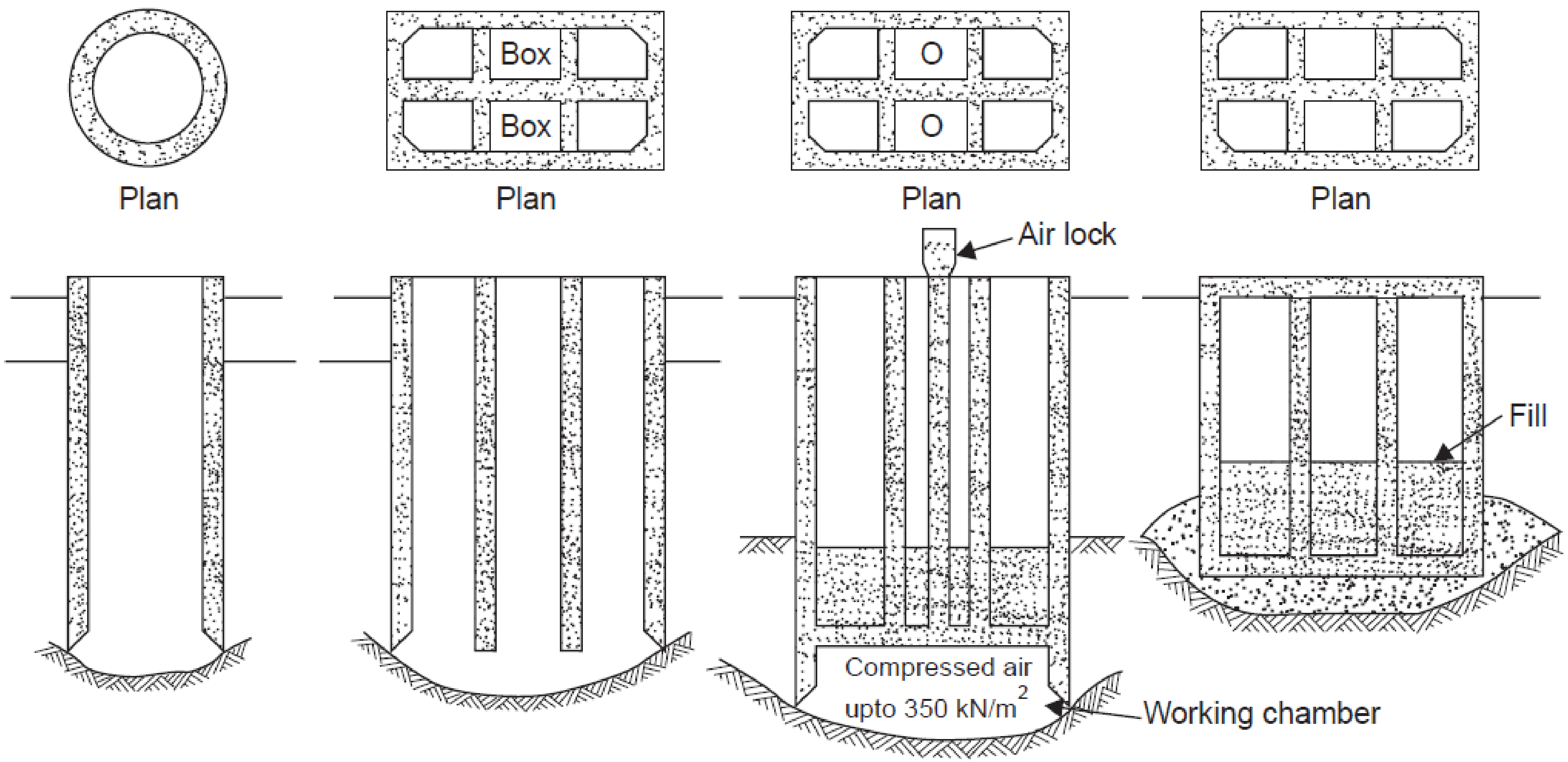


Straight shaft end bearing pier

Caisson Foundation

- A caisson is a structural box or chamber that is sunk into place or built in place by systematic excavation below the bottom.
- Caissons are classified as 'open' caissons, 'pneumatic' caissons, and 'box' or 'floating' caissons.
- Open caissons may be box-type or pile-type.
- Can withstand lateral loads

Caisson Foundation



(a) Pile-type open caisson

(b) Box-type open caisson

(c) Pneumatic caisson

(d) Box (floating) caisson

Thank you

Introduction to Basic Civil Engineering

Module 3

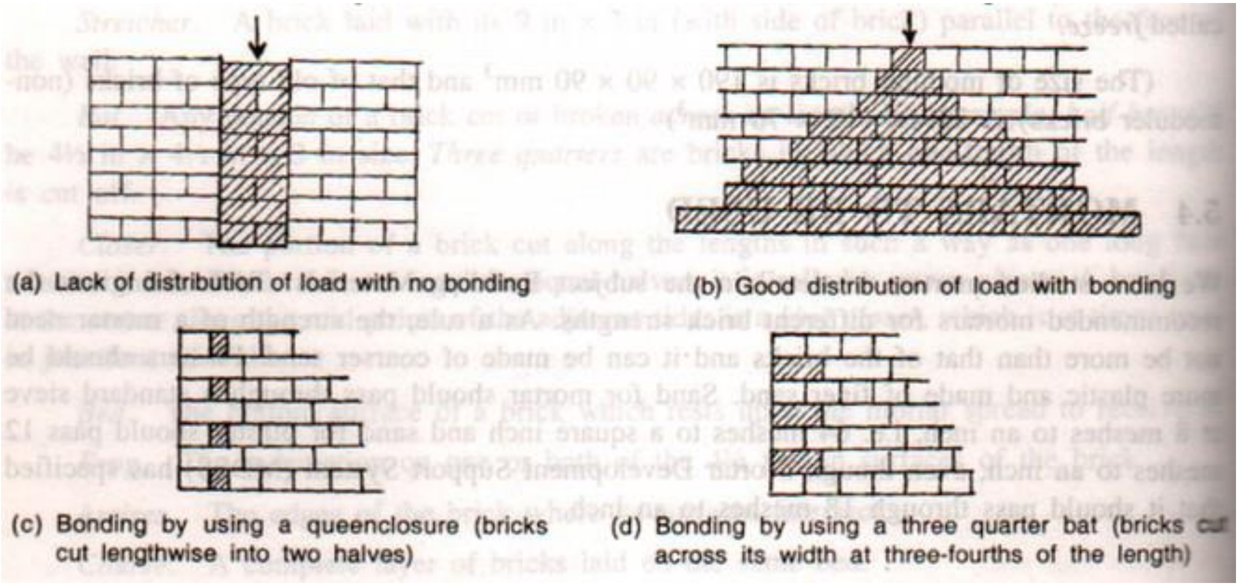
Sreejith Krishnan, *PhD*

Brick Masonry

- The masonry wall is built of individual blocks of materials such as stones, bricks, concrete, hollow blocks, cellular concrete and laterite, usually in horizontal courses cemented together with some form of mortar.

Bonding of Bricks

- Orderly arrangement of bricks
  - Continuous joints are eliminated
  - Good distribution of load takes place
  - Many types of bonds available



(a) Lack of distribution of load with no bonding

(b) Good distribution of load with bonding

(c) Bonding by using a queenclosure (bricks cut lengthwise into two halves)

(d) Bonding by using a three quarter bat (bricks cut across its width at three-fourths of the length)

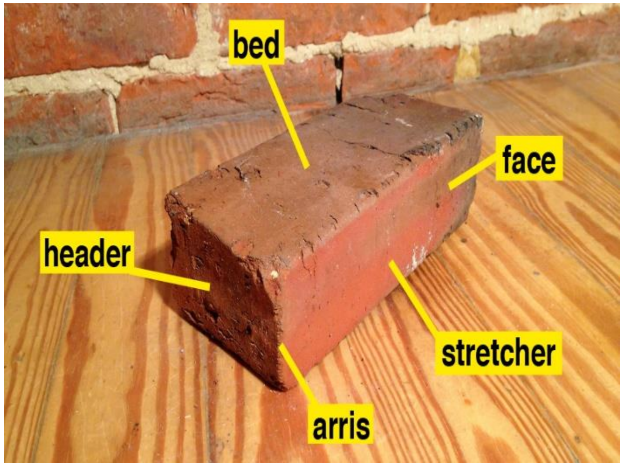
Common Terms used in Brick Masonry

- *Course:* A course is a horizontal layer of bricks or stones.

- *Back:* The inner surface of a wall that is not exposed is called a back. The material forming the back is known as backing.
- *Face:* The exterior of a wall exposed to weather is known as face. The material used in the face of a wall is known as facing.
- *Stretcher:* This is a brick laid with its length parallel to the face or front or direction of a wall. The course containing stretchers is known as stretcher course.

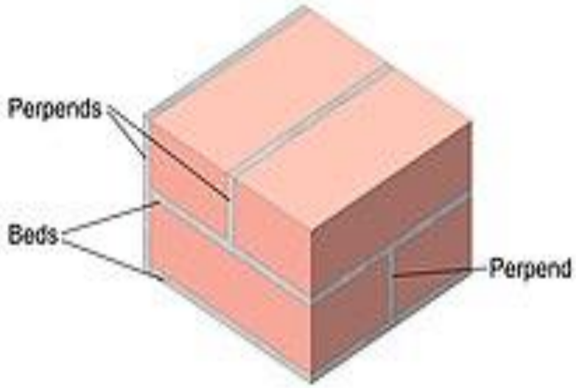
Common Terms used in Brick Masonry

- *Header:* This is a brick laid with its breadth or width parallel to the face or front or direction of a wall.

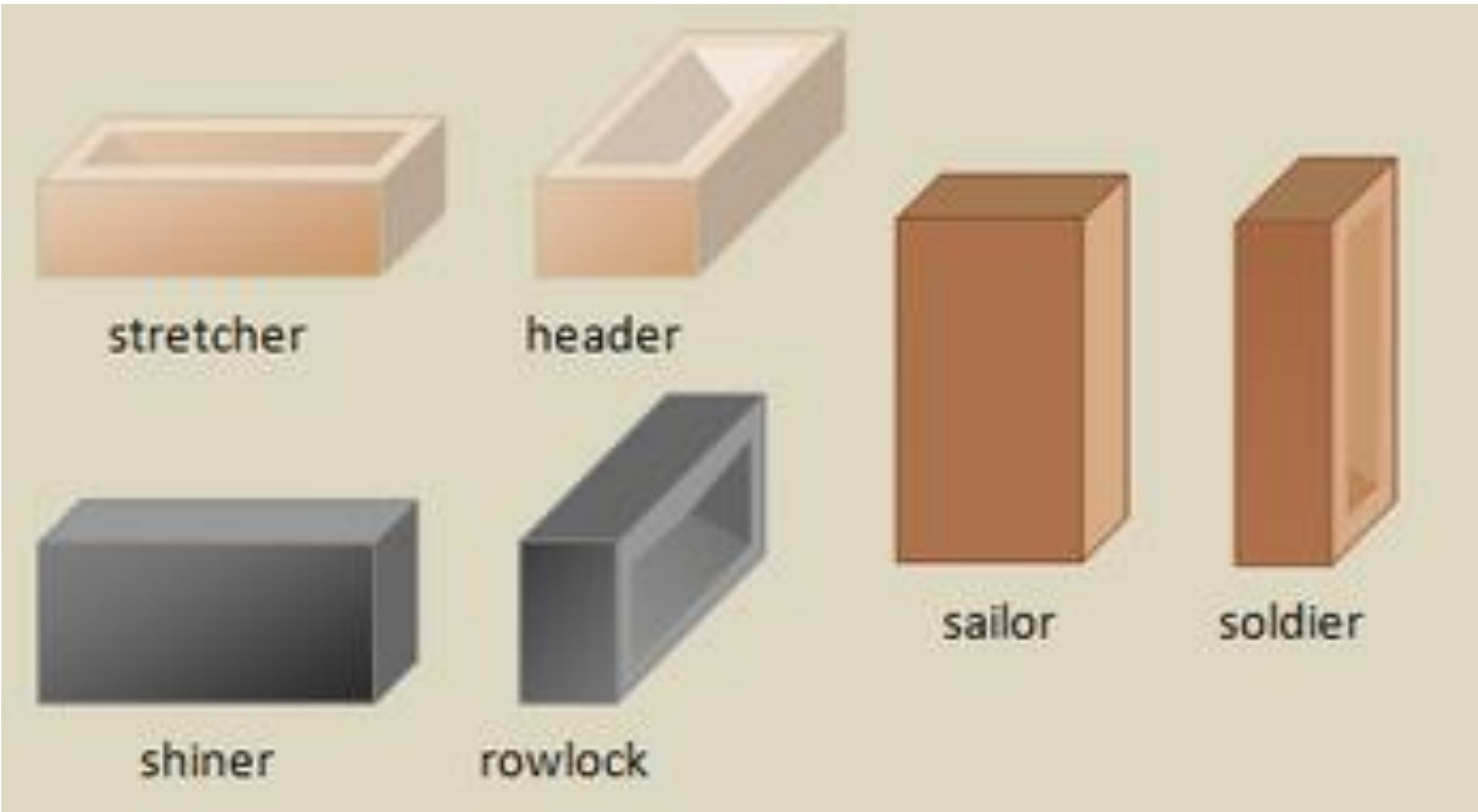


- *Arrises:* The edges formed by the intersection of plane surfaces of a brick are called the arrises and they should be sharp, square and free from damage.

- *Perpends:* The vertical joints separating the bricks in either length or cross direction are known as the perpends; for a good bond the perpends in alternate courses should be vertically one above the other.



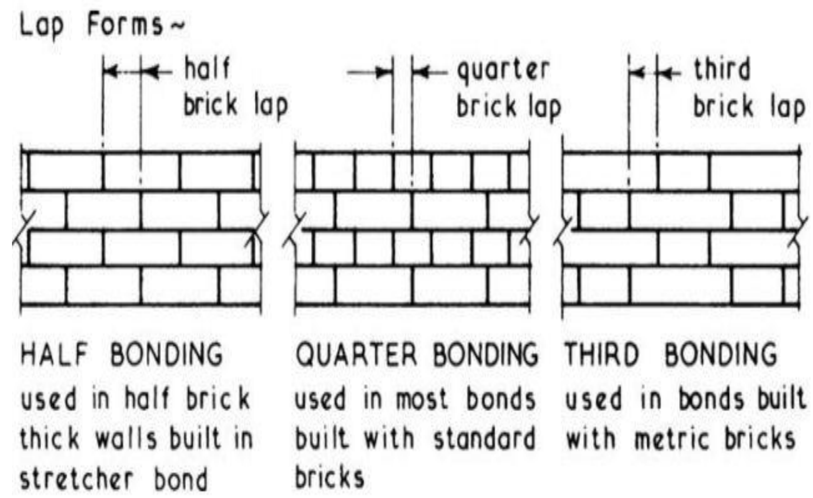
Other laying positions

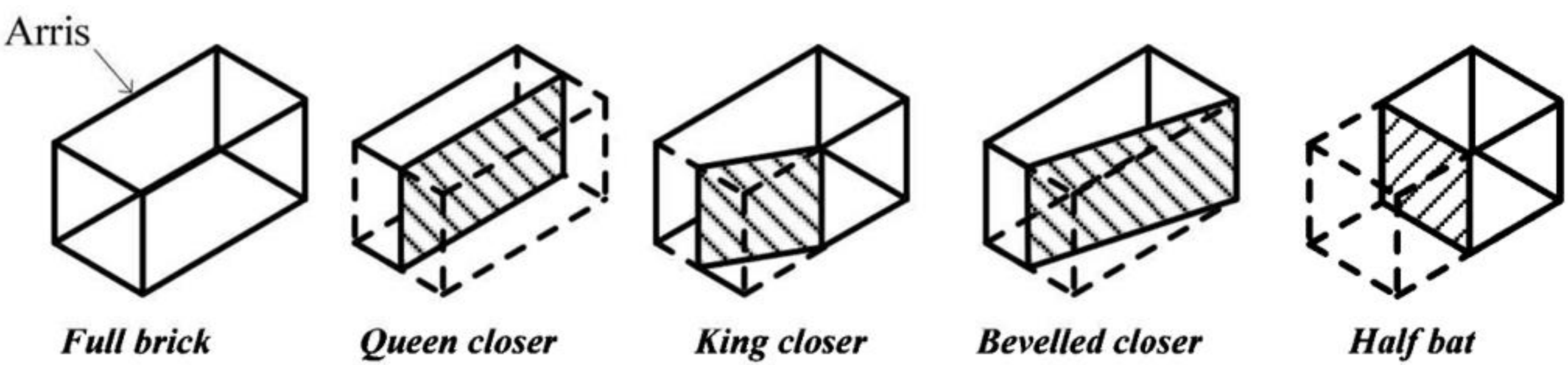


Common Terms used in Brick Masonry

- *Lap:* The horizontal distance between the vertical joints in successive courses is termed as a lap; for a good bond it should be one-fourth of the length of a brick

- *Closer:* A piece of brick which is used to close up the bond at the end of brick courses is known as the closer. It helps in preventing the joint of successive courses to come in a vertical line.





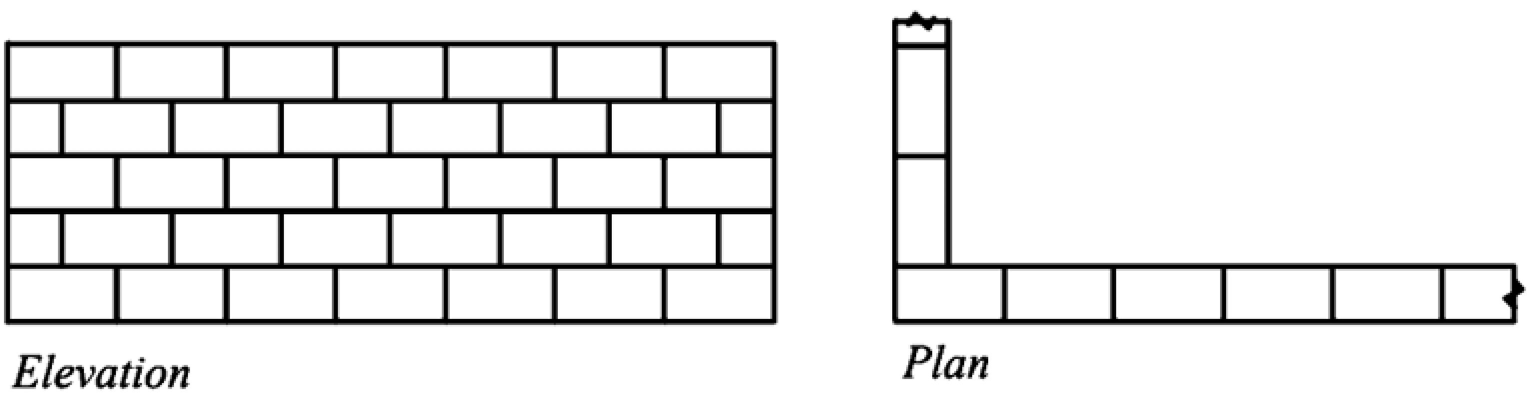
Rules for good bonding

- Bricks should have uniform shape and size
- Minimise the use of bats
- Bricks must be laid in full mortar
- The vertical joints in alternate should lie in the same perpend
- All the joints should be filled with mortar
- The lap distance should be minimum $\frac{1}{4}$ bat along the length of the wall and $\frac{1}{2}$ brick along the width of the wall

Bad Examples...

Bonds

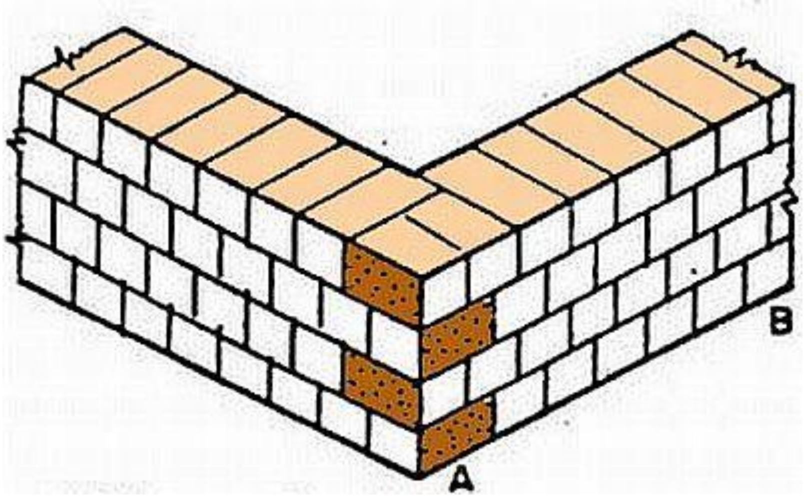
- Stretcher bond - In this type of bond, all the bricks are laid with their length in the direction of the wall. The stretcher bond is useful for one-brick partition walls as there are no headers.
- This bond does not develop proper internal bond and it should not be used for walls having thickness greater than that of one-brick wall.
- To break the vertical continuity $\frac{1}{2}$ brick bat is provided in alternating courses

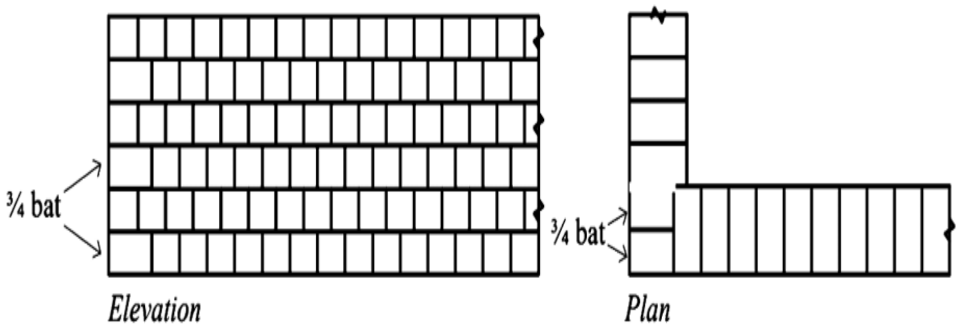


Stretcher bond-one brick wall

Bonds

- Header Bond - In this type of bond, all the bricks are laid with their ends towards the face of the wall.
- Thus, the bond does not have the strength to transmit pressure in the direction of the length of the wall. This bond is used for curved surface
- Not pleasing aesthetically

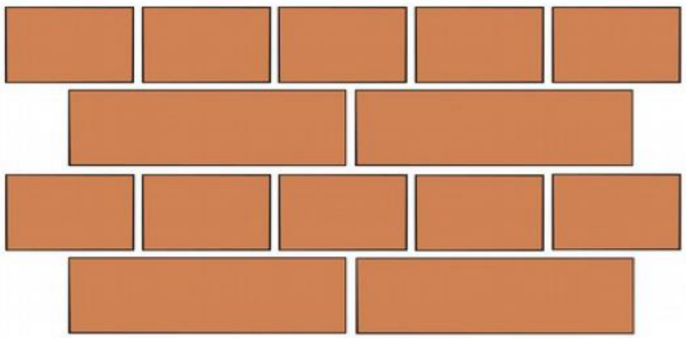


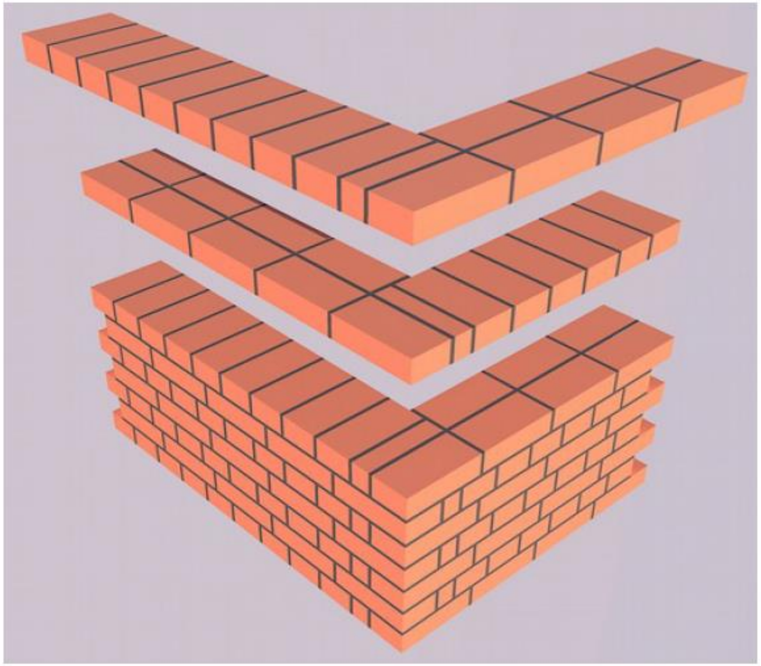


Header bond -one brick wall

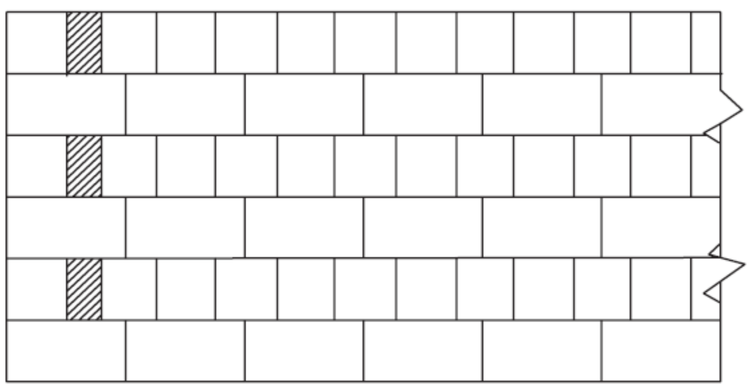
Bonds

- English bond - In this type of bond, alternate courses of headers and stretchers are laid. It is necessary to place queen closers after the first header in the heading course for breaking the joints vertically

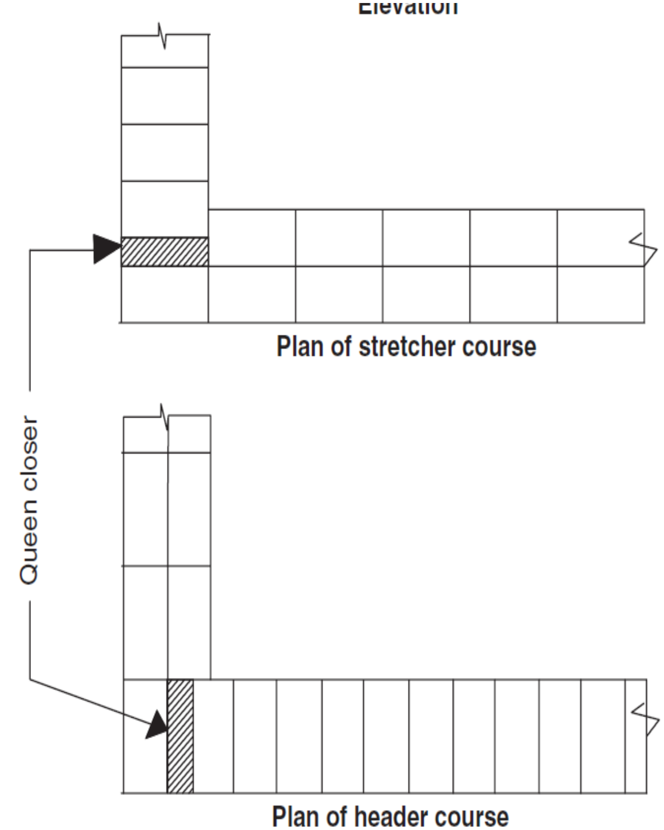




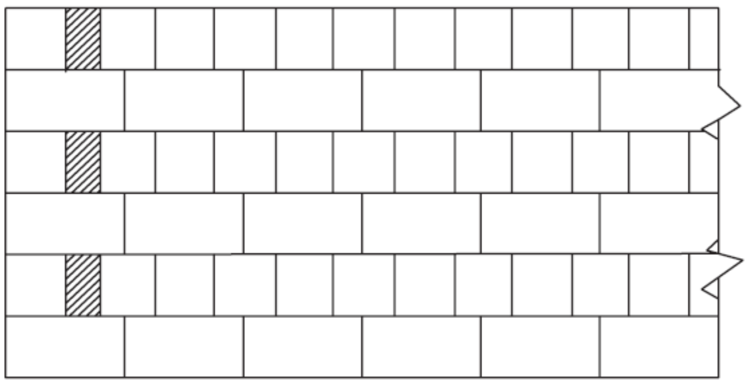
English Bond – 1 Brick Thick



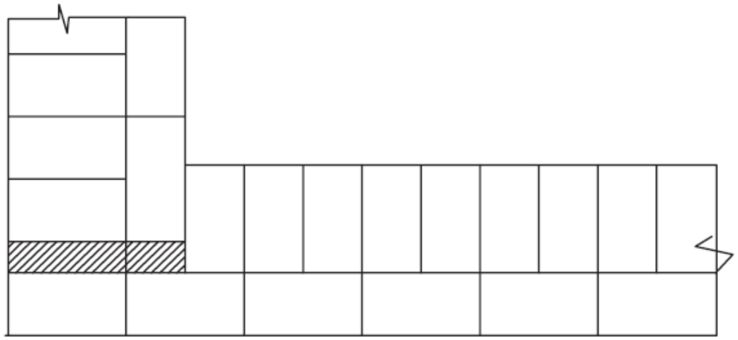
Elevation



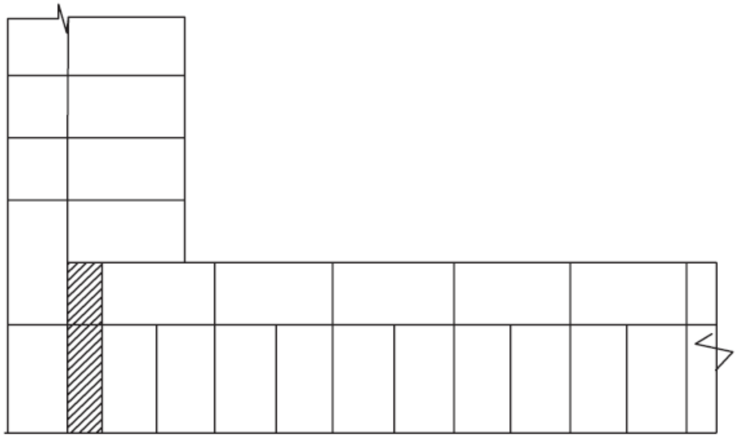
English Bond – 1 and 1/2 Brick Thick



Elevation



Plan of stretcher course



Plan of header course

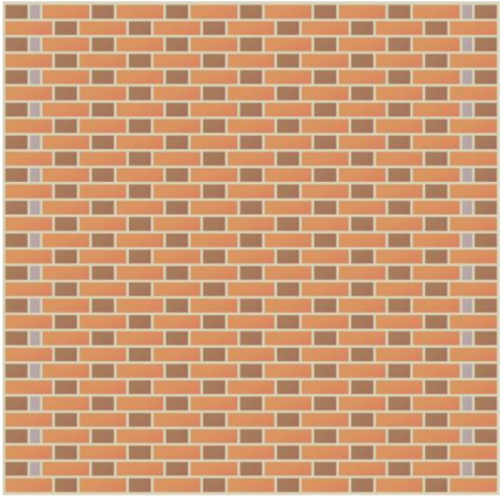
English Bonds

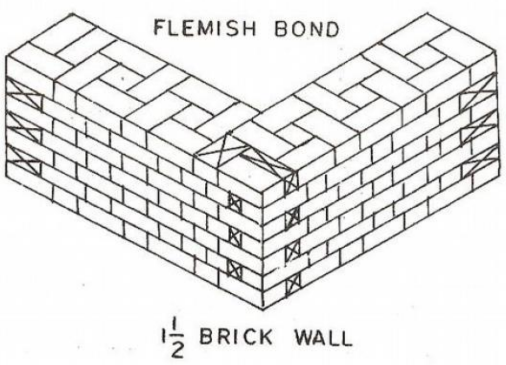
- A queen closer must be provided after a quoin header or first header. A header course should never start with a queen closer.
- Each alternate header should be centrally placed over a stretcher.
- Continuous vertical joints should not be allowed except at the stopped end.
- In case the wall thickness is equivalent to an even number of half bricks, the wall shall present similar appearance in both faces.
- In case the wall thickness is equivalent to an odd number of half bricks, the same course shall have stretcher on one face and header on the other face.
- The joints on the header course should be made thinner than those in the stretcher course. This is because of the fact that the number of vertical joints in the stretcher course is half the number of joints in the header course.

Flemish Bonds

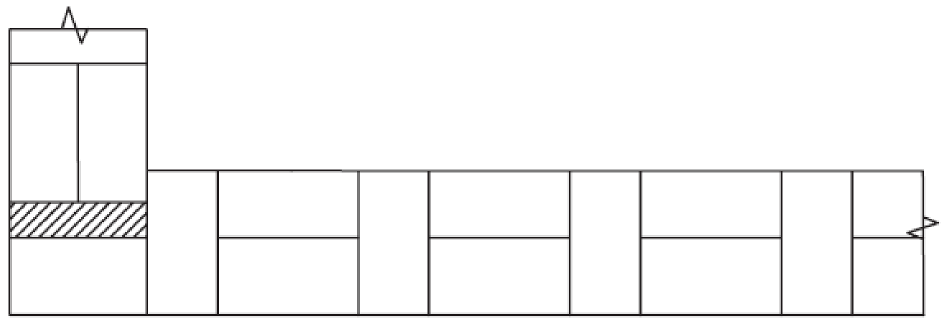
- This type of bond is created by laying alternate headers and stretchers in a single same course. The very next course of brick is laid such a way that header lies in the centered of the stretcher in the course below, i.e. the alternate headers of each course are centered on the stretcher of course below.

- Each and every alternate course of this bond starts with a header at the corner.

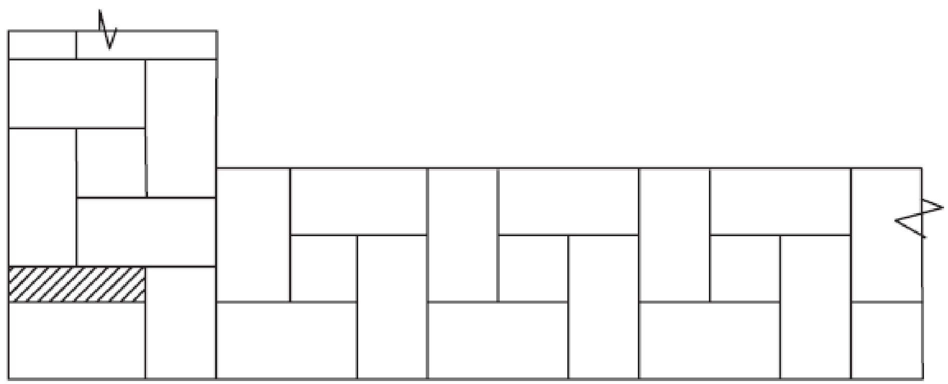




Flemish Bonds



1 brick wall



1½ brick wall

Flemish Bonds

A Comparison Between English and Flemish Bonds

English bond	Flemish bond
More compact and strong for walls having thickness more than 1½ bricks	Less compact and less strength
Less pleasing in appearance from facing	Better appearance in the facing
Strict supervision and skill are not required	Good workmanship and careful supervision required
More in cost	Cheaper in cost

Random Rubble Masonry

- Rubble masonry is rough, uneven building stone set in mortar, but not laid in regular courses.

- In this type of rubble masonry, stones of irregular sizes and shapes are used. The stones are arranged to have a good appearance. It is to be noted that more skill is required to make the masonry structurally stable.

Thank you

Introduction to Basic Civil Engineering

Lecture 14

Sreejith Krishnan, *PhD*

Floors

- Floors are provided to divide a building into different levels for creating more accommodation one above the other within a certain limited space

- Ground floor, basement floor, First floor etc.

- A floor may consist of two main components:
  - A sub-floor that provides proper support to the floor covering and the superimposed loads carried on it.
  - A floor covering which provides a smooth, clean, impervious and durable surface.

- Strength, durability, fire resistance, sound insulation and thermal insulation are some of the requirements from the floor

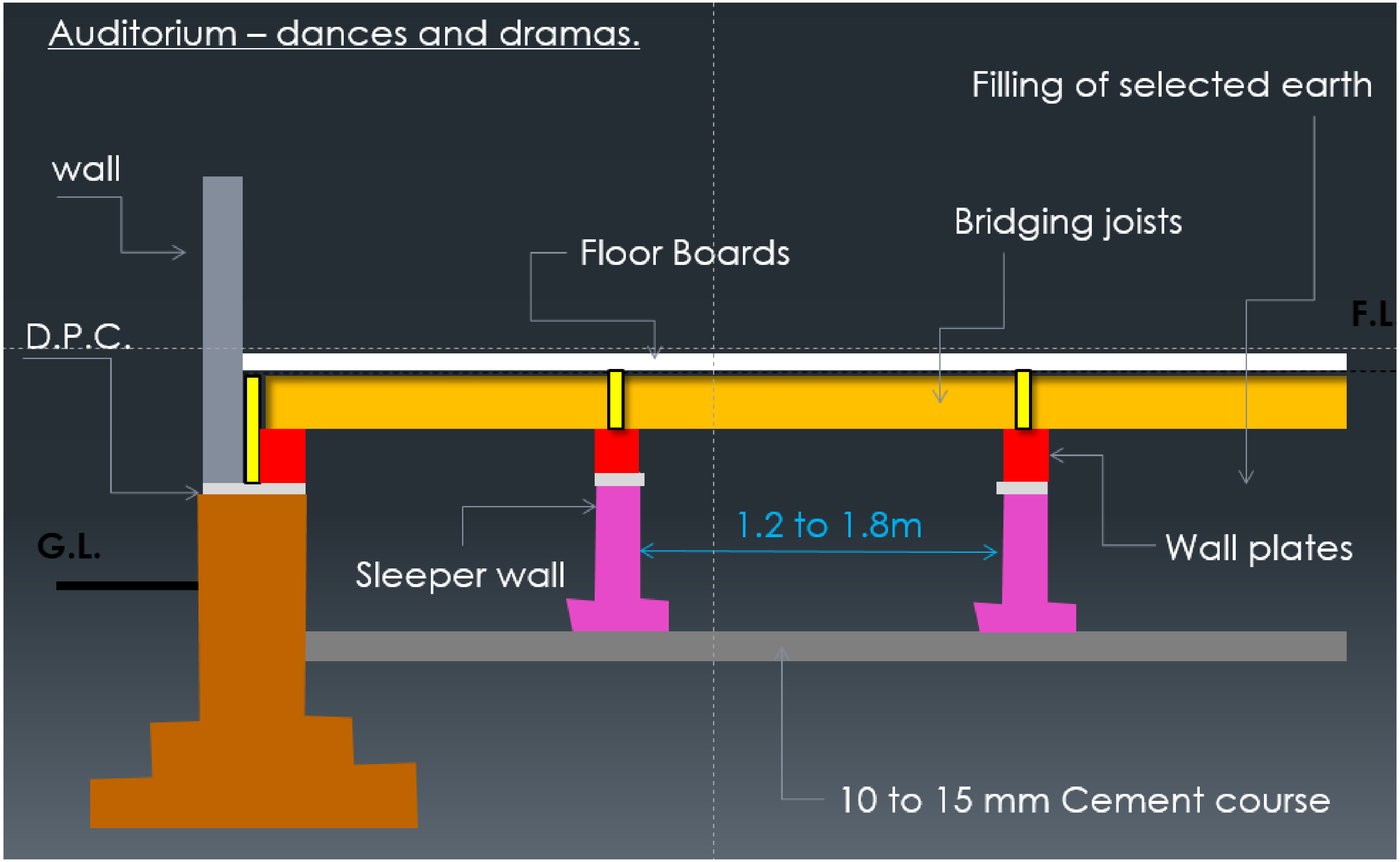
Factors affecting selection

- Initial Cost
- Appearance
- Cleanliness
- Durability
- Damp resistance
- Sound insulation
- Thermal insulation
- Smoothness
- Hardness
- Maintenance

Types of floor

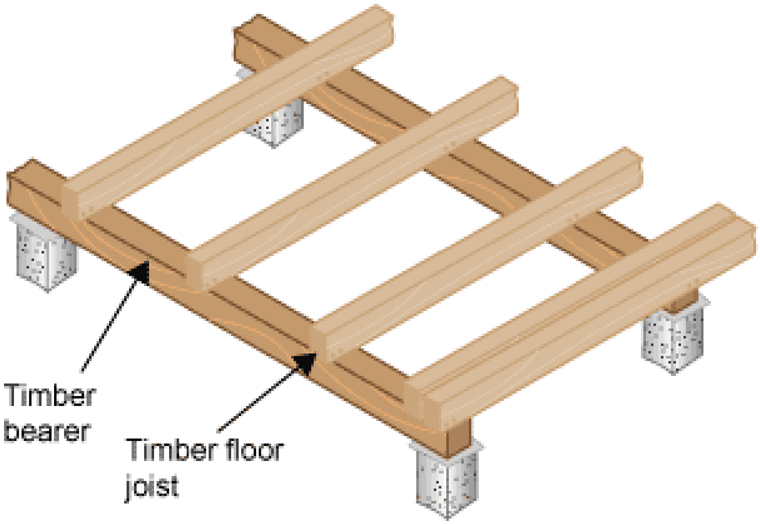
- Basement or ground timber floor
- Single joist timber floor
- Jack arch floor
- Hollow tiled and ribbed floor
- Double flagstone floor
- Flat slab floor
- RCC floor

Basement or ground timber floor



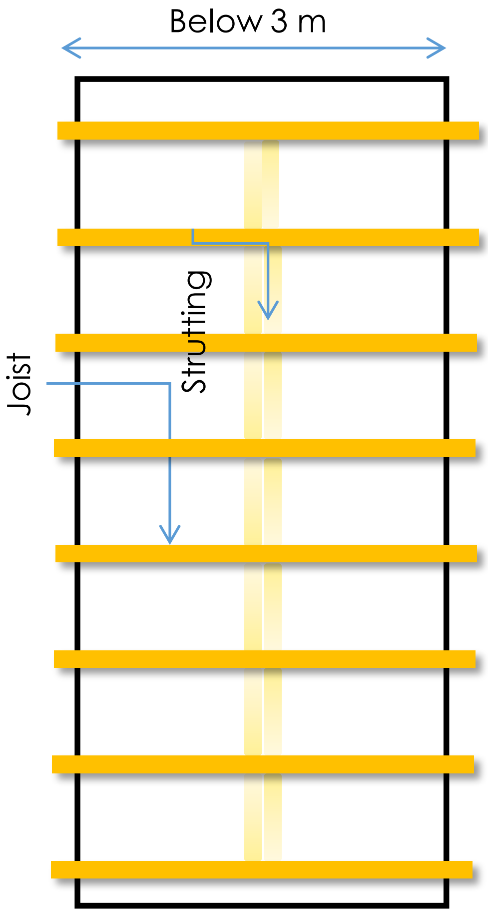
Basement or ground timber floor

- Soil below timber floor – covered with PCC 1:2:4 (100 to 150 mm thick).
- Plain cement concrete- it is used for providing a non porous, firm & level space for laying RCC & also used under flooring .
- DPC – exterior wall + top of the sleeper wall.
- A Sleeper Wall is a short wall used to support floor joists of a ground floor.
- Well seasoned timber is used.
- Hollow space between bottom of concrete and floor level is filled up with selected earth.



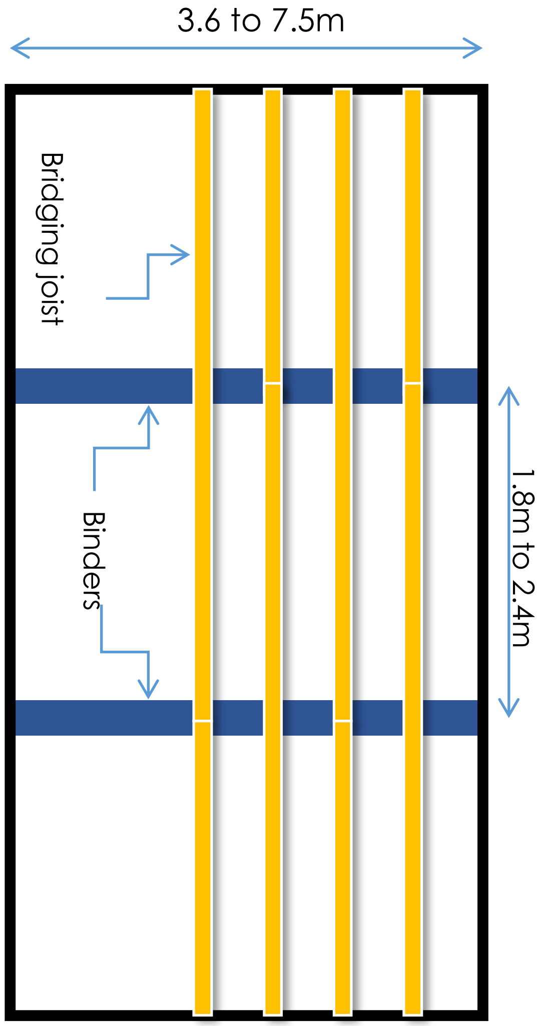
Single Joist Timber Floor

- This type of floor is used for residential buildings where spans are comparatively small and the loads are lighter. The wooden joists are placed at about 30 cm centre to centre, spanning the rooms in the shorter direction.
- Wooden planks are laid over these joists.
- The timber joists are supported on wall plates.
- Joists must be strong enough to withstand the loads and at the same time they should not deflect too much.
- Distribution of loads on the wall is more uniform as the joists are spaced closely.
- Easy construction and cheap



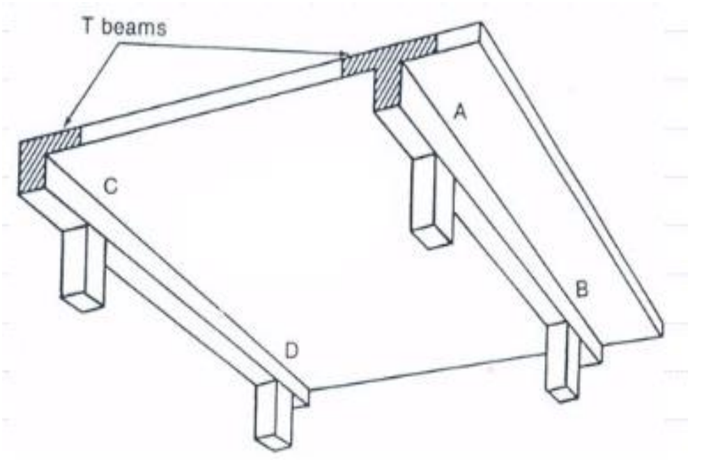
Double Joist Timber Floor

- This type of floor is stronger than the single joist timber floor. They are used for longer spans of 3.6–7.5 m and prevent the travel of sound waves to a great extent.
- Intermediate supports called binders are placed for bridging the joists.
- Binders are spaced at a centre-to-centre distance of about 2 m.
- The depth of the floor is considerably increased and, thus, the head room is reduced
- Loads distributed to few points in the walls



RCC floor

- Reinforced cement concrete (RCC) slab is being more commonly used in the construction of modern buildings.
- For small spans and comparatively lighter loads, a simple RCC slab is suitable.
- If the ratio of the length and width of a room is more than 1.5, the slab is designed to span along the shorter direction. The main reinforcement is provided along this shorter dimension of the room. The thickness of the slab is guided by the superimposed loads, span and type of concrete used.
- For larger spans and greater loads, RCC beams and slab construction are adopted in the construction of buildings.
- The slab acts as a flange of the beam and is cast monolithic with the beams. In this case, the size of the beam is greatly reduced.
- Over the RCC floor suitable covering is laid to get the desired finish



Flat slab floor

- It is directly supported on the columns without providing any intermediate beams.
- This type of construction is adopted when the use of beams is forbidden.
- Simple Formwork,
- More clear head room is available for use.

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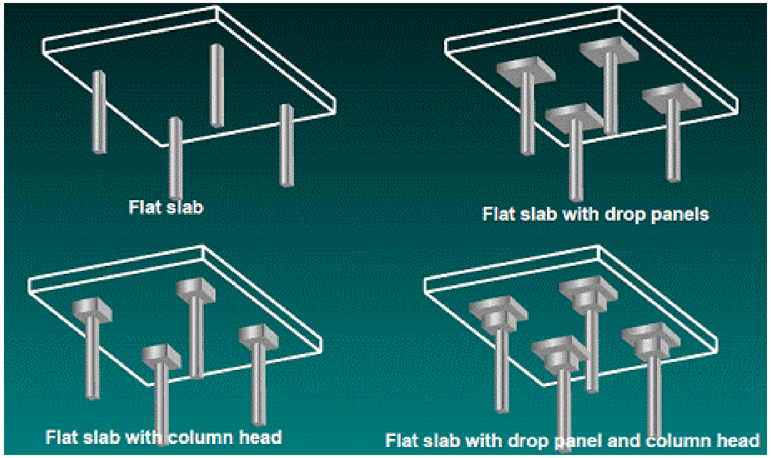
- No projecting of beams is to be seen and, therefore, the need of false ceiling is eliminated.



Types of flooring materials

- Brick flooring - It is employed for cheap constructions such as godowns, sheds, stores and barracks and where good bricks are available.

- Over well-compacted and levelled ground a layer of lean cement concrete mix (1:6:18) of 10 cm thickness is laid. Over this bedding, bricks are placed in proper bonds on their edges.

- Durable, hard, fire resistant, cheap etc.

- They are joined with cement or lime mortar. The only drawback of brick floor covering is that it absorbs water.

Stone flooring

- Square or rectangular slabs of stones are used as the floor covering.
- Generally, 20–40 mm thick stone slabs of size 30 cm × 30 cm, 45 cm × 45 cm, 60 cm × 60 cm, 45 cm × 60 cm, etc. are used. The stone should be hard, durable, tough and of good quality.
- Stones must be dressed
- The earthen base is levelled, compacted and watered. On this surface a layer of 10–15 cm thick concrete is laid and properly rammed. Over this concrete bed the stone slabs are fixed with a thin layer of mortar
- The stone surface may be rough or polished. A rough surface is provided in rough works like godowns, sheds, stores, etc. and a polished surface is provided in superior type of works.
- A slope of 1:40 should be provided in such type of floor covering for proper drainage.

Tiled floor covering

- Clay tiles of different sizes, shapes, thickness and colours are prepared and they are used as floor coverings. They are placed in position on a concrete base with a thin layer of mortar. When these tiles are to be fixed on timber floors, special beds of emulsified asphalt and Portland cement are used.

- Non absorbant, decorative, durable
- Quick installation, easy to repair

- Generally costly initially, slippery when wet

- Vitrified tiles vs ceramic tiles

Wooden floor covering

- This type of floor covering is the oldest type, but nowadays it is used for some special-purpose floors such as theatres and hospitals. It possesses natural beauty and has enough resistance to wearing.

  - Strip floor covering: This is made up of narrow and thin strips of timber which are joined to each other by tongue and groove joints.
  - Planked floor covering: In this type of construction, wider planks are employed and these are joined by tongue and groove joints.
  - Wood block floor covering: It consists of wooden blocks which are laid in suitable designs over a concrete base. The thickness of a block is 20–40 mm and its size varies from 20 × 8 to 30 × 8 cm. The blocks are properly joined together with the ends of the grains exposed.

Concrete Floor Covering

- The concrete flooring consists of two layers:
  - A base course or the subgrade and
  - A wearing course
  - The concrete flooring consists of a topping of cement concrete 2.5–4 cm thick laid on a 10–15 cm thick base of either lime or cement concrete
- It is non-absorbent and, hence, offers sufficient resistance to dampness. This is used for water-retaining floors as well as stores.
- It possesses high durability and, hence, is employed for floors in kitchens, bathrooms, schools, hospitals, etc.
- It provides a smooth, hard, even and pleasing surface.
- It can be easily cleaned and overall has proved economical due to less maintenance cost.
- Concrete being a non-combustible material offers a fi re-resistant floor required for fire-hazardous buildings.

Concrete Flooring

- Defects once developed in concrete fl oors, whether due to poor workmanship or materials, cannot be easily rectified.
- The concrete flooring cannot be satisfactorily repaired by patchwork.
- It does not possess very satisfactory insulation properties against sound and heat.

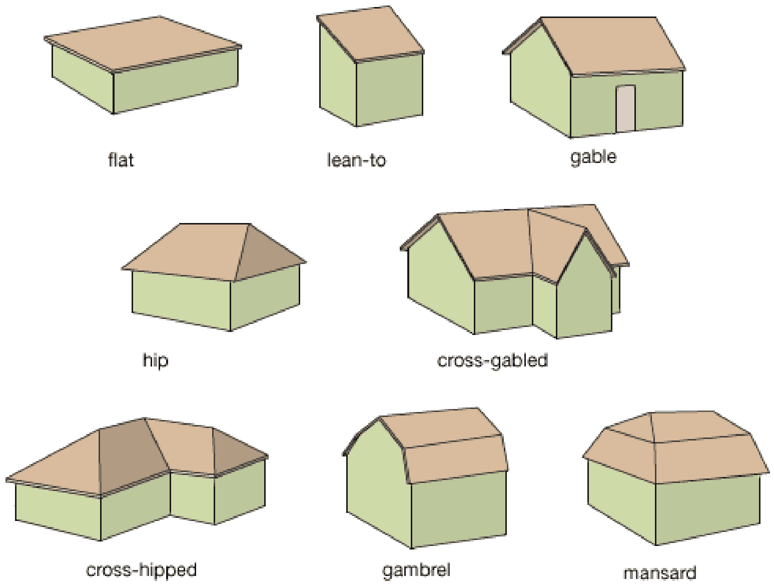
Flooring materials

- Rubber flooring
- Glass flooring
- Mosaic flooring
- Linoleum flooring etc.

Roofs

- A roof is the uppermost part of a building whose main function is to enclose the space and to protect the same from the effects of weather elements such as rain, wind, sun, heat and snow.

- A good roof is just as essential as a safe foundation.



Requirements from a roof

- ***Strength and stability:*** The roof structure should be strong and stable enough to take up the anticipated loads safely.
- ***Weather resistance:*** The roof covering should have adequate resistance to resist the effects of weather elements such as wind, rain, sun and snow.
- ***Heat insulation:*** The roofs should provide adequate insulation against heat, particularly in the case of single-storeyed buildings where the roof area may exceed that of walls with a consequent greater heat loss.
- ***Sound insulation:*** The roof construction for all buildings should provide adequate degree of insulation against sound from external sources.
- ***Fire resistance:*** The roof should offer an adequate degree of fire resistance in order to give protection against the spread of fire from any adjacent building and to prevent early collapse of the roof. The form of construction should also be such that the spread of fi re from its source to other parts of the building by way of roof cannot occur.

Types of roofs

- Pitched or sloping roofs
- Flat roofs
- Shell roofs
- Domes

Flat Roofs

- **Flat Roofs:** These roofs are nearly flat. However slight slope (not more than 10°) is given to drain out the rain water.

- All types of upper storey floors can serve as flat roofs.

- Many times top of these roofs are treated with water proofing materials- like mixing water proofing chemicals in concrete. With advent of reliable water proofing techniques such roofs are constructed even in areas with heavy rain fall.

Flat Roofs - Advantages

(a) The roof can be used as a terrace for playing and celebrating functions.

(*b*) At any latter stage the roof can be converted as a floor by adding another storey.

(*c*) They can suit to any shape of the building.

(*d*) Over-head water tanks and other services can be located easily.

(*e*) They can be made fire proof easily compared to pitched roof.

Flat Roofs - Disadvantages

a) They cannot cover large column free areas.

b) Leakage problem may occur at latter date also due to development of cracks. Once leakage problem starts, it needs costly treatments.

c) The dead weight of flat roofs is more.

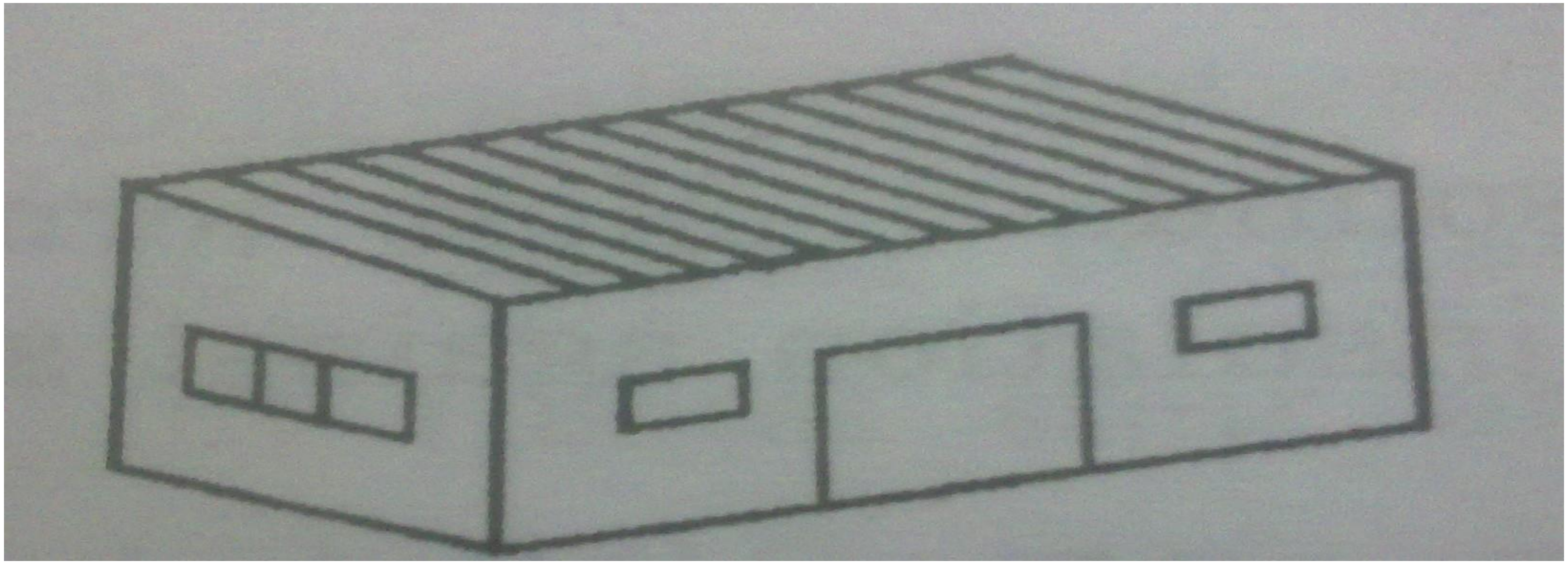
d) In places of snow fall flat roofs are to be avoided to reduce snow load

Pitched or Sloping Roofs

- Sloping top surface
- Suitable in areas with heavy rain and snowfall
- Can be used when the width of the building is small and simple plans
- The slope of roof shall be more than 10 degrees. They may have slopes as much as 45 to 60 degrees.
- The sloping roofs are preferred in large spanned structures like workshops, factory buildings and ware houses.
- In all these roofs covering sheets like A.C. sheet, G.I. sheets, tiles, slates etc.

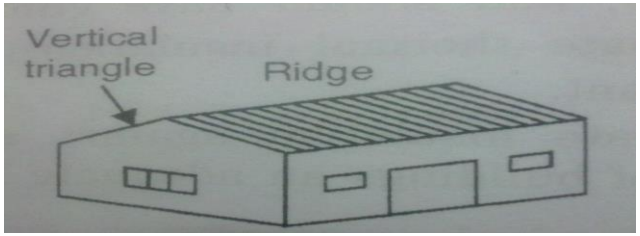
Forms of Pitched Roofs

- **LEAN-TO-ROOF:-**It is the simplest form of a pitched roof and it is known as pent roof. In this type of roof, one wall is carried up sufficiently higher than the other to give necessary slope to the roof.

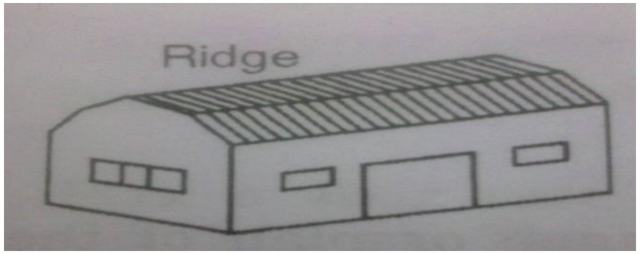


Forms of Pitched Roofs

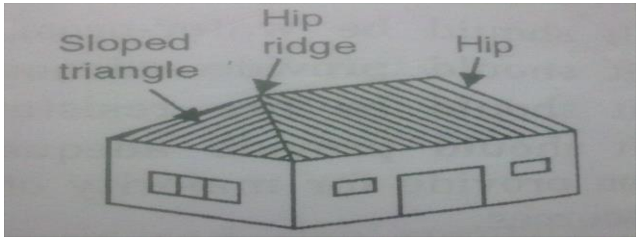
- **GABLE ROOF:-** This is the common type of sloping roof which slopes in two direction. The two slopes meet at the ridge.



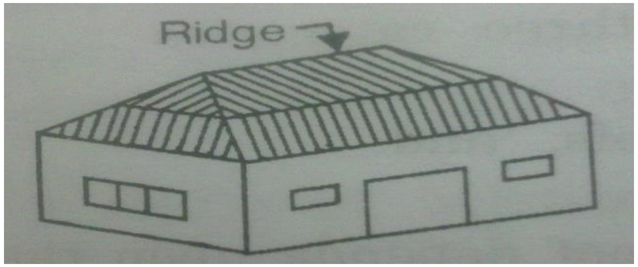
- **GAMBREL ROOF:-** This roof like gable roof, slopes in two directions but there is break in each slope.



- **HIP ROOF:-** This roof is formed by four sloping surfaces in four directions.

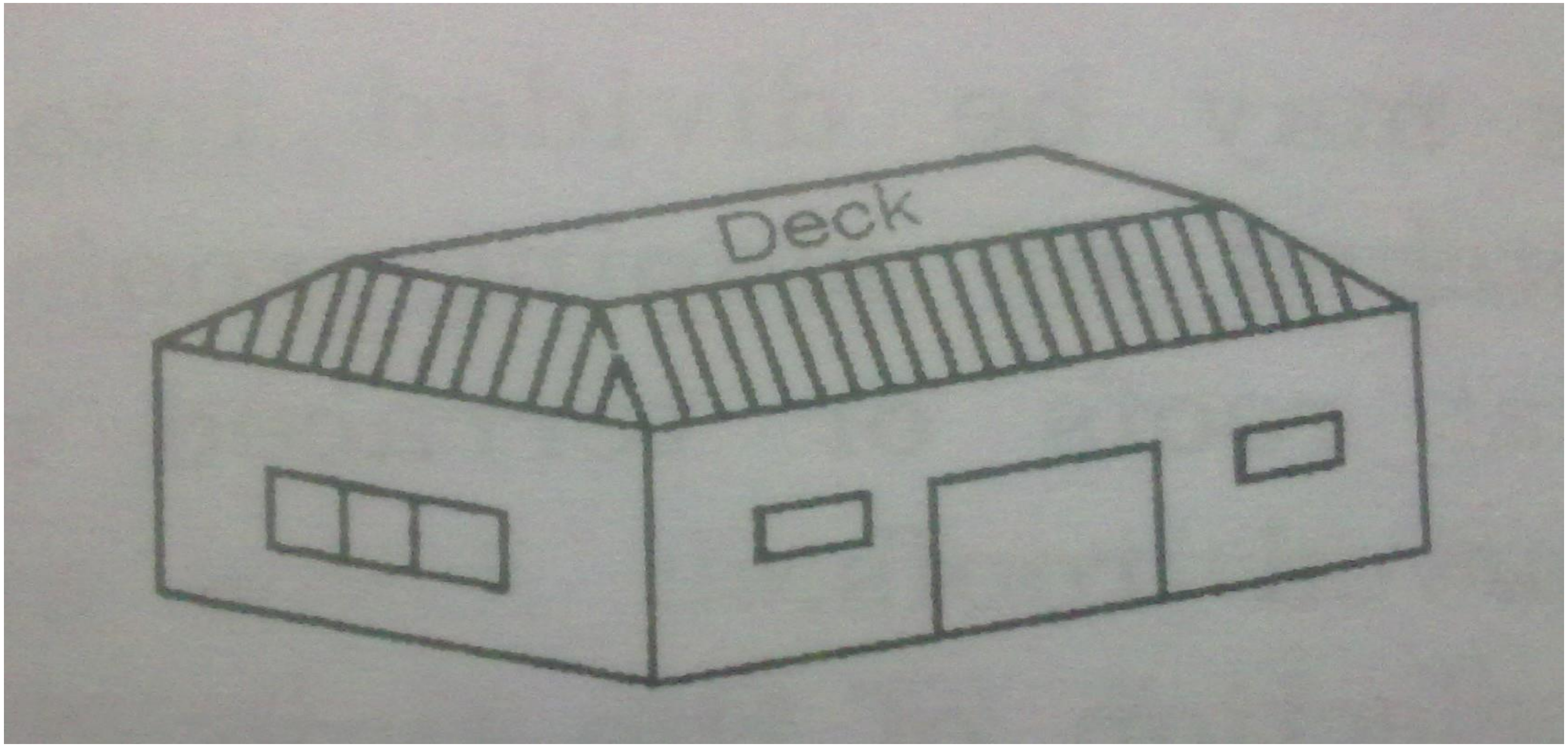


- **MANSARD ROOF:-** This roof like a hip roof, slopes in four directions but each slope has a break.



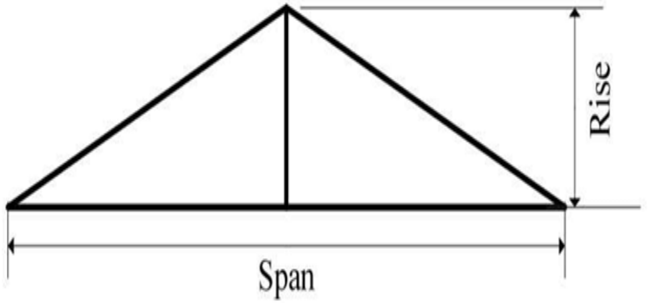
Forms of Pitched Roofs

- **DECK ROOF:-** A deck roof has slopes in all the four directions, like a hip roof but a plane surface is formed at the top.

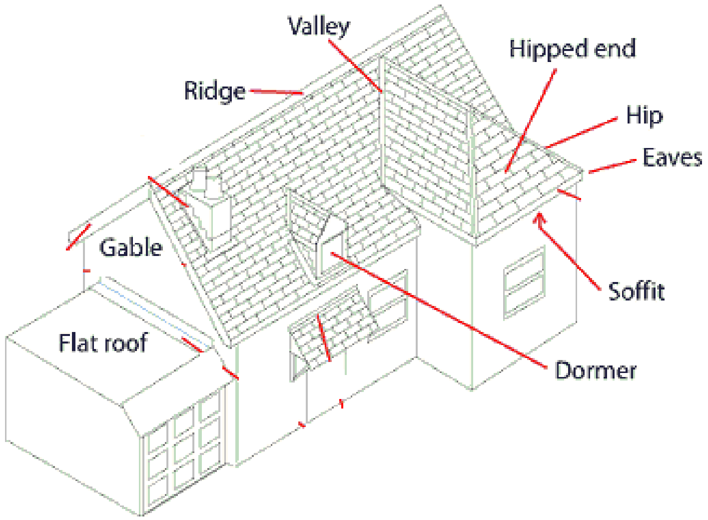


Parts of a Pitched Roofs

- **SPAN:-** The horizontal distance between the internal faces of walls or supports is known as span or clear span.
- **RISE:-** It is the vertical distance between the top of the ridge and wall plate.
- **PITCH:-** It is the inclination of the sides of a roof to the horizontal plane. It is expressed in degrees or as a ratio of rise to span.
- **RIDGE:-**It is defined as the apex line of the sloping roof.
- **EAVES:-**The lower edge of a roof which are resting upon or projecting beyond the supporting walls are known as eave.



Rise of truss



Parts of a Pitched Roofs

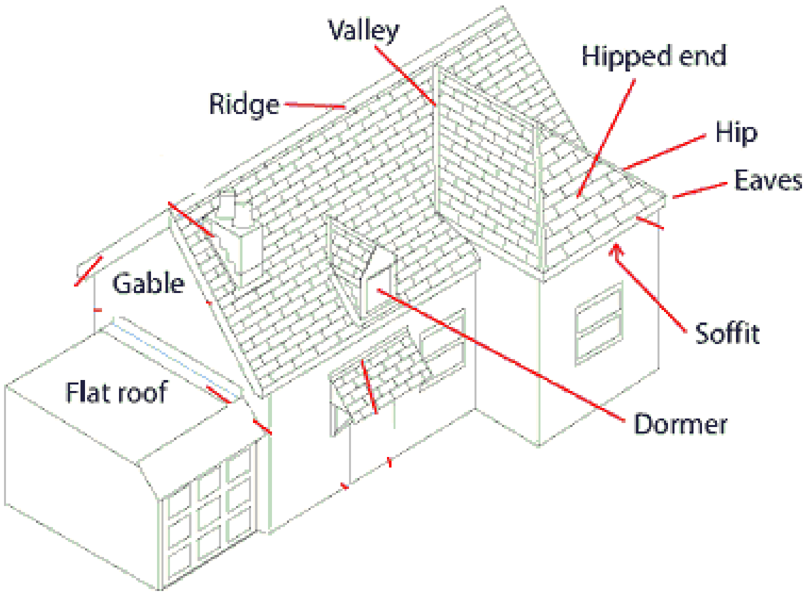
- **HIP:-**The angle formed at the intersection of two roof slopes is known as hip.

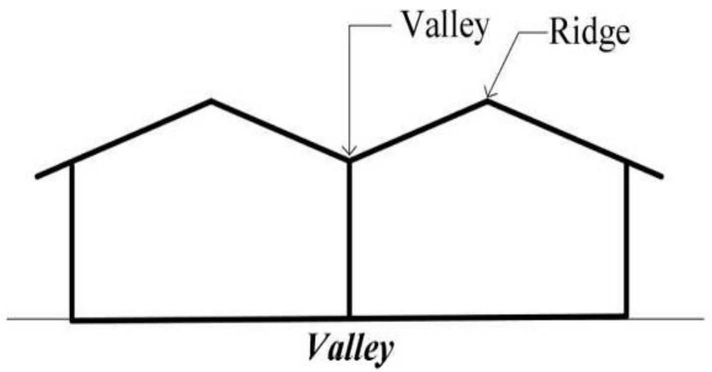
- **VALLEY:-**When two roof surfaces meet together and form an internal angle, a valley is formed.

- **VERGE:-** The edge of a gable, running between the eaves and ridge is known as a verge.

- **COMMON RAFTER:-**These are the intermediate rafters, which give support to the roof coverings.

- **PRINCIPAL RAFTER:-** These are the inclined members of a truss.





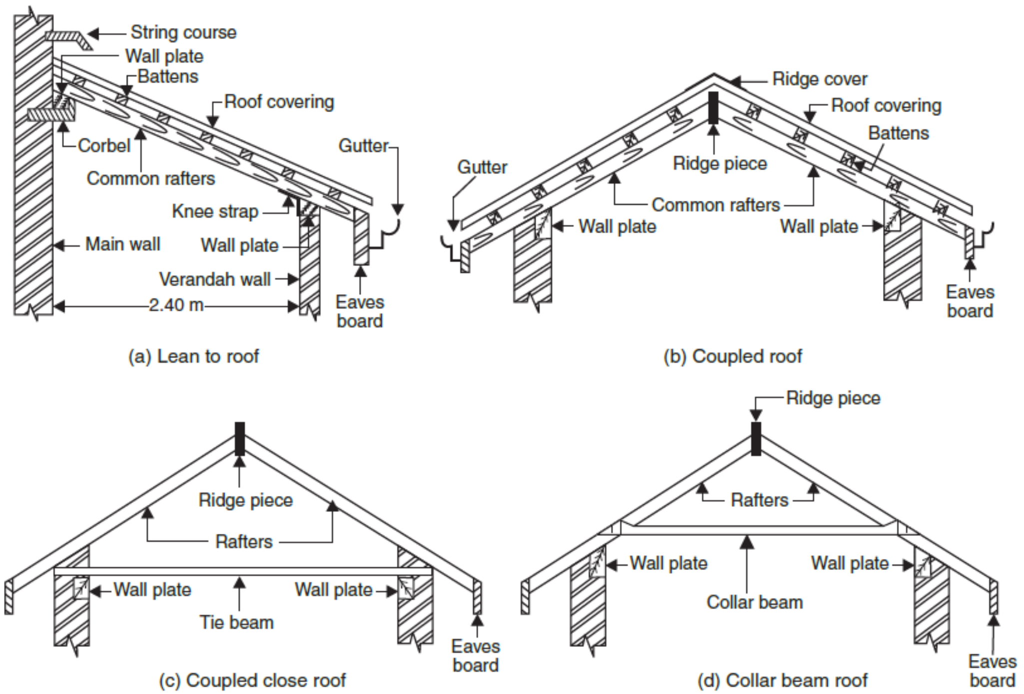
Pitched Roofs

- The pitched roofs are classified into
  - Single roofs
  - Double or purlin roofs
  - Trussed roofs.

Pitched Roofs – Single Roof

- **Single Roof:** If the span of roof is less than 5 m the following types of single roofs are used.

- Rafters placed at 600 mm to 800 mm spacing are main members taking load of the roof. Battens run over the rafters to support tiles



(a) Lean to roof

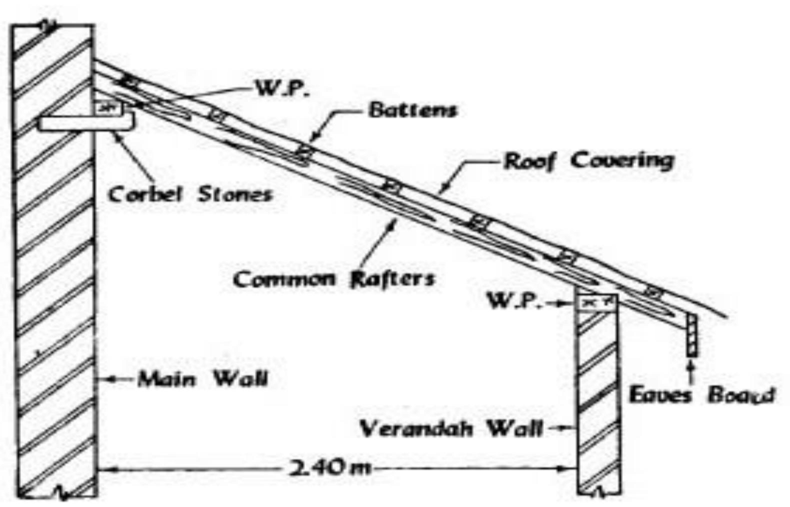
(b) Coupled roof

(c) Coupled close roof

(d) Collar beam roof

Single Roof – Lean to

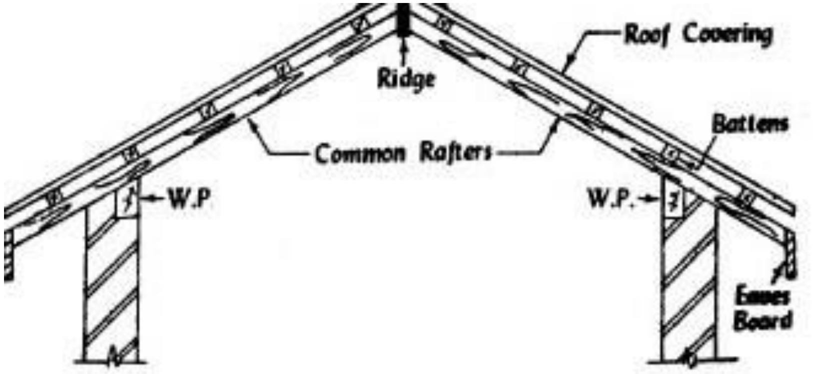
- A lean-to roof is generally used for sheds, outhouses attached to main buildings verandah etc.
- This is suitable for a maximum span of 2.4m



Lean-to roof

Single Roof – Couple Roof

- This type of roof is formed by couple or pair of rafters which slope to both the sides of the ridge of the roof.
- In this type of roof the common rafters slope upwards from the opposite walls and they meet on a ridge piece in the middle
- A couple roof is suitable for spans up to about 3.6m.



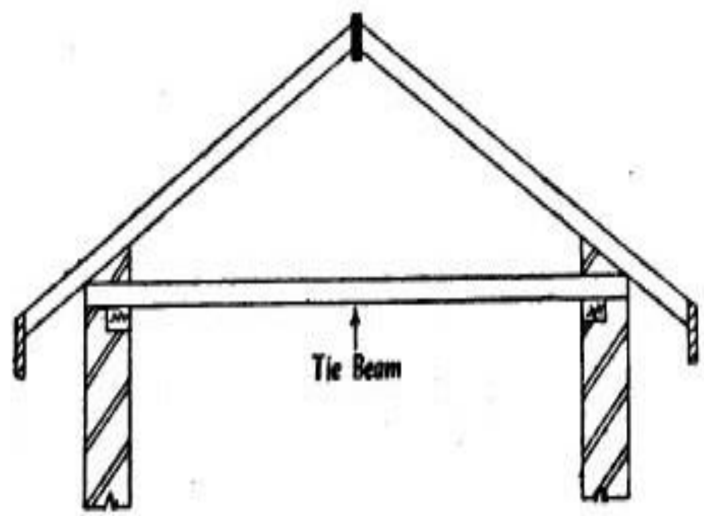
Single Roof – COUPLE CLOSE ROOF

- This roof is just similar to couple roof except that the ends of the couple of the common rafters is connected by horizontal member, called tie beam.

- The tie beam prevents the tendency of rafters to spread out and thus danger of overturning of the walls is avoided.

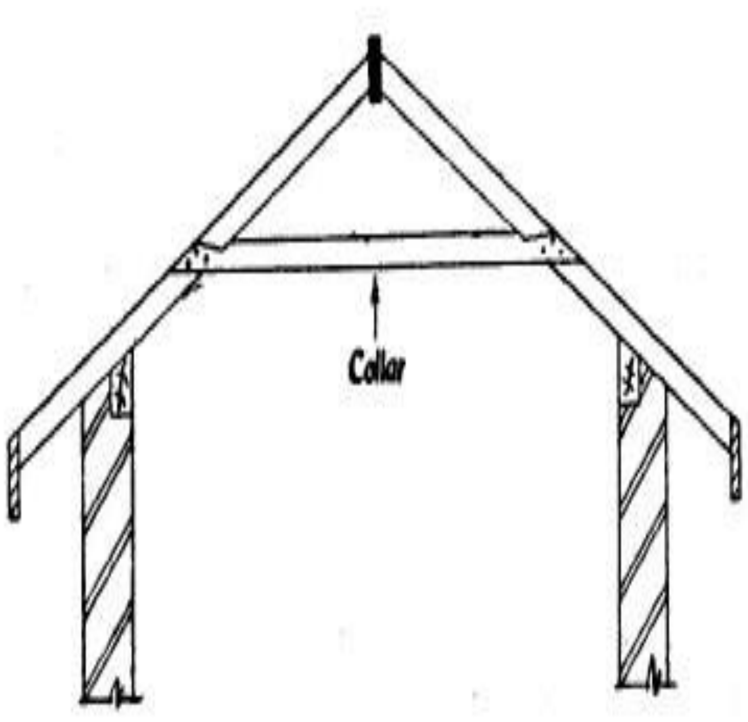
- The tie beam may be a wooden member or a steel rod.

- This roof can be adopted economically up to the span of 4.2m.



Single Roof – COLLAR BEAM ROOF

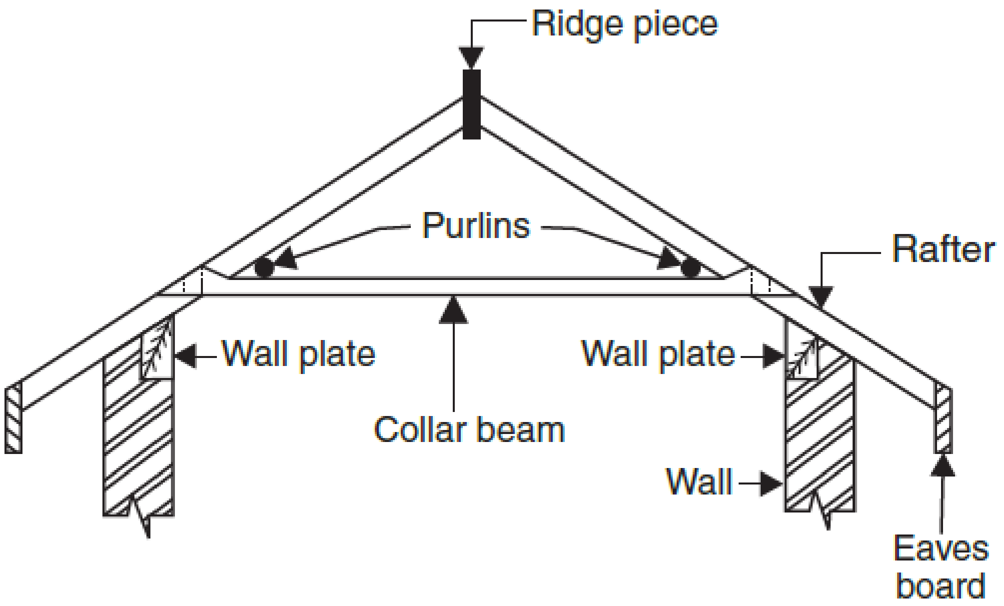
- When the span increases or when the load is more the rafters of the couple close roof have the tendency to bend.
- This is avoided by raising the tie beam and fixing it at one-third to one-half of the vertical height from the wall plate to the ridge. This raised beam is known as collar beam.
- This beam roof is adopted to economise the space and to increase the height of a room.



- This roof can be adopted up to a maximum span of 4.8m.

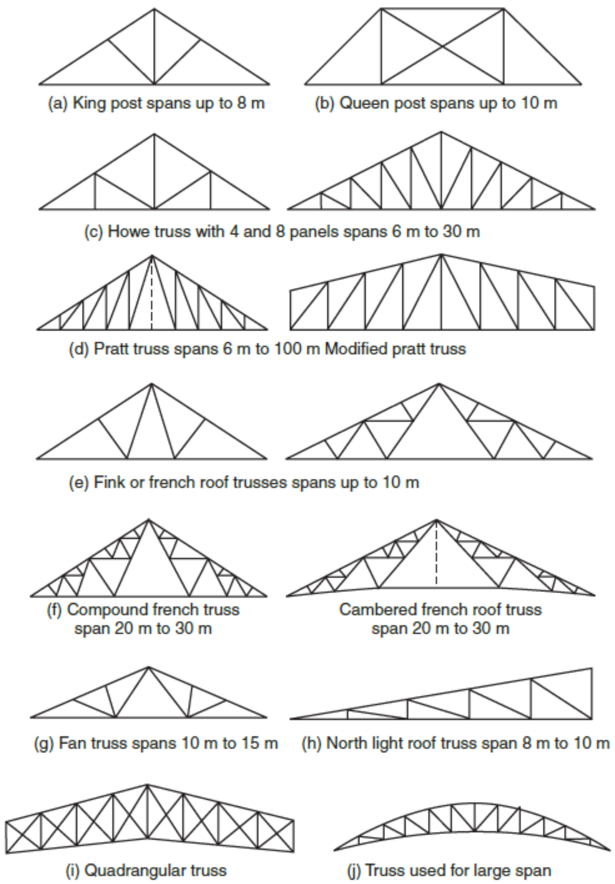
Pitched Roofs – Double Roofs

- **Double or Purlin Roofs:** If span exceeds, the cost of rafters increase and single roof becomes uneconomical.
- For spans more than 5 m double purlin roofs are preferred. The intermediate support is given to rafters by purlins supported over collar beams



Pitched Roofs – Truss Roofs

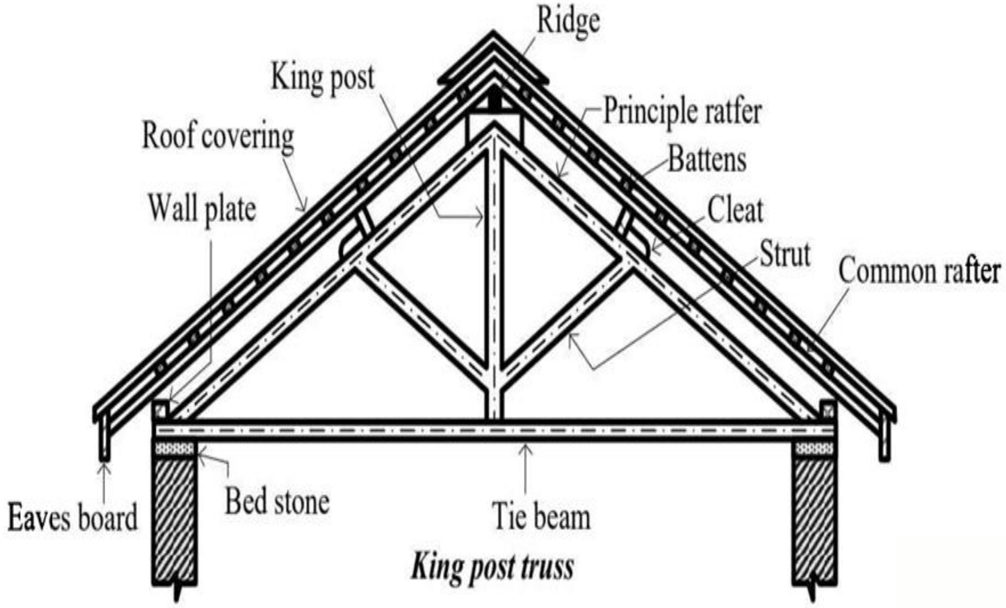
- **Trussed Roof:** If span is more, a frame work of slender members are used to support sloping roofs.
- These frames are known as trusses. A number of trusses may be placed lengthwise to get wall free longer halls.
- Purlins are provided over the trusses which in turn support roof sheets.
- For spans up to 9 m wooden trusses may be used but for large spans steel trusses are a must.



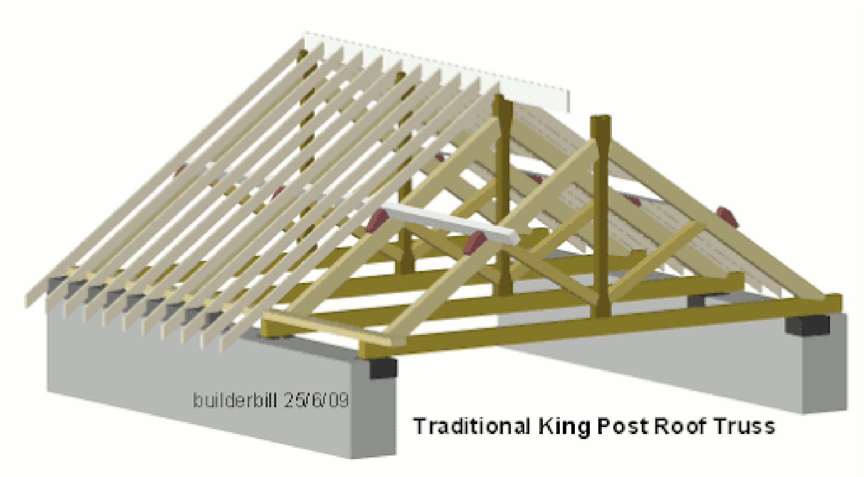
Truss Roofs

- King Post Truss
- Queen Post Truss
- Mansard Truss
- Steel Truss

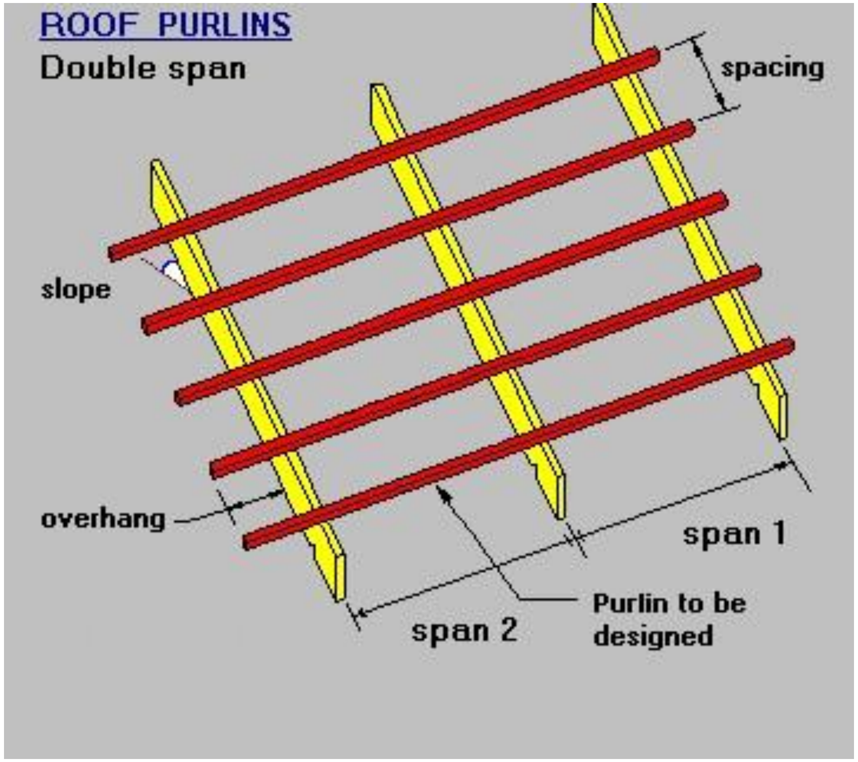
King Post Trussed Roofs



5 to 8m Span

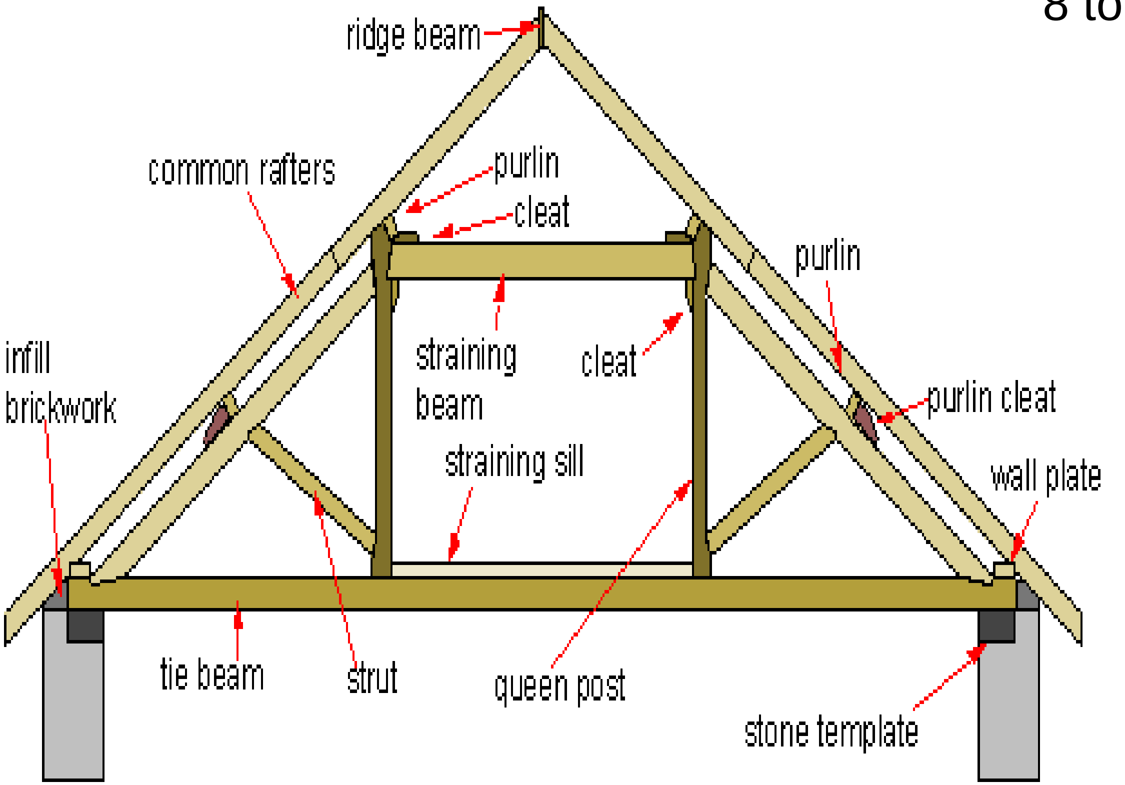


Trussed Roof



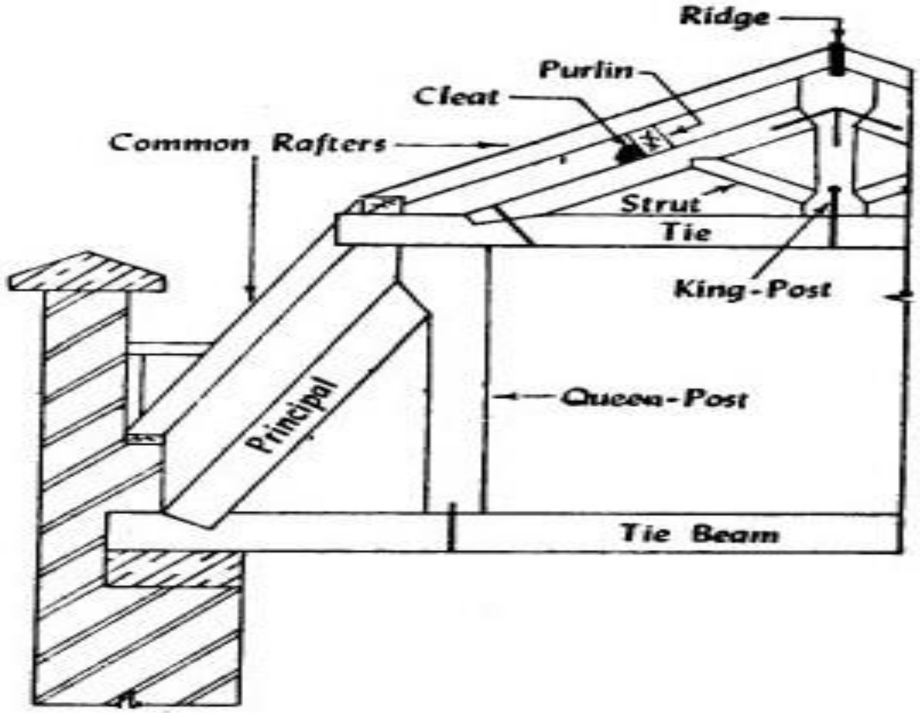
Queen Post Truss

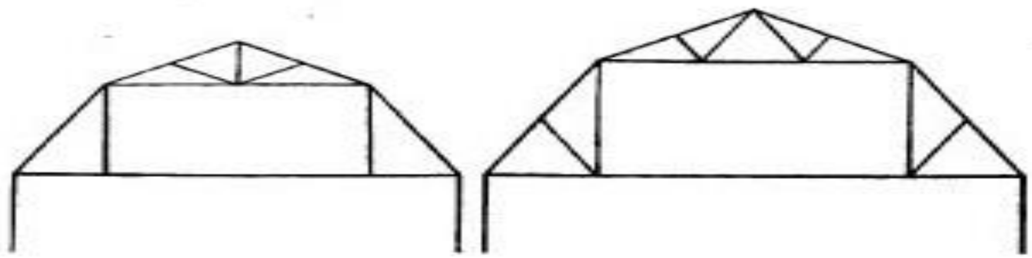
8 to 12 m spans



Queen Post Roof Truss

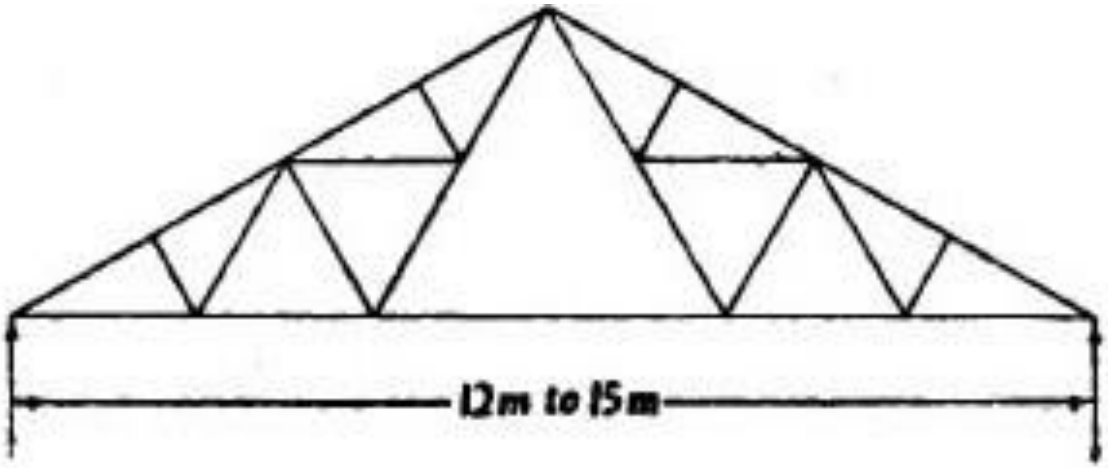
Mansard Truss

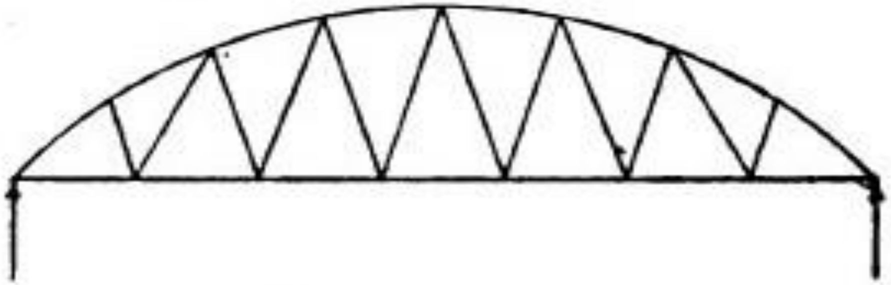




Steel Truss

- For spans greater than 12 m





Bow-string truss

Roofing Materials

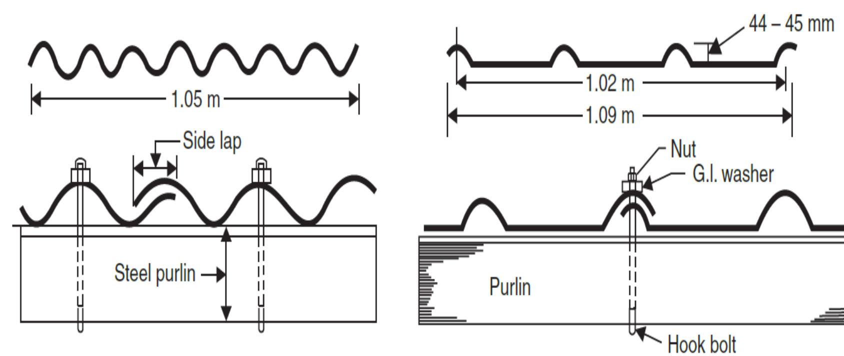
- Climatic Conditions – wind rain
- Slope of the roof
- Initial Cost
- Maintenance Cost
- Durability
- Resistance to fire
- Heat insulation
- Weight of roofing materials

Roofing Materials

- Thatched Roofing - This is the cheapest roof covering, commonly used in villages.
- It is very light, but is highly combustible.
- It is unstable against high winds. It absorbs moisture & liable to decay.
- The framework to support thatch consists of round bamboo rafters spaced 20 to 30 cm apart & tied with split bamboos laid at right angles to the rafters.
- The thickness of thatch covering should at least be
- 15cm, normal thickness varies from 20 to 30 cm.

Roofing Materials

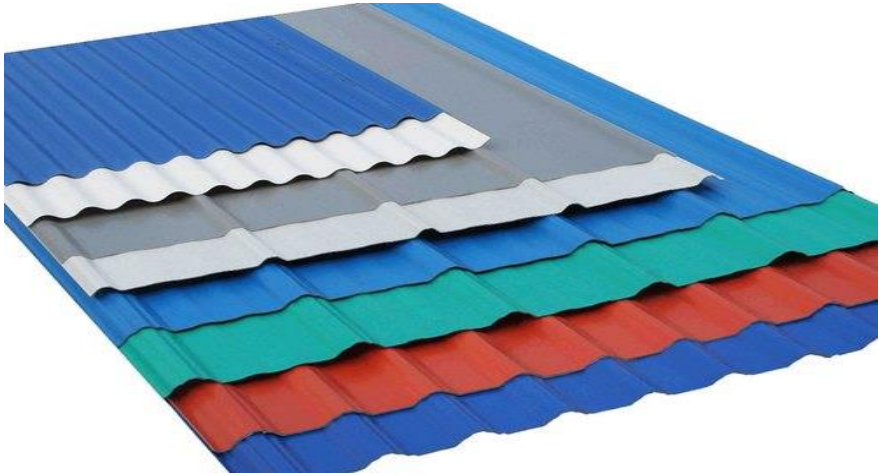
- AC sheets (Asbestos Cement Sheet) – Manufactured from asbestos and portland cement
- Used for large buildings such as industrial building, cinema halls, auditoriums etc.
- Cheap, light weight, fire resistant, durable
- Don’t require protective painting, les maintenance, faster construction
- Brittle, algae growth, dangerous to manufacture



(a) Corrugated sheet covers (b) Trafford sheet covers

Roofing Materials

- GI sheets or Galvanised Iron Sheets – Costly but stronger than asbestos sheet
- Iron sheets are galvanised with Zinc to prevent rusting



- They are fixed to steel purlins using J-bolts and washers.
- They are durable, fire proof, light in weight and need no maintenance.

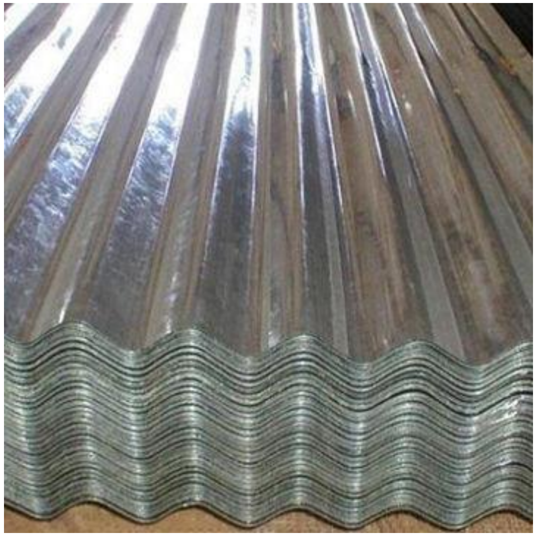
Comparison

S. No.	*GI Sheets*	*A.C. Sheets*
1.	Sheets are thin.	Not as thin as GI sheets.
2.	Light in weight.	Slightly heavier.
3.	Do not break while handling.	Chances of breaking are there during handling.
4.	Chances of corrosion can not be ruled out	No problem of corrosion.
5.	More noisy, if something falls over them.	Less noisy, if something falls over them.
6.	Less fire resistant.	More fire resistant.
7.	Less resistance to acids and fumes.	More resistant to acids and fumes.
8.	Cost is more.	Less costly.

Roofing Materials

- Aluminium sheets – sheets of aluminium with small percentage of manganese

- Corrosion free, light, eco friendly, low maintenance, economical than steel, PVC etc.



Roofing Materials

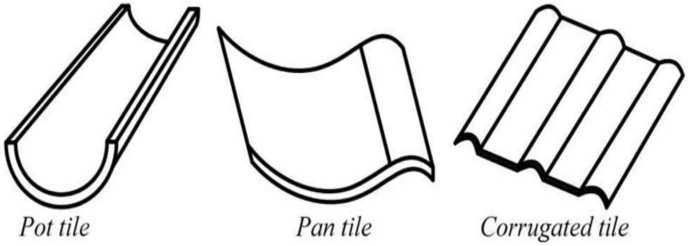
- Powder Coated Sheets – Powder coating is a type of coating that is applied as a free-flowing, dry powder. Unlike conventional liquid paint which is delivered via an evaporating solvent, powder coating is typically applied electrostatically and then cured under heat or with ultraviolet light.

- Powder coating GI and Aluminium sheets

- Increase life and enhances appearance

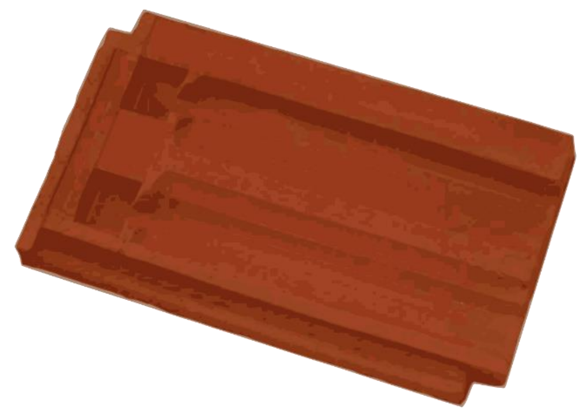
Roofing Tiles

- Roof Tiles – Thin members made from clay or concrete
- Clay tiles are more common. Similar manufacturing process as bricks
- Plain tiles – rectangular in shape, concrete or clay
- Pot tiles – Semi circular in shape, tapering along length
- Pan tiles – Flat along longitude, wave shape along transverse
- Corrugated tiles – Tiles which have corrugations



Types of tiles

Roofing Materials



Thank You!

- Any doubts..???

Introduction to Basic Civil Engineering

Lecture 15 – Basic Infrastructure Services

Sreejith Krishnan, *PhD*

Elevator or Lift

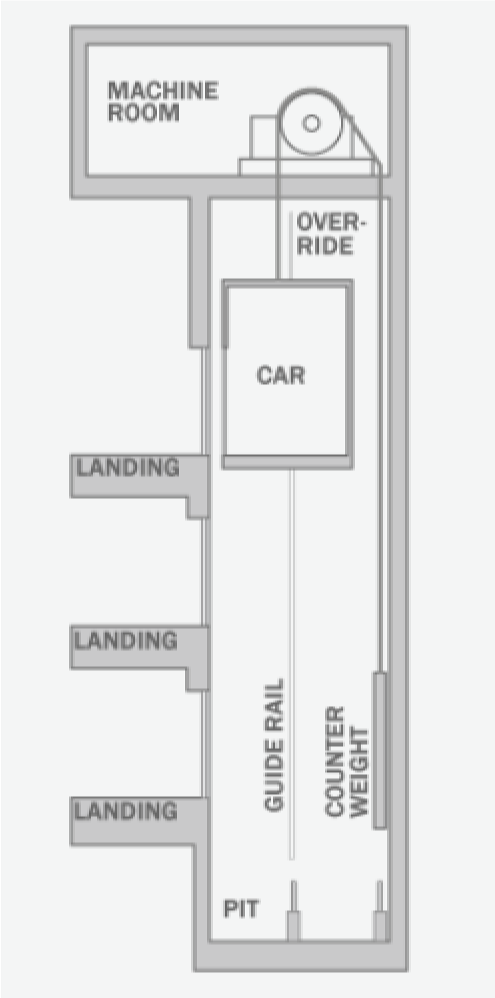
- Appliance used to transport persons or materials between two levels in a building with a guided car
- Generally for buildings with more than 4 floors
- Powered by electric motors

Based on Use -

- Passenger Elevator – transport of people
- Service Elevator – Goods along with people
- Goods Elevator – Primarily to transport goods

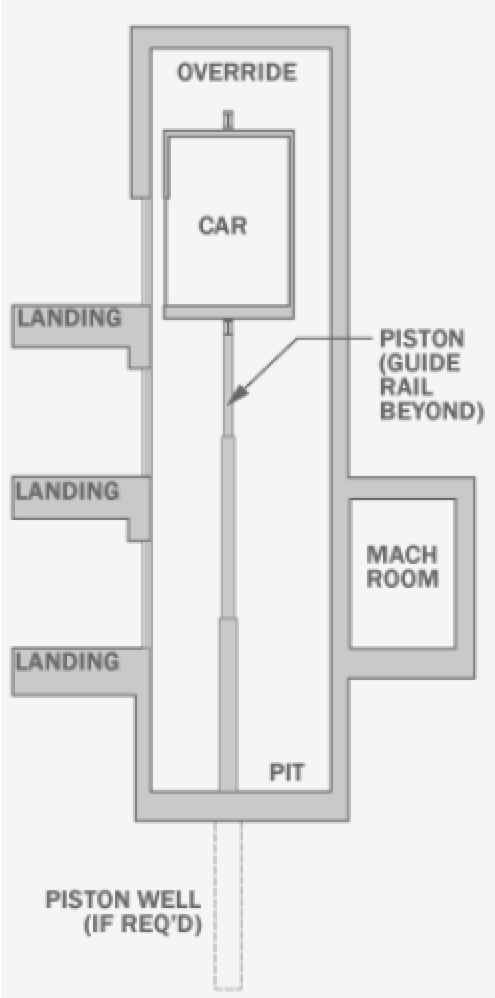
Based on Operating Mechanism

- **Traction elevators** are lifted by ropes, which pass over a wheel attached to an electric motor above the elevator shaft.
- They are used for mid and high-rise applications and have much higher travel speeds than hydraulic elevators.
- A counter weight makes the elevators more efficient by offsetting the weight of the car and occupants so that the motor doesn't have to move as much weight.
- It is important that traction elevator ropes and sheaves are checked for wear on a regular basis. As they wear, the traction between the sheave and the cables is reduced and slippage becomes more regular, which reduces the efficiency and can become dangerous if left unchecked.



Based on Operating Mechanism

- Hydraulic elevators are supported by a piston at the bottom of the elevator that pushes the elevator up as an electric motor forces oil or another hydraulic fluid into the piston
- The elevator descends as a valve releases the fluid from the piston.
- They are used for low-rise applications of 2-8 stories and travel at a maximum speed of 200 feet per minute
- The machine room for hydraulic elevators is located at the lowest level adjacent to the elevator shaft.



Design Considerations of Lift

- Governed by Lift Acts and Rules, Indian Electricity act, NBC and local fire regulations

- Quantity and quality of the service needs to be considered
  - Handling capacity at the peak periods
  - Waiting time of passengers at different floors
  - Needs detained study of the passenger behaviour

- Floor to floor distance, number of floors, population to be served on each floor, maximum peak demand

Design Considerations of Lift

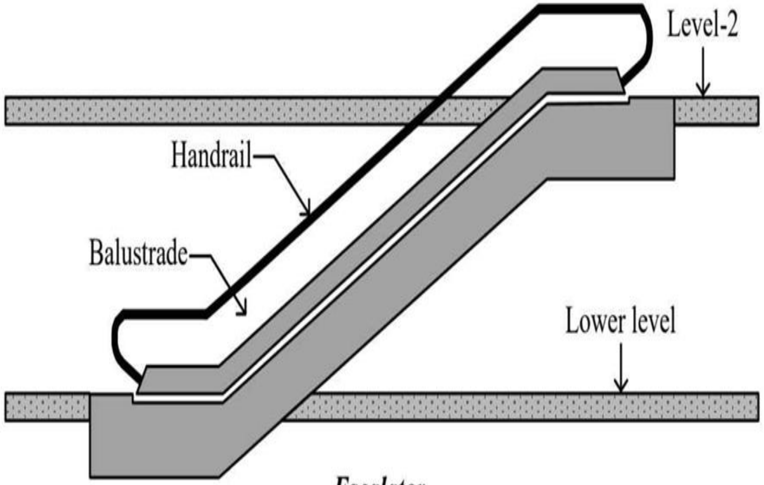
- Lift is mandatory
  - More than 3 storeys for hospital buildings/medical buildings
  - More than 4 storeys for other buildings with plinth area more than 2500 m^2
  - One lift to be provided for additional increase for 2500m^2 in plinth area
  - This is in addition to the staircase requirements
  - Minimum car size for a single purpose building 884kg
  - For commercial buildings, 2040 kg is recommended

Design Considerations of Lift

- Lift should be easily accessible from all entrances
    - Preferably near the centre of the building
    - Maximum of 3 lifts together
    - Corridor sufficiently wide for waiting and through passengers
- Can be placed near staircase if the lift is serving 2 to 3 apartments per floor
- Else in a well ventilated tower adjoining the building
- In commercial building, the lift position should aid the work flow and movement of goods

Escalators

- Moving staircase for transporting people between different levels
- Motor driven chain of steps, steel trussed frame and hand rails
- Continuous operation
- High volume of people transported at slow rate

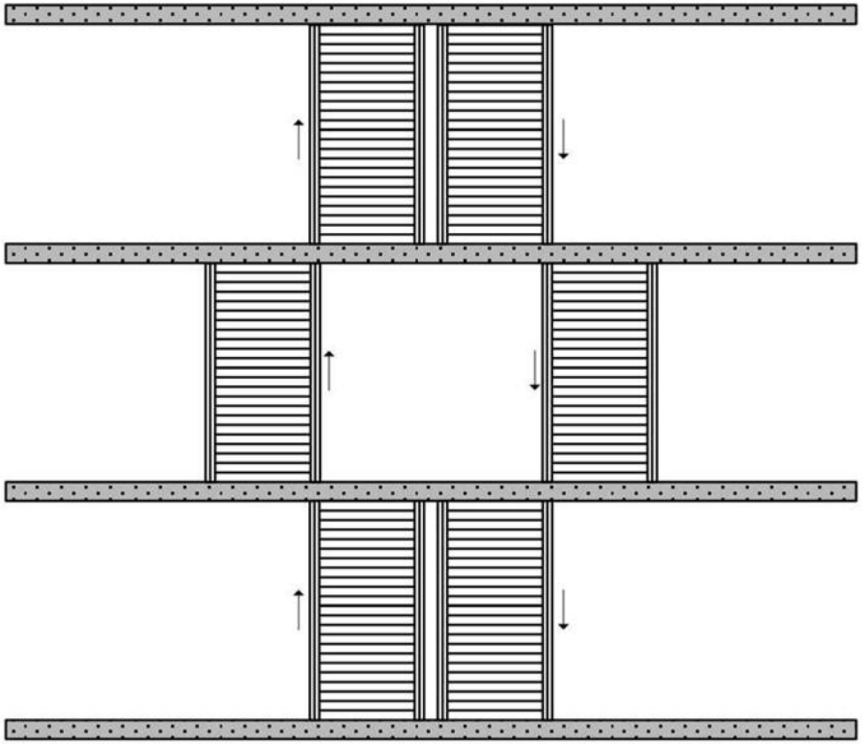


Escalator

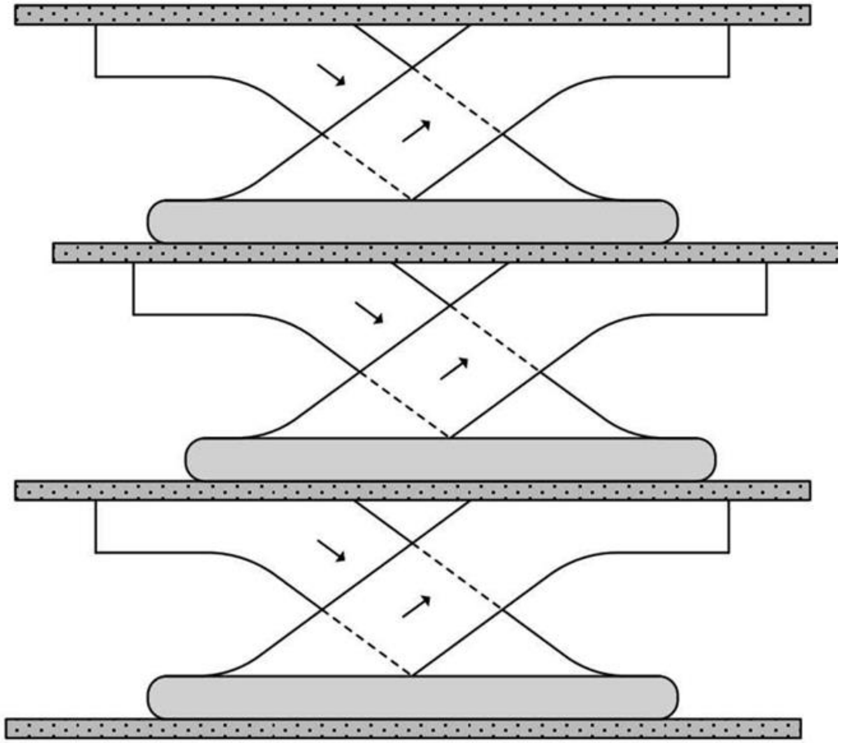
Design Criteria

- Escalators should operate at a constant speed
- Recommended capacity is 3200 to 6400 people per hour
- Angle of inclination not more than 30 degrees (expect for rises exceeding 6m and speed less than 0.5m/s, 35 degrees can be provided)
- Balustrades shall be provided with a moving handrail operating at the same speed as elevators
- Installed where the traffic is heaviest.
- Generally arranged in pairs

Design Criteria



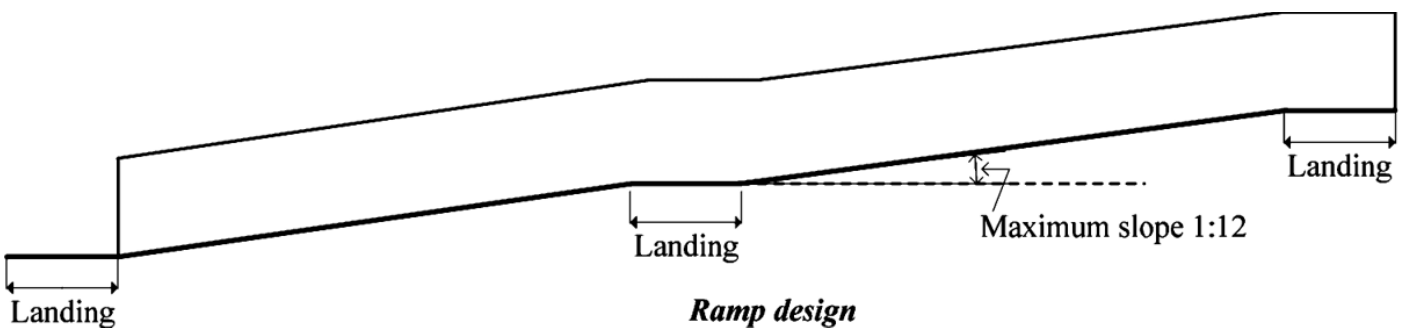
Parallel arrangement of escalators
(Top view)



Cris-cross arrangement of escalators
(Side elevation)

Ramp

- Sloping surface provided to connect between floors
- Movement of vehicles, people, PwD



Ramp design

Ramp - Design

- Hand rails on one side at least, preferably both sides (at least 0.8m)
- Curved, Zig-Zag, Spiral or U-Shaped
- Slope should not exceed 1:12, recommended 1:20
- Located in the exterior, indoor ramps require lots of space
- Should be provided with landings at change of direction/top and bottom for resting manoeuvring etc.
- Minimum landing of 1.5m

MEP

MEP stands for ***mechanical***, ***electrical*** and ***plumbing engineering***. These three technical disciplines include the systems that make building interiors suitable for human occupancy. Mechanical, Electrical, and Plumbing design are important for building construction planning, decision making, documentation, cost estimation and building construction. MEP encompasses the in depth design and selection of systems, as opposed to a tradesperson simply installing equipment. For example, a plumber may select and install a commercial hot water system based on common practice. MEP engineers will research the best design according to the principles of engineering. A brief explanation of each term follows.

MEP

- Mechanical Systems – Space heating, air conditioning, and mechanical ventilation in commercial buildings

- Heating, cooling, ventilation and exhaustion are all key areas to consider in the mechanical planning of a building.

- These systems interact with each other to control temperature and humidity and to provide comfort

- Ensures sufficient air circulation to bring in fresh air and reduce pollutants

MEP

- Electrical Engineering – deals with the design of conduits and wiring for electricity supply
  - Reduce the circuit length
  - Optimise cost
  - Prevent conflict between mechanical and plumbing networks

- Plumbing – Laying out and optimising the pipe networks for distribution of water and removing sewage

HVAC

- HVAC stands for Heating, Ventilation, and Air Conditioning
- Part of Mechanical Engineering under MEP
- Uses principles of thermodynamics and fluid mechanics
- HVAC equipment perform cooling and heating for residential and commercial buildings
- Provides fresh air from outside, reduces pollutants etc.
- Engineers install pipework, duct work, equipment etc. to regulate air movement

HVAC

- Work to be done as per NBC Part VIII – Air conditioning and heating

- Comfort air conditioning – for providing comfort
  - Temperature Control
  - Air velocity control
  - Humidity Control

- Industrial air conditioning – for creating an environment suited for specific applications

HVAC

- Types of Air Conditioning
  - ***Central AC*** - In this system, all the equipment pertaining to air conditioning are installed at one focal or central point and then the conditioned air is distributed to all the rooms or enclosures by ducts.
  - This type of system requires less space for installation and the maintenance is also easy.
  - Due to the presence of ducts, it requires large space.
  - ***Self-contained or unit system:*** Special portable attractive cabinets which fit in with the decoration of modern rooms are placed inside the room near the ceiling or window.
  - They are self-contained in every respect and conditioned air is formed inside the unit itself.
  - The conditioned air is then directly thrown into the room without the help of any ducts.

HVAC

- ***Semi-contained or unitary central system:*** In this system, every room is provided with an air-conditioning unit and the room unit obtains its supply from the central system.
- Such a system results in the smaller size of ducts.
- Another form of this system is adopted in which conditioned air may be supplied from a central unit but the heating or cooling may be carried out in the room itself
- ***Combined Systems –*** A combination of any of the two systems

Fire Safety

- Buildings have to be designed for acceptable levels of fire safety
- Aim is always to reduce the loss of lives
- NBC – Part 4 (Fire and Life Safety – 2005)

Fire Safety

- Fire safety can be improved by
  - Using suitable materials
  - Combustible vs Non Combsutible materials
  - NC materials do not catch fire, but can decompose at higher temperatures leading to building failures
  - Combustible materials catch fire and act as fuel for the spread of fire
- Use non combustible materials as much as possible
- Design sufficient fire escapes,

Fire Safety

a) ***Walls*** – Brick walls with cement plaster gives better fire resistance.

b) ***Roof*** – RCC flat roofs have good fire resistance. Hence they should be preferred.

c) ***Ceiling*** – Ceilings should be made up of cement plaster, asbestos cement board or fibre boards.

d) ***Floors*** – R.C.C. floor is very good fire resisting floor.

e) ***Doors and Window Openings*** – All these openings should be protected against fire by taking the following precautions:

   i. The thickness of shutters should not be less than 40 *mm*.
   ii. Instead of wooden, aluminium or steel shutters should be preferred.
   iii. They should be provided with fire proof paints.

f) ***Stairs*** – Wood should be avoided in the stair cases. To minimize fire hazard, stairs should be centrally placed in the buildings so that people can approach them quickly. More than one stair case is always preferable. Emergency ladder should be provided in the building.

Fire Resistance

- Good Materials – Bricks, RCC, Terracota, etc.
- Bad Materials – Steel, Timber, aluminium, stone
- Fire alarm must be provided
- Fire extinguishers must be provided

Intelligent Building

- An intelligent buildings integrate different systems in a coordinated way so as to provide maximum comfort and performance, operating cost and flexibility
- Energy savings is one of the important characteristics of intelligent building
- Advanced security control and remote control of systems
- A powerful customised computer program will control the different aspects of the building
- Integrated camera and sensors collect the required information and informs different gadgets and application
- Informative, predictive, responsive, adaptive, diagnostic, corrective, and self-healing.

Intelligent Building - Features

- HVAC systems – Program can take into account the weather conditions and preferences

- Information fed into a control programme

- Depending on the requirements, the computer can control the building components
  - Open and close the windows, curtains etc.
  - Start and stop A/C

Intelligent Building - Features

- Security system – Closed circuit cameras and motion sensors
- Prevent unauthorised entry to the home
- Surveillance cameras that can be controlled remotely
- Alarm systems/ computer can call the police station automatically

Intelligent Building - Features

- Life safety systems – Motion sensors, glass break sensors, electronic shutter control, fire sensors, Carbon monoxide sensors etc. are connected to emergency services

- Automatically call emergency services

- Electrical Power Distribution Systems – Different power sources are coordinated to use optimise power consumption.

- In a sunny day, the computer stops using energy from the grid and switches to solar power

Intelligent Building - Features

- Communication Systems – An important feature of the intelligent building

- Person to person, machine to machine, person to machine communication within the building and outside the building using wired and wireless systems

- Connected to occupant, emergency services police etc.

- Inform stakeholders in case of an emergency

Intelligent Building - Features

- Lighting systems – Sensors that turn on the light only when there is someone in the room
- Monitor day light variations to adjust the lighting levels
- Significant energy savings
- Intelligent buildings can record all the information regarding the various functioning of the building and can use AI etc. for further optimisation

Intelligent Building

- Some disadvantages
  - Expensive
  - Complex building management
  - Computer – Know-how
  - Internet and security

Green Building

- Sustainable development has become the key objective for the present generations

- **Green building** (also known as **green construction** or **sustainable building**) refers to both a structure and the application of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from planning to design, construction, operation, maintenance, renovation, and demolition.

- Does not imply a reduction in comfort

- Use less water, energy efficiency, less waste generaton

Green Building

- Construction activities cause significant environmental damages
  - Over mining
  - CO_2 emissions

- However, we cannot completely avoid using these materials.

- Need to use materials produced sustainably

Green Building Rating System

- LEED– Leadership in Energy and Environmental Design (LEED) is a green building certification program used worldwide

- It includes a set of rating systems for the design, construction, operation, and maintenance of green buildings, homes, and neighbourhoods which aims to help building owners and operators be environmentally responsible and use resources efficiently.

Green Buildings

- Site Selection is the first step and arguably the most important part of the green building process.

- The potential environmental effects of the project depends on where you plan to build it.

- LEED awards the location you've chosen based on items ranging from proximity to public Transit to bike storage and showers.

Green Buildings

- Water Usage - LEED awards the reduction of water used in toilets as well as the re-use of grey water

- Energy and Atmosphere - This category has the most points available and focuses on commissioning, energy efficiency, refrigerants and the original source of the energy

- Materials and Resources - MR deals with two items, reducing WASTE which is sent to landfills and Reducing the environmental impact of a building’s materials. LEED looks at how Materials are: Selected, Disposed and Reduced. Points are awarded for materials reuse, recycling, renewable materials and maintaining a building already on the proposed site.

Green Buildings

- Indoor Environmental Quality - IEQ is a large section in LEED and addresses the environment inside a building and how it affects the occupants inside. IEQ awards points for lighting, temperature, ventilation, indoor pollution and the amount of daylight

- Innovation in Design - This section of LEED awards points for inventive, sustainable and green building strategies which are beyond the scope of the LEED Rating System and not properly rewarded.

Point Table - LEED

LEED 2009 for New Construction and Major Renovation

Project Checklist

Project Name

Date

Sustainable Sites — Possible Points: 26

Y	N	?			
Y			Prereq 1	Construction Activity Pollution Prevention	
			Credit 1	Site Selection	1
			Credit 2	Development Density and Community Connectivity	5
			Credit 3	Brownfield Redevelopment	1
			Credit 4.1	Alternative Transportation—Public Transportation Access	6
			Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1
			Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	3
			Credit 4.4	Alternative Transportation—Parking Capacity	2
			Credit 5.1	Site Development—Protect or Restore Habitat	1
			Credit 5.2	Site Development—Maximize Open Space	1
			Credit 6.1	Stormwater Design—Quantity Control	1
			Credit 6.2	Stormwater Design—Quality Control	1
			Credit 7.1	Heat Island Effect—Non-roof	1
			Credit 7.2	Heat Island Effect—Roof	1
			Credit 8	Light Pollution Reduction	1

Water Efficiency — Possible Points: 10

Y	N	?			
Y			Prereq 1	Water Use Reduction—20% Reduction	
			Credit 1	Water Efficient Landscaping	2 to 4
			Credit 2	Innovative Wastewater Technologies	2
			Credit 3	Water Use Reduction	2 to 4

Energy and Atmosphere — Possible Points: 35

Y	N	?			
Y			Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2	Minimum Energy Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
			Credit 1	Optimize Energy Performance	1 to 19
			Credit 2	On-Site Renewable Energy	1 to 7
			Credit 3	Enhanced Commissioning	2
			Credit 4	Enhanced Refrigerant Management	2
			Credit 5	Measurement and Verification	3
			Credit 6	Green Power	2

Materials and Resources — Possible Points: 14

Y	N	?			
Y			Prereq 1	Storage and Collection of Recyclables	
			Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 3
			Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Elements	1
			Credit 2	Construction Waste Management	1 to 2
			Credit 3	Materials Reuse	1 to 2

Materials and Resources, Continued

Y	N	?			
			Credit 4	Recycled Content	1 to 2
			Credit 5	Regional Materials	1 to 2
			Credit 6	Rapidly Renewable Materials	1
			Credit 7	Certified Wood	1

Indoor Environmental Quality — Possible Points: 15

Y	N	?			
Y			Prereq 1	Minimum Indoor Air Quality Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
			Credit 1	Outdoor Air Delivery Monitoring	1
			Credit 2	Increased Ventilation	1
			Credit 3.1	Construction IAQ Management Plan—During Construction	1
			Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1
			Credit 4.1	Low-Emitting Materials—Adhesives and Sealants	1
			Credit 4.2	Low-Emitting Materials—Paints and Coatings	1
			Credit 4.3	Low-Emitting Materials—Flooring Systems	1
			Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Products	1
			Credit 5	Indoor Chemical and Pollutant Source Control	1
			Credit 6.1	Controllability of Systems—Lighting	1
			Credit 6.2	Controllability of Systems—Thermal Comfort	1
			Credit 7.1	Thermal Comfort—Design	1
			Credit 7.2	Thermal Comfort—Verification	1
			Credit 8.1	Daylight and Views—Daylight	1
			Credit 8.2	Daylight and Views—Views	1

Innovation and Design Process — Possible Points: 6

Y	N	?			
			Credit 1.1	Innovation in Design: Specific Title	1
			Credit 1.2	Innovation in Design: Specific Title	1
			Credit 1.3	Innovation in Design: Specific Title	1
			Credit 1.4	Innovation in Design: Specific Title	1
			Credit 1.5	Innovation in Design: Specific Title	1
			Credit 2	LEED Accredited Professional	1

Regional Priority Credits — Possible Points: 4

Y	N	?			
			Credit 1.1	Regional Priority: Specific Credit	1
			Credit 1.2	Regional Priority: Specific Credit	1
			Credit 1.3	Regional Priority: Specific Credit	1
			Credit 1.4	Regional Priority: Specific Credit	1

Total — Possible Points: 110

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110

LEED

- The more points, the higher the reward. With LEED, there are many rewards, ranging from healthier spaces to buildings that save money and resources. The number of points a project earns determines the level of LEED certification it receives. There are four levels of certification:
  - Certified (40–49 points)
  - Silver (50–59 points)
  - Gold (60–79 points)
  - Platinum (80+ points)
- Tax Benefits, credits etc.

GRIHA Rating

- Rating system similar to LEED developed in India by TERI and GoI

- Green Rating for Integrated Habitat Assessment

GRIHA V 2019 Rating Thresholds	GRIHA Rating
25-40	★
41-55	★★
56-70	★★★
71-85	★★★★
86 or more	★★★★★

Thank You!!!!

- Any Doubts???

Elements of Green Building Design

Following are the components of a Green Building to make it sustainable:

1. Materials for Green Building

Materials for a green building are obtained from natural, renewable sources that have been managed and harvested in a sustainable way; or they are obtained locally to reduce the embedded energy costs of transportation; or salvaged from reclaimed materials at nearby sites.

Materials are assessed using green specifications that look at their Life Cycle Analysis (LCA) in terms of their embodied energy, durability, recycled content, waste minimisation, and their ability to be reused or recycled.

Fig: Parasoleil Recycled Content Panels

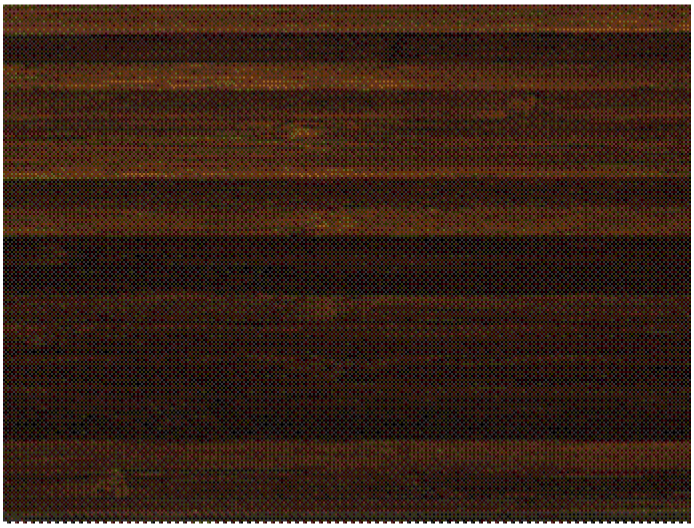
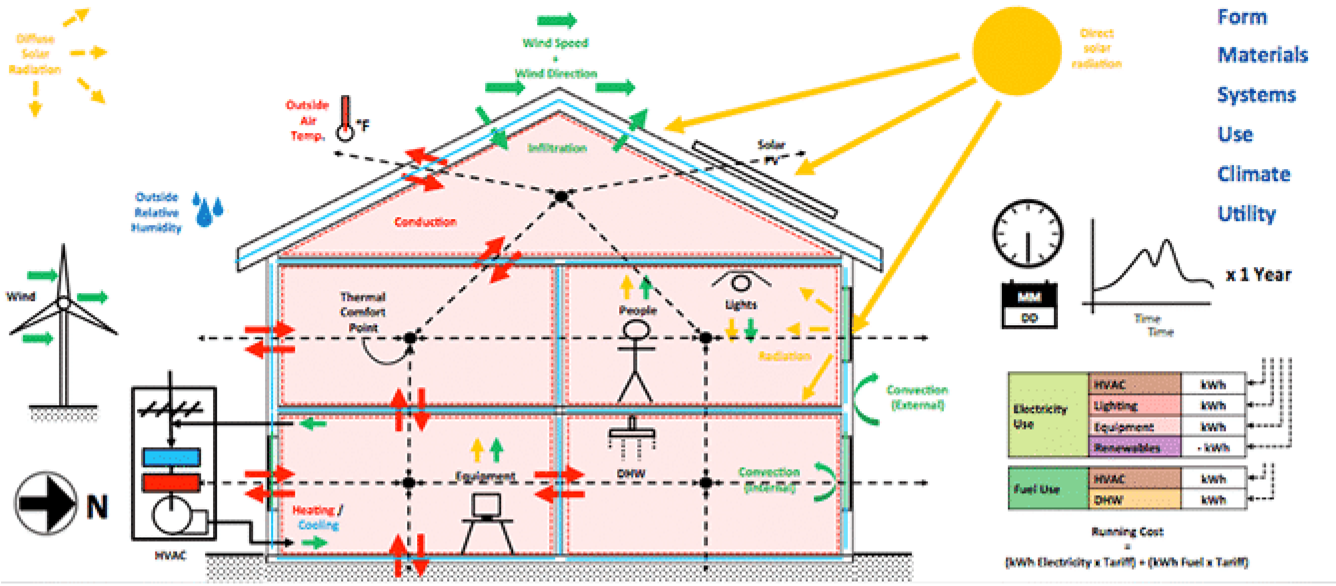


Fig: Chocolate bamboo

2 Energy Systems in Green Buildings

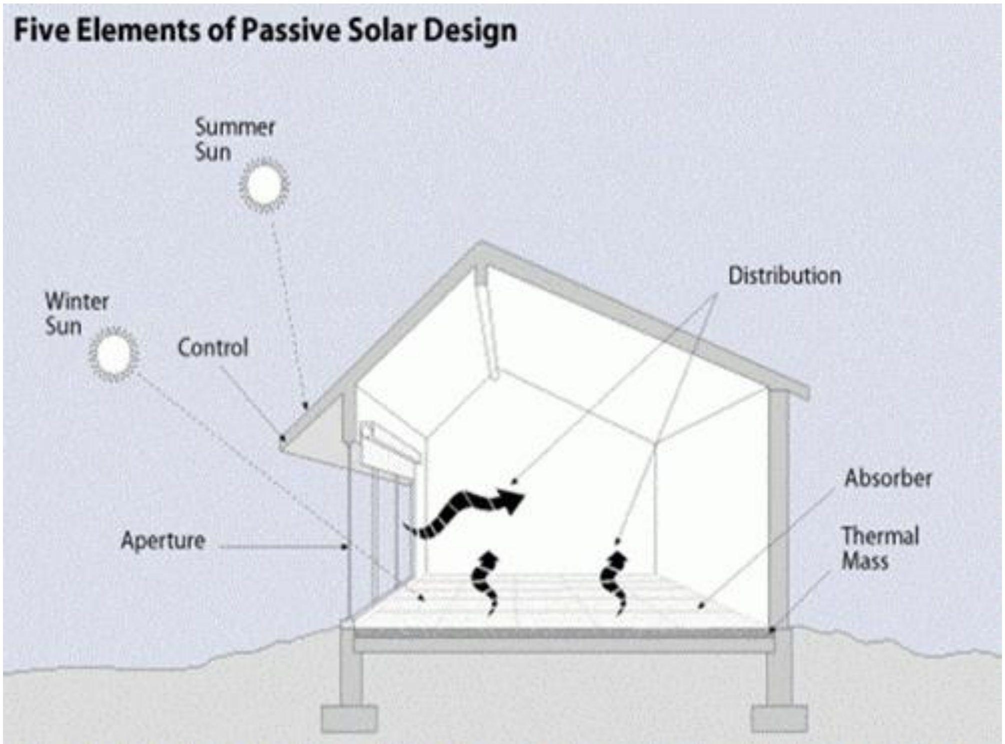
Passive solar design will dramatically reduce the heating and cooling costs of a building, as will high levels of insulation and energy-efficient windows. Natural daylight design reduces a building's electricity needs, and improves people's health and productivity.

Green buildings also incorporate energy-efficient lighting, low energy appliances, and renewable energy technologies such as wind turbines and solar panels.



2.1 Passive Solar Design

Passive solar design uses sunshine to heat, cool and light homes and other buildings without mechanical or electrical devices. It is usually part of the design of the building itself, using certain materials and placement of windows or skylights.



2.1a) Rules Of Passive Solar Systems

- The building should be elongated on an east-west axis.
- The building’s south face should receive sunlight between the hours of 9:00 A.M. and 3:00 P.M. (sun time) during the heating season.
- Interior spaces requiring the most light and heating and cooling should be along the south face of the building. Less used spaces should be located on the north.

2.1b) The Advantages Of Passive Solar Design

- **H**igh energy performance: lower energy bills all year round.
- **I**nvestment: independent from future rises in fuel costs, continues to save money long after initial cost recovery.
- **V**alue: high owner satisfaction, high resale value.
- **A**ttractive living environment: large windows and views, sunny interiors, open floor plans.
- **L**ow Maintenance: durable, reduced operation and repair.
- **U**nwavering comfort: quiet (no operating noise), warmer in winter, cooler in summer (even during a power failure).
- **E**nvironmentally friendly : clean, renewable energy doesn’t contribute to global warming, acid rain or air pollution.

2.2 Passive Solar Heating

The goal of all passive solar heating systems is to capture the sun’s heat within the building’s elements and release that heat during periods when the sun is not shining. At the same time that the building’s elements (or materials) is absorbing heat for later use, solar heat is available for keeping the space comfortable (not overheated).

2.2a) Two primary elements of passive solar heating are required:

- South facing glass
- Thermal mass to absorb, store, and distribute heat.

2.2b) There are three approaches to passive systems

1. Direct Gain: Sunlight shines into and warms the living space.
2. Indirect Gain: Sunlight warms thermal storage, which then warms the living space.
3. Isolated Gain: Sunlight warms another room (sunroom) and convection brings the warmed air into the living space.

3. Water Management in Green Building

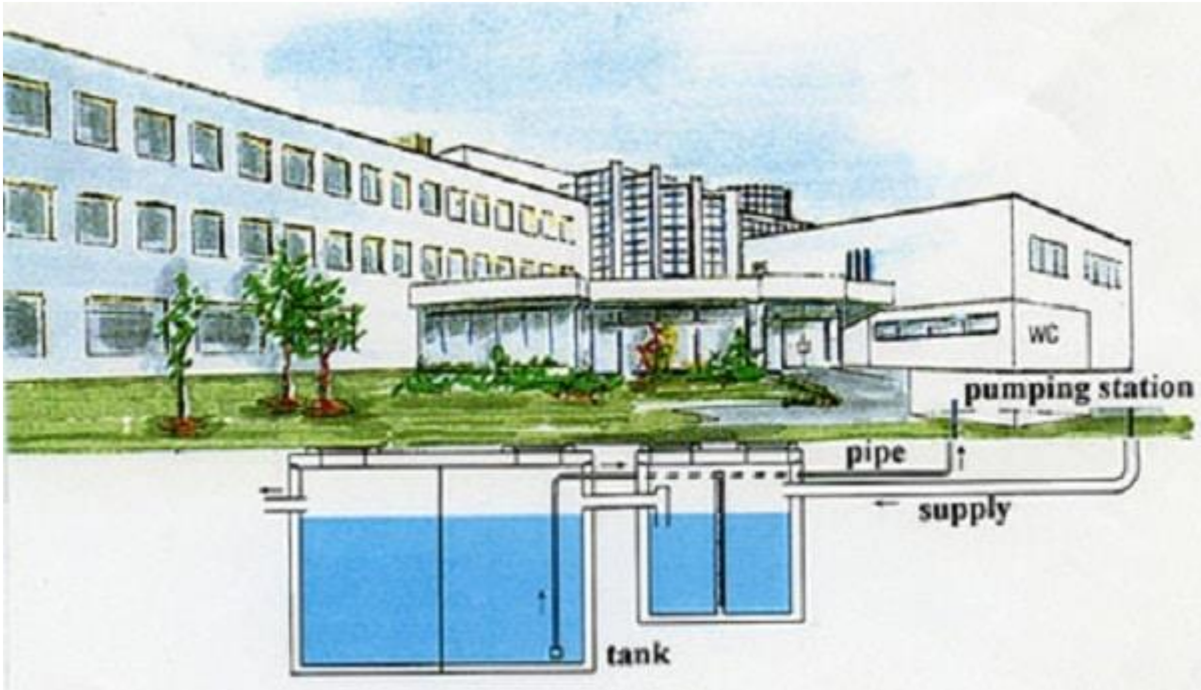
Minimising water use is achieved by installing greywater and rainwater catchment systems that recycle water for irrigation or toilet flushing; water-efficient appliances, such as low flow showerheads, self-closing or spray taps; low-flush toilets, or waterless composting toilets. Installing point of use hot water systems and lagging pipes saves on water heating.

3.1) Rainwater Harvesting in Green Building

Rainwater harvesting is the principle of collecting and using precipitation from a catchments surface.

An old technology is gaining popularity in a new way. Rain water harvesting is enjoying a renaissance of sorts in the world, but it traces its history to biblical times.

Extensive rainwater harvesting apparatus existed 4000 years ago in the Palestine and Greece. In ancient Rome, residences were built with individual cisterns and paved courtyards to capture rain water to augment water from city's aqueducts.



3.2) Rainwater harvesting is essential

Surface water is inadequate to meet our demand and we have to depend on groundwater. Due to rapid urbanization, infiltration of rainwater into the subsoil has decreased drastically and recharging of groundwater has diminished.

As you read this guide, seriously consider conserving water by harvesting and managing this natural resource by artificially recharging the system.

3.3) [Rainwater Harvesting Techniques] for Green Buildings

There are two main techniques of rainwater harvestings.

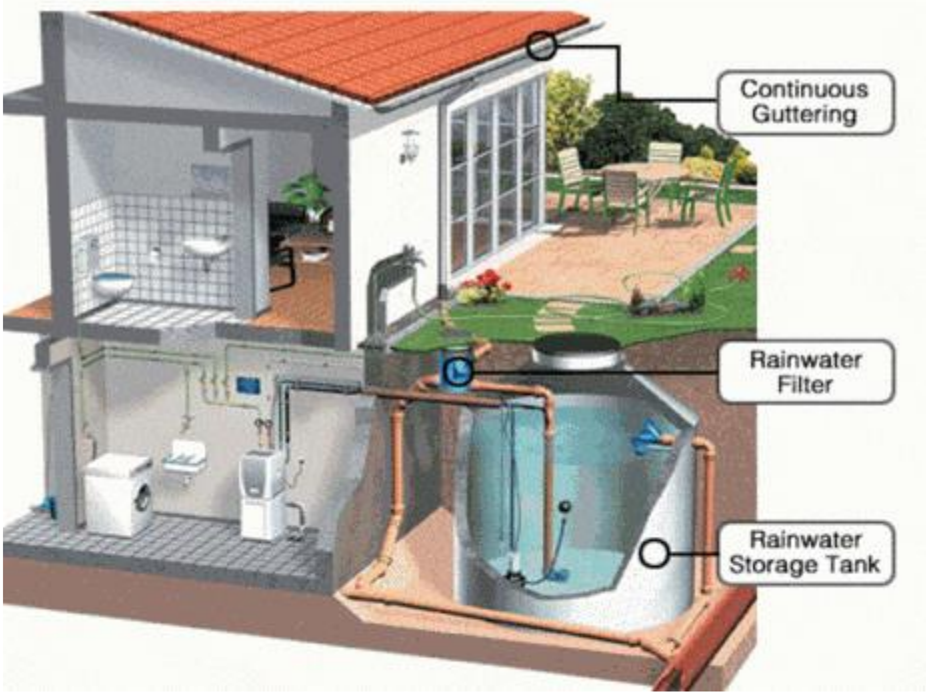
1. Storage of rainwater on surface for future use.
2. Recharge to groundwater

3.3.a) Storage of rainwater on surface for future use.

The storage of rainwater on surface is a traditional techniques and structures used were underground tanks, ponds, check dams, weirs etc.

3.3.b) Recharge to groundwater

Recharge to groundwater is a new concept of rainwater harvesting and the structures generally used are **Pits ,Trenches, Dug wells, Hand pumps, etc.**



4. Health Components of Green Building

Using non-toxic materials and products will improve indoor air quality, and reduce the rate of asthma, allergy and sick building syndrome. These materials are emission-free, have low or no VOC content, and are moisture resistant to deter moulds, spores and other microbes.

Indoor air quality is also addressed through ventilation systems and materials that control humidity and allow a building to breathe.

In addition to addressing the above areas, a green building should provide cost savings to the builder and occupants, and meet the broader needs of the community, by using local labour, providing affordable housing, and ensuring the building is sited appropriately for community needs.