Unit I - Construction Techniques

Structural systems - Load bearing structure - Framed structure - Load transfer mechanism - floor system - Development of construction techniques - High rise building technology - seismic effect - Environmental impact of materials - responsible sourcing - Eco building (Green building) - Material used - Construction methods - Natural buildings - Passive buildings - Intelligent (smart) buildings - Meaning - Building Automation - Energy efficient buildings for various zones - case studies of residential, office buildings and other buildings in each zones.

Structural system

Structured system refers to the system in the structure comprised of interconnected structural members through which loads on the structure are transferred safely to the ground without exceeding the allowable stress in members. Following are the structural systems.

→ Horizontal system (Floor system)
→ Vertical system
→ Lateral load resisting system

Horizontal systems (Floor system)

The floor system in a structure is responsible for resisting gravity loads that are acting on the building. Gravity loads include dead loads and live loads. Dead load includes self weight of floor, floor finish etc which can be

Computed from their sizes. Live load includes weight of persons, movable partitions, dust loads, weight of furniture etc. Live load varies for different types of structures buildings which can be obtained from codal provisions. Due to gravity loads the floor system is subjected to flexure (bending) and shear (displacement). These loads are transmitted to vertical systems

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Vertical systems

The vertical systems are responsible for resisting the loads that are coming from floor system. These loads are then transferred to the ground through foundation.

Following are the types of vertical systems

1) Framed structure
2) Load bearing structure
3) Membrane structure

1) Framed structure

Framed structures are comprised of series of frames These frames are formed by columns and beams which are rigidly connected at floor and roof levels. Walls within these frames are not subjected to loads other than self weight and hence called as non load bearing walls. The loads from roof, floor and walls gets transferred to beams which in turn

transfers these loads to column. The frames can be of materials like wood, steel and RCC.

Advantages of framed structure

→ It is possible to carry out construction of framework of upper floors and finishing of lower floors simultaneously and hence speed in construction

→ It is possible to make changes in wall (door, window location) at any time.

→ Walls can be of low cost material

→ Can resist vibrations in earthquake zones and industrial buildings

→ Economic to construct on soft soil.

2) Load bearing structure

Disadvantages of framed structure

→ Span length is restricted to 40ft. Greater spans result in large lateral deflections

Load bearing structure is one in which the walls resists the the loads from roof or floor and walls above, in addition to its self weight. Hence load bearing wall is the active structural element. The materials used are concrete, blocks, clay bricks etc. The load bearing walls should be of ~~suit~~ suitable thickness (9inch or more), ~~so that~~ depending on type of building and number of floors, if not the materials fail leading to collapse of the building.

Advantages of load bearing structure

→ As load bearing walls are thick, they are capable of weather

resistance, sound insulation, fire resistance

→ Good and economic for residential buildings upto two floors

→ Less lateral deflections

Disadvantages of load bearing structure

→ Does not perform well in earthquakes

→ Openings should be limited as the wall resists load.

→ Foundation depth and size is more and hence high foundation cost

→ Material requirement is high.

3) Membrane Structure

Membrane structure are structures with thin curved slabs that carries loads through its tensile stress.

Ex: Shell, Dome.

Lateral load resisting system

The above described floor system and vertical systems are capable of resisting gravity loads (dead & live load). But in case of tall buildings, lateral loads like wind load, earthquake load are considerable and proper structural systems should be used to resist such loads. Following are the lateral load resisting systems,

→ Frames - rigidly connected beams and columns

→ Shear wall - wall designed to resist lateral forces and made of reinforced concrete walls, reinforced brick walls, or steel plates

→ Steel tubes - Used as bracing between columns

Development of Construction techniques

Construction of buildings, roads, ports, dams etc has been an ancient building activity done for shelters, transport etc. But with passage of time some development has appeared in construction due to the following reasons,

→ Increase in population and hence shelter
→ Space limitations that led to high rise buildings
→ Safety against natural calamities like earthquakes
→ Evolution of industrial and commercial buildings.
→ Accuracy and ~~reliability~~ quality
→ Speed in construction

A brief description of the reasons for development of construction activities are given below

Materials used

Early building materials were natural materials like grass, wood, stone, mud, leaves and branches, animal skin etc. These materials are less durable and hence use of alternative materials came into practice. Some of the durable materials used are given below,

Natural materials - Clay, Stone, timber
Synthetic materials - Bricks, Concrete, metals, plastics

Architecture

Nowadays buildings are constructed with pleasant architectural views. Flat slabs are replaced by shell roof structures (New building materials like steel sheets glass are used in elevation). The Construction of building with shell roof structures like dome, folded plates etc requires advanced construction techniques.

High rise buildings (Towers, Skyscrapers, apartments)

High rise buildings are becoming popular due to reasons like scarcity of land, commercial aspects, aesthetic purposes etc. Such buildings require advanced structural systems like space truss, braced tubular columns, braced frames etc in case of steel structures and core walls, shear walls, in case of steel structures and core walls, shear walls, mega frame in case of reinforced concrete structures. Further they Advanced construction techniques like slipforms, climbing formwork tunnel forms has been developed for construction of these systems

Underwater construction

During the construction of bridges, dams etc the foundation is to be placed underwater. Construction under water is difficult when the depth of water is high and hence a dry and water free environment has to be made. Hence there is a requirement for development in construction

techniques. Construction techniques like caissons, cofferdam, diaphgram walls are adopted for this purpose.

Seismic technology

Damage to buildings due to earthquake can be avoided by following suitable construction techniques like vibration control (dampers) and seismic isolation (base isolation). Dampers absorb vibrations created by earthquake while base isolation technique isolates the foundation and structure thereby reducing transfer of seismic forces to upper floors

Tunneling technology

Tunnel serves as underground passage for transport gas and water pipelines, sewage etc. Tunnel construction usually involves blasting rocks and removing them where there is a possibility of collapse of tunnel. Tunneling using Tunnel Boring Machine (TBM) is now a predominantly used advanced construction technique where collapse of tunnel can be avoided

Bridge technology

Construction of subways for rail and road transport without disturbing the traffic above was common and can be achieved using construction of techniques like box jacking where precast boxes are inserted beneath the overbridge

Construction of bridges in place with high traffic is not easy and hence the bridge slabs has to be cast on factory, transported and should be placed on site. This requires construction equipments like movable scaffold systems, launching girders etc which can be operated by placing it in top of already casted piers (supports - pillars)

High rise building technology (tall buildings)

High rise buildings can be defined as the multistoreyed building in which most occupants use the system of vertical transportations (ie) elevators (lift) to reach their destination. It can also be defined as the structure that exceeds a height than the maximum reach of available fire fighting equipments. Height varies between 75 feet (23m) and 100 feet (30m) or seven to ten storeys in case of residential or commercial buildings and 40 storeys or more in case of skyscrapers.

Advantages of high rise buildings

- → Land use can be reduced (small built up area)
- → Large open space for which ensures day lighting and greater airflow, lesser street noise
- → Provides panoramic view of the city (unbroken view of whole region)

Disadvantages (or) problems of high rise building

→ Parking difficulties
→ Density of population in that area becomes high
→ Social and human problems

Seismic effect

Earthquake causes shaking of ground. So a building resting on ground experiences a movement at its base. Though the base moves along with the ground, the roof has a tendency to stay in its original position. This (Newton's first law of motion). This tendency to continue to remain in its original position is called as inertia. and corresponding inertia force is given as

Inertia force, $F = ma$ (Newton's second law of motion)

where $m \rightarrow$ mass of roof

$a \rightarrow$ acceleration

But since the columns or walls are stiffer tend to stay in original straight position As the columns are connected to the base they tend to drag the roof along with d then in the direction of earthquake force. This ~~tend to to and~~ fro motion of building (inertia force of roof and ~~stiffness of columns~~) ~~leads to shaking of building~~. Hence the building oscillates back and forth horizontally (due to inertia force of roof and

stiffness of columns respectively) and comes to rest after some time. The time taken in seconds for one complete cycle of oscillation is called fundamental natural period 'T' and inverse of natural period is called natural frequency 'f' of the building. When this frequency of building matches with frequency of ground vibrations, resonance occurs. Due to this resonance, the amplitude of oscillations gets increased suddenly resulting in high damages.

Seismic effect on tall buildings

Taller buildings have larger mass and are more flexible and hence the oscillations are large. This results in large natural period of vibration 'T'. Fundamental natural period of normal single storey to 20 storey buildings are usually in the range 0.05 to 2 sec

Due to flexibility, larger horizontal displace occur. Non structural elements like glass windows wooden doors, shelves gets crushed or severly damaged. These damages are severe in upper storey stories of tall buildings. and hence causes economic losses, injuri etc. To avoid this large horizontal displacements the frames should be braced using tubes or shear walls or should be provided lateral load resisting frames

Another damage is ~~pounding~~ pounding of buildings with each other which results in huge damage

Environmental impact of materials

Construction industries have a larger part in contributing to environmental problems like ~~tsuna~~ tsunami, wildfires, flood, drought, global warming, rising of sea level, land loss due to contamination of soil. The main reason for this impact to environment due to construction industry is due to the materials used in construction. The life cycle of a building material can be considered to have five stages

- Extraction / Mining
- Manufacture
- Construction
- Use
- Demolition

Of the above stages, for most building materials, the major environmental impact occur, during first two stages extraction and manufacture. But as waste disposal problems increase, impacts associated with demolition stage has also to be considered

(i) Environmental impact during extraction

Natural resources are limited on earth while there is an uncontrolled consumption of natural resources as construction material

Sand is extracted from beaches and dredged from ocean and river beds. Sand extraction from river leads to several impacts on the natural river environment as given below,

→ Loss of living species
→ Bank erosion
→ Lowering of river bottom
→ Enlargement of river mouth
→ Salt water intrusion
→ Decrease in water quality

Sand extraction also affects nearby groundwater system and the local people those who make use of the river

Aggregate is mined from earth or obtained from blasting of quarries. Mining of aggregates or blasting of quarries have environmental impacts as given below,

→ Removal of natural vegetation and top soil leading to erosion problem
→ Migration of animals to new places as vegetations are destroyed
→ Human beings adjacent to quarries are affected by noise, dust, noise pollution, air pollution due to dust,

and contamination of water.

→ Pits created due to blasting ~~affects~~ interrupts the movement of surface water and ground water.

→ Reduction in quantity and quality of drinking water sources which are near to a quarry site.

(ii) Environmental impact during manufacture

Construction materials require high energy for their extraction, manufacture and ~~land~~ transportation. The energy required for major construction material steel is about 32 MJ/kg and for cement is about 7.8 MJ/kg. Generation of this required energy needs the use of naturally available materials like gas, oil, electricity (coal), water etc.

Manufacture of cement and steel ~~result~~ involves large emissions of Carbon di oxide (Co_2) among which manufacture of cement is the major source of emission of Co_2. Emission of Co_2 results in global warming, depletion of ozone layer, increase of temperature etc. About 40% of ~~construction~~ Carbon di oxide emission from a construction industry is from manufacture of cement

(iii) Environmental impact during demolition

Demolition or ~~reno~~ renovation of a building leads to more land fills which in turn affects the natural seepage of rain water into ground, loss of land etc. Recycling and reuse of these demolished waste ~~avo~~ avoids

land fill problems and also reduces extraction of construction materials

Recycling of steel - Construction steel (structural sections used as beams, columns) is highly recycled when compared to reinforcing steel as reinforcing bars are difficult to separate from concrete.

Recycling of concrete - Concrete can be crushed and the aggregates obtained called as recycled aggregates can be used as base material for pavements, roads, filter material placed under pipes, footings, landscaping material. They can also be used as aggregates in new concrete by some percentage. They can also be used in protection of shores and erosion control.

Responsible sourcing

Construction industry has a large impact on the environment due to extraction of natural resources, emissions of CO_2, problems in disposing demolished wastes. Hence there is a responsibility in reducing this impact by ensuring that the materials are extracted in a legal way, emissions of toxic gases are within permissible limits. This is called responsible sourcing

There should be a documented set of criteria describing the obligations of an industry in supply of construction materials in accordance to environmental limitations. Moreover the consumers of construction products should gather informations regarding source of material, impact of material on environment, quality of product etc.

Green buildings (or) Eco buildings

Definition

Green buildings (or) eco buildings (or) sustainable buildings refer to a building which is designed, built, operated, maintained or reused with objectives to protect occupant health, ~~improve employee productivity~~, optimum usage of natural resources and reduction in environmental impact.

~~Aspects to attain~~ Construction methods

Green buildings are constructed ~~so as to attain the following aspects~~. using following methods,

1) Design, preparation and development

Efficient design, accurate preparation of drawings and development of construction activities helps to lower environmental impact and improve performance of new constructions. The plans should include trees around building, ~~carbon~~ should indicate rain water retention / infiltration ~~purpose~~ features, orientation of building should be in such a way it receives solar power and daylight.

2) Resource efficiency

Using available material resources and obtaining their maximum functions optimises the use of natural resources. Efficiency in material resources can be obtained by reduction in wastage of materials in site and also avoiding left over materials from construction process. Also reducing demolished waste helps in reducing the quantity of landfills

3) Energy efficiency

Power generation is the most expensive feature in construction of building. Energy efficiency can be achieved by lowering the power consumption in construction and generation of energy using alternative methods.

Reducing consumption – Achieved by installation of solar energy panels
- orientation of windows, doors, walls, portico's, trees etc gains solar energy
- Effective placement of windows, building location and orientation can provide natural light thereby reducing electrical lighting
- Solar water heating further reduces energy consumption

Alternate methods – Energy through solar power, wind power, hydropower, biomass can be alternate source of energy.

4) Water efficiency

Green buildings focus on conserving water both indoor and outdoor. Water can be conserved indoor by implementing more efficient water delivery systems, proper flushing of toilets etc. Outdoor water conservation can be achieved by construction of water retaining landscaping activities. ~~Rain water~~ and ~~waste can~~ by Rain water can be stored for further use. Waste water can be reused for irrigation purposes after filtering and removing contaminants.

5) Environmental quality

Environmental quality can be achieved by reducing the contamination of environment by emission of Co_2 by either controlling the source or diluting the source and ~~filter~~ filtering the contaminant. ~~Si~~ Producers should be educated with alternative environmental friendly materials.

6) Material efficiency

Energy efficient building materials like timber, renewable materials like bamboo and straw, recycled stone, recycled metals and other non toxic products should be used.

Green Materials

The choice of green materials depends on the following parameters,

→ Physical suitability - Compressive strength, tensile strength, water resistance etc.

→ Cost effectiveness – Affordable according to budget
→ Local availability – Easily available in required quantities
→ Workability – Ease with which it can be used.
→ Environmental performance – recyclable, less toxic emissions,

Following are the green building materials used in construction

→ Earthen materials – Earthen materials in the form of rammed earth are used for construction in olden days
– For good strength and durability chopped straw, grass, natural fibres are added to earth

→ Wood (or) Timber – Wood is used in construction of small buildings in the form of boards and planks
– Wood is used in doors, windows etc.

→ Bamboo – Bamboo is a durable material used to construct frames, walls, floor etc
– They give good appearance to the structure

→ Structural Insulated Panels (SIP) – SIP's consist of two wooden sheets or boards connected with each other using keys, pins with foam layer (or) insulation between them
– They are used in walls of structure

→ Insulated Concrete Forms (ICF) – ICF's contains two insulation layers with some space in between them in which reinforcement is placed and concrete is poured
– Used as walls and floors
– They are light in weight, have good sound and thermal insulation properties

→ Slate roofing (or) flooring - Slate is naturally formed rock which is used to make tiles
- Slate tiles are durable, locally available and cheap

→ Steel - Steel is used in roof in the form of panels
- Steel panels are highly durable, recycled and reused

→ Straw - It is oldest roofing material,
→ It is a good insulating material

→ Natural fiber - Natural fibers like cotton, wool can be used as flooring materials

→ Cellulose - Cellulose is a recycled product of paper waste used for insulation purposes

→ Cork - Cork boards can be used as insulation and flooring material

→ Natural clay - Clay can be used in plastering of walls other than using cement.

→ Stone - most durable and has good resistant to weathering.
- Used to construct exterior walls, of steps etc

→ Rice husk ash & fly ash - Used as a replacement of cement
- Landfill of waste rice husk ash and fly ash can be avoided

~~Construction methods - Write methods of natural bldg~~

Natural buildings

Natural buildings are those which involves building systems and building materials which are durable, which has minimum extraction of natural resources, which uses recycled products etc. Also natural building involves human labour than modern technology.

Aims of natural buildings

-> Reduces energy consumption
-> Prevents extraction of natural resources
-> Economic and easily available

Methods of natural building (or) Materials used for natural buildings

Following are the methods of natural building,

-> Soil based - Adobe brick, rammed earth, Earth bag
-> Plant based - Timber, Strawbale, Bamboo. Thatch and other plant
-> Composites - structural Insulated Panels, Insulated Concrete Forms
-> Mineral based - Stone, Concrete demolished waste
-> Waste products - Tires, Bottle and cans

1) Adobe brick

Adobe brick is a composite material made of earth mixed with organic material such as straw or cowdung. The earth is usually composed of clay (15%), silt (10-30%) and sand (55-75%). Straw is useful in binding the brick together and to avoids cracking of bricks during drying. Cowdung is added for making the adobe bricks water resistant and also avoids cracking of bricks. Stabilizing agents like asphalt or Portland cement can be added upto 10% by weight.

The materials are mixed manually and cast in open moulds made of timber or steel ~~placed~~ arranged on ground The inner size of mould is 8"x4"x12" or 10"x4"x14"

The bricks are sun dried for five days or more and never kiln dried. The bricks are then removed from mould and dried for few more days. After that the bricks are used to construct load bearing walls. The minimum compressive strength of bricks was expected to be 2.07N/mm^2

2) Rammed earth

Rammed earth is a technique used for construction of walls (parts of Great wall of China), foundations, floors using natural materials like ~~earth~~ sand, lime, clay, gravel etc. Following is the construction of rammed earthen wall,

→ Formwork is made of wood or steel for required shape and dimensions of wall. The formwork should be durable, water tight, well braced, properly clamped

→ Rammed earth was prepared in damp state by mixing ingredients sand, gravel with stabilizers like lime

→ The damp material is poured into formwork to a depth of 10 to 25cm and then compacted to approximately 50% of its original height. Compaction is done using manual or pneumatic rammers

→ The material is poured and compacted up to top of formwork

→ After hardening the formwork is removed and required surface texture can be applied.

3) Earth bag

Earthbag buildings uses polypropylene bags filled with

earthen materials and sewed (stitched), and then stacked like masonry and tied using barbed wire to avoid slipping. Following is the construction procedure

→ Preparation of ground - The site is cleared off vegetation, loose and top soil was removed. A trench is dug and filled with gravel to a height of 12 inches. Stringlines and corner guides are provided to maintain alignment

→ Filling the bags - Woven polypropylene bags are filled with earthen material like soil, pebbles, gravel etc approximately 90% full. The bags are sewed (stitched) after filling using steel wires

→ Placing lower course - Place gravel filled bags on lower course (for high strength) starting from corners towards the center. Alignment can be checked using stringwires and guides

→ Tamping - Tamp earthbags after each course is complete so that they are in same level

→ Add barbed wire - Use barbed wire in between each course of bags

→ Placing additional courses - Place additional courses of earth bags using a sliding sheet metal in order to avoid tearing of earthbag due to barbed wire

Upon completion the wall is plastered.

4) Straw bale construction

Straw bale construction is a building method that uses bales of straw (stalk) like wheat, rice, oats etc in walls covered by earthen, lime or cement plaster

Following is the procedure of straw bale construction.

→ Structural components like floor, roof, columns, beams are constructed using concrete or timber

→ Straw is baled in the form of rectangular blocks and tied using ~~strings~~ steel wire or twine or bamboo.

→ The blocks are arranged to desired height with wooden planks in between 5 to 6 layers of blocks in order to maintain stability of blocks.

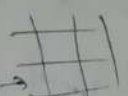
→ Once the wall is ~~formed~~ formed, it is plastered using earthen, lime or cement mortar

5) Bamboo construction

Use of bamboo for construction is achieved by arranging it in frame (or) grid pattern - Following is the Construction procedure for various elements.

Foundations - Bamboo can be inserted directly into ground, on rock or concrete footings

Floors - In between the concrete footings earth is filled and compacted. Bamboo is arranged over the compacted earth in the form of joists. Bamboo mats formed by weaving small strips of bamboo is laid above this joists. The mat is either nailed or tied with the joist.



Walls - Bamboos are arranged vertically by driving the directly into ground or on joists. The vertical members are supported by horizontal members at suitable intervals. Mats can be attached to the walls or it can also be plastered.

Roof - Roof is in the form of trusses, the inclined members called as rafters. The member running along length at ends is called as eave beams and other members are called purlins

Roof coverings - Roof coverings can be of bamboo tiles, bamboo mats, Corrugated bamboo roofing sheets, plastered bamboo.

6) SIP

7) ICF

Passive buildings

Passive buildings are buildings which maintains a thermal comfort (constant, pleasant temperature) without the requirement of extra energy for heating or cooling. Following are the techniques adopted.

Orientation

→ The orientation of the building should be such that the longer axis of the building is in east/west direction

→ The south side of the home must be oriented (inclined) to within 30° of south axis (geographical south)

→ By orienting so, during summer months the building window and door such sunshades restricts the entry of sunlight into the building and during summer or winter months, the sunlight is allowed to enter the building.

→ Due to such orientation, the south facing windows receive 90% heat gain from solar radiation during winter and less heat during summer.

Overhangs and shading

→ Overhangs and shading are important devices in reducing overheating during summer season.

→ The type of sunshade, size and its slope should be properly designed such that it allows the sun rays during winter and shades the building during summer.

→ For designing the size and slope of sunshades the incident angle of sunrays should be considered (Summer - 66.5°, winter - 29.5°)

Selection of windows

→ Windows facing east, west and north should be kept minimum in number

→ The basic position of windows is southern position because it allows them to collect solar energy when heat is needed or to let fresh air when it is needed.

→ Frame material should be of wood, aluminium or PVC.

Insulation

→ Well insulated building helps in reducing heat loss during winter and keeps warm during winter.

⇒ The various type of insulation materials used are cellulose, cotton, fibreglass, polyurethane, mineral wool, perlite and sheep's wool.

Reflective Coating

→ The heat reflective paint coating consists of small particles often made with glass that reflects the sun light.

⇒ They are mainly used on horizontal surfaces of buildings and ~~exte~~ may be used on exterior vertical surfaces

→ Examples of reflective coating are polymer, white paints

Heat storage (or) Thermal mass

→ Heat storage is achieved by using materials which can store heat and releases it when needed

→ Materials like concrete, masonry, tiles, water filled containers can be used for heat storage.

→ The main properties required for the materials to behave as storage material is high density, good thermal conductivity and low reflectivity

→ The thermal capacity of some materials are given below

* water = 4186 KJ/m³
* Concrete = 2060 KJ/m³
* Sandstone = 1800 KJ/m³
* Brick = 1360 KJ/m³
* Earth = 1300 KJ/m³

Daylighting (or) Natural lighting

→ Daylighting within the building serves as a additional resource
→ Better illumination can be achieved by using white diffusive materials for ceilings and low emissivity coatings for wall etc (absorb)

Intelligent (Smart) buildings

Intelligent or smart buildings is one that provides cost effective, comfortable, secure and long term flexibility using technological building systems, telecommunication infrastructure, efficient building services and proper energy management.

Building Technologies

1) Building automation

Building automation is the automatic centralized control of a building's heating, ventilation, air conditioning and lighting through a building automation system (BAS). BAS is a control system which is computerized and connected with a network of electronic devices. Following are the features of BAS,

- Keeps the building temperature within a specified range
- Provides lighting occupancy based on occupancy sensors, photo sensors and timers
- Monitors performance of electronic items
- Provides notifications in case of any failure of electronic items
- Provides alarms in case of fire or smoke problems

3) Elevators and Escalators

→ Smart buildings provide occupants with improved elevator service like multiple elevators grouping, incorporating traffic patterns etc. Some elevators may be shut down for a part of day to save energy

→ Escalators save energy by slowing down or stopping when detectors indicate that there is no traffic

3) Security systems

The security systems includes controlling access, surveillance

1) Controlling access

→ Restricts how and which people can enter an area

→ Identification can be done through magnetic cards, coded keys, hand, face, voice, finger or retina readers.

→ These systems are used in many business centres, hotels and apartments

2) Surveillance

→ Surveillance helps in monitoring movement within and outside a building through Closed Circuit Television Camera (CCTV camera)

→ Intrusion alarms helps in alerting the security in case of unauthorized entry

Life safety systems

Smart structures consist of safety systems like fire alarms, smoke detector, emergency control of elevators, escalators, leak detection

In case of smoke, the alarms system gets activated, the dampers closes and prevents air from entering into the building, exhaust system (exhaust fan) gets activated and moves smoke out of the area.

In case of fire, the protection system pumps water to the areas where the fire occurs and water gets sprinkled through nozzles to put off fire

Telecommunication

Smart buildings provides the following telecommunication features...

- Private telephone intercoms
- Audio, visual and video conferencing
- Satellite communications
- Electronic mail, Internet access

HVAC systems

HVAC stands for Heating, Ventilation and Air Conditioning

HVAC system is designed to control the environment in which it works. This can be achieved by,

- Controlling the temperature of room through heating and cooling
- Controlling humidity level in room
- Controlling movement and distribution of air inside the

1) Heating

Heating is needed to increase the temperature in a space to compensate for heat loss and keep the building warm.

Heaters - Heaters are appliances used for keeping a building warm
- Uses a central heating system which contains a boiler, furnace or heat pump to ~~pump water~~, steam or air at a central location by admitting it into the system & exhaust the wa
- ~~This system~~ heats the air, and keeps the building warm

Hot water systems - Applied by transferring heat through hot water flowing through pipes.
- Heating system consists of a pump which moves or circulates hot water through pipes
- The heat can be transferred through surrounding air through heat exchangers like radiators, hot water coils

Duct system
- This system distributes heated air through metal or fibre glass ducts
- The duct is fitted with air cleaners or air filters to remove dust.

2) Ventilation

Ventilation is needed to supply air to a space and extract polluted air from that space. Ventilation can be improved effectively by

-) Effective use of air coming through ventilation by using in

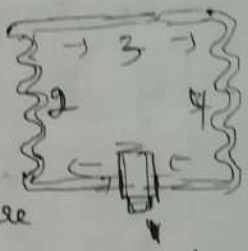
with respect to demand or occupants. Changes in occupancy can be found out or measured using CO_2 sensorys

→ Avoiding waste collection inside building, avoiding more storage, reducing exhaust systems enchance efficiency.

→ Usage of grilles, louvers echance ventilation.

3) Air Conditioning

Air conditioning system provides cooling and humidity control by removing heat through radiation, convection or conduction. Following is the refrigeration cycle,



1) The compressor pumps the refrigerant gas up to a high pressure and temperature
2) From there it enters condensing coil or condensor where it loses energy (heat) to outside, cools and condenses into liquid phase
3) An expansion value regulates the flow of refrigerant liquid
4) The liquid refrigerant evaporates by absorbing energy from the inside air thereby making it cool. and this process gets repeated

Energy efficient buildings

Buildings comprises of activities like heating, cooling, lighting, running machineries and electrical appliances, maintenance purposes etc. In developing countries there is a demand for electricity although there are renewable energies like hydropower, wind energy, geothermal energy as they requires huge investment and take time to implement

Investments in installing energy efficiency methods in a building is less compared to investment in producing renewable energy and investment in energy supply. Hence the importance of energy efficiency in buildings become important by using energy efficient materials and methods.

Definition

Energy efficiency of a building is the extent to which the energy consumption per square metre of floor area of the building is within the limits. These limits are fixed by analysing energy data of different building types within a country.

Methods

Following are the methods of achieving energy efficiency of buildings

→ Reducing heating demand
→ Reducing cooling demand
→ Reducing energy requirements for ventilation
→ Reducing energy use for lighting
→ Reducing energy use for heating water
→ Reducing electricity consumption of office equipment and electrical appliances
→ Good housekeeping and people solutions

1) Reducing heating demand

Heating demand can be reduced by,

Limiting the exposed surface area of building
- Shape of building determines how much space is exposed to heating
- Plan should be simple square or rectangle
- Complex shapes should be avoided

Improving air tightness
- Air leaks through cracks or holes in walls, ceilings, floors and around doors and windows should be avoided by sealing cracks

Improving insulation
- Heat loss through floors, roofs, ~~and~~ windows and doors can be reduced by using insulation.

By selecting efficient heating system
- Radiant floorheating is followed for large buildings
- Hot water systems is followed for small buildings.

2) Reducing Cooling demand

Cooling demand can be reduced by,

Avoiding large areas of glazing (windows)
- Large areas of glazing leads to heat gain in summer and high heat loss in winter leading to alternative arrangenat for cooling

Use of shading (sunshade)
- Sunshades prevents entry of sunlight into building thereby keeping the building cool

Solar control glass
- Window glazing is available with selective coatings that prevents the entry of high intensity sunlight

Selecting equipment or appliances with less heat output - Equipments that liberates heat should be used less in number or kept off whenever not in use (Ex TV, Computer

Using thermal mass - Materials with high heat absorbing capacity like concrete, bricks and tiles should be used
- This absorbs heat and keeps building cool

3) Reducing energy requirements for ventilation

The energy required for ventilation can be minimized by,

Building design - More effective form of ventilation is cross ventilation

Effective window design - Windows should be located such that its operation is easier by building occupants

Mixed mode ventilation - Mixed mode ventilation ~~used~~ allows natural ventilation to be used during most part of the years and mechanical cooling (AC) during summer.

4) Reducing energy use for lighting

Maximizing the use of daylight - Introducing natural sun light into buildings saves electrical energy

Energy efficient lighting system - Lighting should be provided only the required illuminance level according to use

Lighting controls - Controls of lighting (switches) should be provided near to work area so that they can be switched off wherever not in use

5) Reducing energy use for heating water

The energy use for heating can be reduced by

- Installing time controls – This automatically on/off the heating appliance according to the hot water requirement.
- Using alternative methods – Using solar radiation for keeping the water warm
- Proper maintenance – Proper replacement and maintenance of pipes used for hot water is essential

6) Reducing electricity consumption of office equipment and electrical appliances

→ Office equipments like computers, printers, fax machine, scanners, projectors and telecoms are using 15% of total electricity in offices

→ The consumption of office equipments and electrical appliances can be reduced by

(i) Switching off when not in use

(ii) Upgrading existing equipment

(iii) Using standard appliances

7) Good housekeeping and people solutions

→ Energy savings can be achieved by proper management of electrical energy by office staffs

→ This can be done by setting up energy policy, issuing notice to switch off appliances, conducting inspection, checking metre readings etc

Zones of energy efficient buildings

The design of energy efficient buildings depends on climate, sola path and intensity of solar radiation, humidity, wind flow, temperature of that particular place. Based on the above parameters, the country has been classified into five zones.

→ Hot and dry – Ex Jodhpur, Ahmedabad
→ Warm and Humid – Ex Chennai, Kolkatta
→ Moderate – Ex Bangalore
→ Cold – Ex Shillong, Shimla
→ Composite – Ex Bhopal, Delhi

Case studies –

1) Zone – Hot and Dry
Building type – Residential building Year of start/completion – 1996/97
Owner – Mahendra Patel Built up area – 550m²
Location – Ahmedabad
Cost – Rs 2 million

Design features

→ Power usage was limited to 18KW without any comfort
→ Air conditioning load reduced from 36 to 26 tonnes
→ Fly ash bricks ~~wh~~ are used for masonry
→ External walls and roofs are insulated
→ Windows are with double glass shutters
→ Walls are painted white
→ There is 1.2m projection of slab for shading
→ Solar water heating system is used
→ Building Automation system is used to avoid wastage of energy

2) Zone - Cold

Building type - office building

Owner - Himachal Pradesh Energy Development Agency (Himruja)

Year of Completion - 1997

Built up area - 635 m^2

Cost - Rs 8.3 million

Design features

→ Heating panels are designed as an integral part of south wall which provides heat gain
→ Double glazed windows
→ Insulated north wall to avoid heat loss.
→ Solar chimney
→ Integration of windows to provide effective daylighting
→ Solar water heating system

3) Zone - Composite

Building type - Institutional

Owner - Tata Energy Research

Year of start / completion - 1997 / 2000

Built up area - 3000 m^2

Cost - civil works - Rs 23.6 million, Electrical works - Rs 2.5 million, Technologies - Rs 18.54 million

Design Features

→ Wall and roof insulation
→ Building oriented to maximise winter gain and shade summer gains
→ East and west walls are shaded
→ Earth air tunnels of length 70m and 70cm diameter laid at depth of 4m below ground to supply conditioned air to rooms

→ Four fans of 2hp for forcing air in and solar chimneys force air out of rooms
→ Alternative energy system 50kW biomass and 10.71kW solar
→ 2000 lpd solar water heating system
→ Energy efficient lighting by fluorescent lamps & tubes
→ Good daylighting and lighting controls
→ Waste water management by root zones
→ Building monitoring and management system.

s) Unit II - Construction Practices

pecifications, details and sequence of activities and construction co-ordination - Site clearance - Marking - Earthwork - masonry - Stone masonry - Bond in masonry - Concrete hollow block masonry - flooring - damp proof courses - Construction joints - movement and expansion joints - precast pavements - building foundations - basements - temporary shed - centering and shuttering - slip forms - scaffoldings - de shuttering forms - Fabrication and erection of steel trusses - frames - braced domes - laying brick - weather and water proof - roof finishes - acoustic and fire protection.

Specifications

Specifications are of two types as below,

General (or) Brief specifications
- Gives general idea of whole work which shows the building plan that shows dimensions of room, passage etc.
- It gives brief description of parts such as foundation, superstructure, flooring, roofing, doors, windows etc.
- Using these specifications approximate cost of building can be estimated

Detailed specifications
- Gives details regarding materials and workmanship
- Useful in preparing detailed estimate.

Sequence of Construction activities

The order of planning and execution of various activities in construction work is called 'Sequence of construction activities'. The sequence of construction activities is explained below,

1) Study of site layout

→ The location of building site should be studied ~~from site drawing~~

→ Access roads for bringing materials through lorries and carts should be determined

→ Location of sheds for storage of materials like cement, lime, bricks should

be determined

2) Site Clearance

Site clearance is the process of,

→ Surface cleaning of grass, bushes, trees, anthills, hillocks etc
→ Cleaning of obstructions which may be above or below the ground level such as old foundations, old septic tanks, soak pits etc
→ Cleaning of obstructions belonging to other organizations such as drainage or water supply lines, underground electric or telephone cab with consult of the concerned party or proper arrangements should be made for its protection.

3) Enclosing the site

Enclosing the site with boundary wall is essential for the below,

→ Securing the materials from theft.
→ Safety of public from construction activities like excavation, material handling

3) Water Supply for Construction Activities

Water is an important material essential for construction. It can be made available by following methods.

→ Groundwater can be used by making bores
→ Can be brought by lorries and temporarily stored in storage tanks built for storage purposes.
→ Can be obtained from municipal corporation through pipelines

4) Electrical Supply

Electrical supply is necessary for modern building works

→ Temporary switch board and meter box can be established at one co of site layout
→ The temporary arrangement should be properly enclosed and located atleast 1.5m from ground level.

5) Protection of existing service lines

→ Provision should be made to protect water, electricity, telephone lines which may be running through side
→ Service lines should be marked on plan so that workers can identify them during construction
→ Suitable pipe ducts or concrete coverings should be provided to protect these services

6) Initial check on drawings

It is very important before commencing actual setting out of building on ground. Following are the checks
→ The sum of individual dimensions of rooms and walls should match with overall dimensions
→ levels like road level, floor level etc
→ location of building on site layout.

7) Setting out of buildings (Marking)

Setting out of buildings consist of the following two operations
→ Setting out of centre lines - This consist of establishing the centre of walls in case of load bearing structures or the centre of columns in case of framed ~~building~~ structures.
→ Setting out trenches - This consist of establishing excavation lines on both sides of trenches for proceeding with excavation.

8) Earthwork or Excavation

After establishing the excavation lines, following procedure is carried out using a water level. A plastic tube is filled with water ~~level~~ and used as water level
→ First the required depth is excavated at one place
→ Using this and taking the water level as reference point all other points are determined
→ Excavation is carried out and bottom of trenches is made level.

9) Foundation works

→ Laying concrete bed in trenches
→ Construction of footings
→ Soil filling around sides

10) Basement Construction

→ Brickwork upto basement height.
→ Filling of earth upto basement height
→ Providing damp proof course
→ Placing floor concrete

11) Construction of superstructure

→ Construction of brickwork above basement
→ Provision is made for doors, windows, sunshade, loft
→ Provision of lintel.

12) Roof concreting

→ Placing reinforcement
→ Concreting.

13) Other works

→ Plastering - Ceiling, Inner and outer walls
→ Water supply and electrical works
→ Floor finishing and wall tiles
→ White washing and Painting.

Masonry

Masonry is defined as the construction of building units bonded together with mortar. The building units may be stones, bricks, concrete hollow blocks, concrete blocks etc. The mortar may be lime or cement. Depending upon the building units, masonry is classified as stone masonry, brick masonry, concrete hollow block masonry etc.

Stone Masonry

Masonry laid with stones as building units is called Stone masonry. Stone masonry is classified as

Stone Masonry

Rubble Masonry	Ashlar Masonry
(i) Uncoursed rubble	(i) Ashlar fine
(ii) Coursed rubble	(ii) Ashlar rough tooled
(iii) Random rubble	(iii) Ashlar rock or quarry faced
(iv) Dry rubble	(iv) Ashlar chamfered
(v) Polygonal rubble	(v) Ashlar block in course
(vi) Flint rubble	(vi) Ashlar facing

Rubble Masonry

→ ~~Stones are used either dressed or undressed roughly dressed~~

→ Stones are used as obtained from the quarry with either undressed or roughly dressed.

→ Stones have wider joints.

Uncoursed rubble masonry

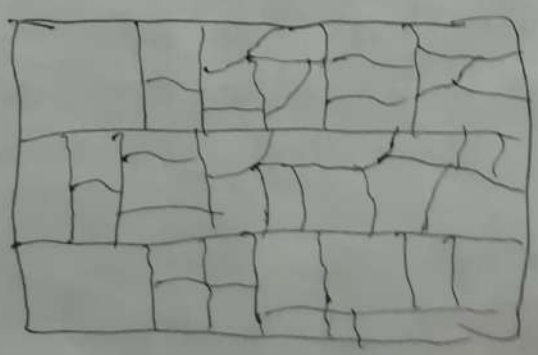
→ Cheapest, roughest and poorest form of stone masonry

→ Stones of widely different size and shapes are used

→ Care should be taken in arranging the stones. Larger stones are so laid on flat beds to break joints as much as possible.

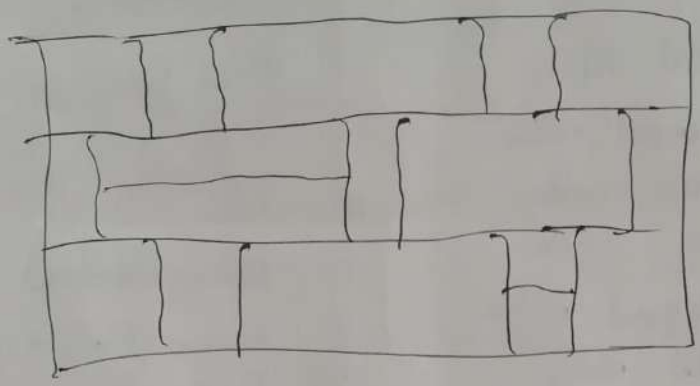
→ Joint thickness should be kept within 15mm

→ Courses are not maintained regularly. ~~Small brought to a level every~~



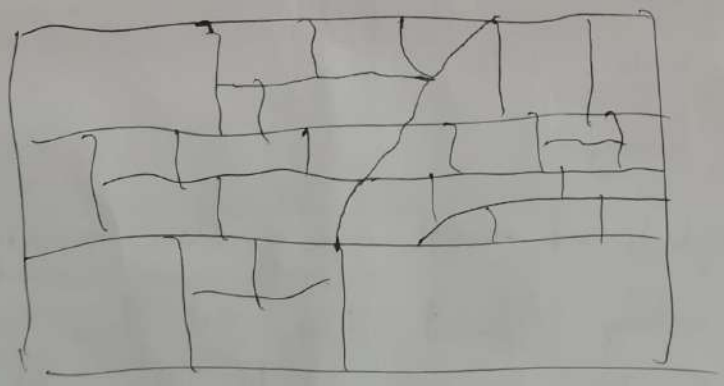
Coursed rubble masonry

→ Height of stones vary from 50mm to 200mm
→ Stones used in a paticular course should be of equal heights
→ Stones should be sorted out before commencement of work
→ Used in low height walls of public and residential buildings



Random Rubble Masonry

→ Stones of irregular size and shape are arranged to produce a good appearance
→ More skill is required to make this masonry structurally stable



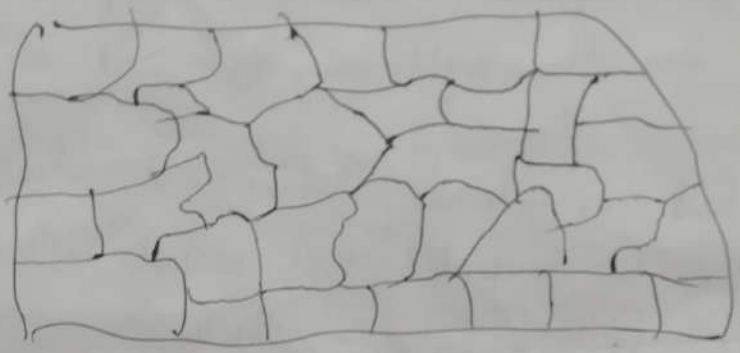
Dry Rubble Masonry

→ Coursed rubble masonry without mortar in joints is called dry rubble masonry. The spaces left around big stones should be tightly packed with small stones.
→ Used in retaining walls, earthen dams and canal slopes.
→ Requires skilled labour and supervision

Polygonal rubble masonry

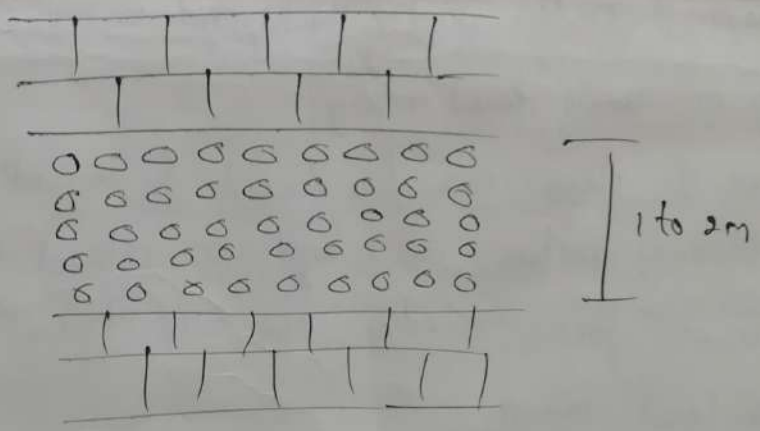
→ Stones are roughly dressed to polygonal shape and arranged to

avoid vertical joints
→ Joints will be irregular in pattern
→ More skilled labour is essential and it is difficult to arrange



Flint rubble masonry

→ Flint stones or cobbles are used and this masonry is used where flint stones are available in plenty
→ Flint stones with thickness 8 to 15cm and length 15 to 30cm is arranged in facing either coursed or uncoursed
→ Strength of flint wall is increased by introducing courses of stones or brider at vertical distances of 1 to 2m

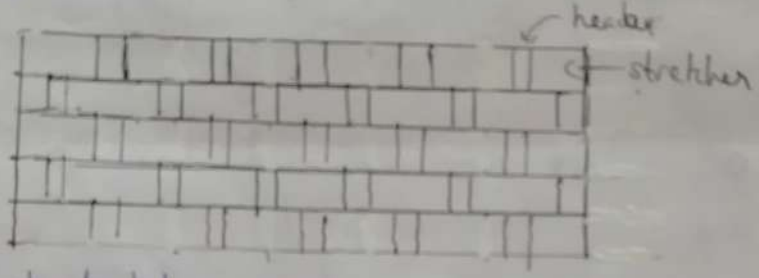


Ashlar Masonry

→ Costlier and superior quality
→ Stones are accurately dressed so that thickness of joints do not exceed 3mm
→ Height of stones vary about 25 to 30cm
→ Length of stone should not exceed three times the height and depth into wall should be atleast half the height
→ Used in heavy structures, piers, abutments

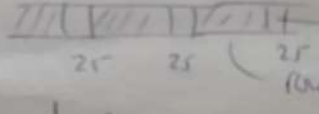
Ashlar Fine Masonry

→ Beds, Sides and faces of stone are dressed perfectly
→ Stones are laid in regular pattern with height not less than 20cm and width not less than height and length not two times more than height
→ Stones are laid as alternate headers and stretchers
→ All joints should be horizontal and vertical with thickness less than



Ashlar Rough tooled masonry

→ Beds, sides of stones are finely dressed while the exposed face is fine dressed for a width of 25mm and the portion between the 25mm strip is roughly dressed



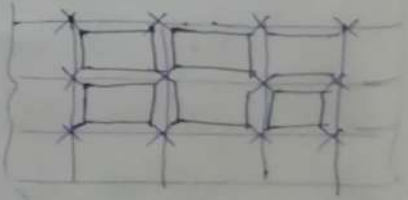
→ Thickness of mortar joint should not exceed 6mm

Ashlar rock or quarry faced masonry

→ All sides of stones are fine dressed for a width of 25mm and all other remaining portion are left as obtained in quarry
→ Projections on face exceeding 8cm are broken by hammer

Ashlar chamfered masonry

→ Same as that of ashlar quarry faced masonry but the 25mm strip is chamfered or bevelled at angle of 45° by chisel



Ashlar block in course masonry

→ The height of course is between 20 to 30cm
→ Faces are dressed with hammer and joint thickness does not exceed 6mm

Ashlar facing

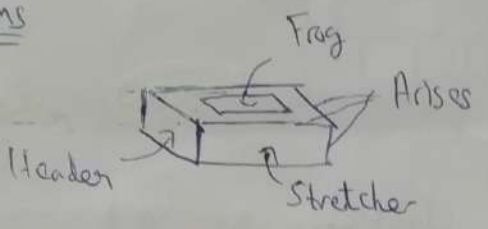
→ Facing is constructed using ashlar masonry while the backing may be in brick masonry, rubble masonry, concrete masonry. This leads to economy.
→ Facing is roughly tooled or chamfered

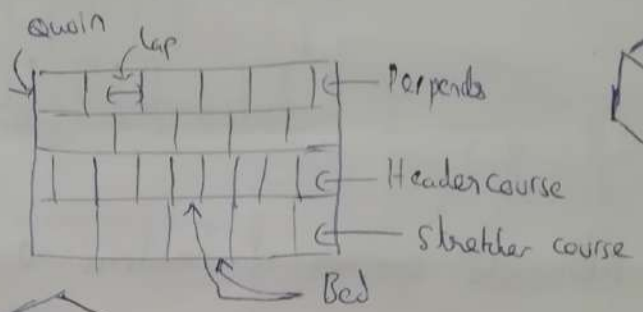
Bond in Masonry (Brick masonry)

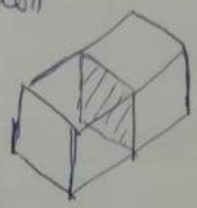
Bonding

Process of arranging bricks in such a way that vertical joints are minimum (discontinuous). A wall having continuous vertical joints shall act as independent column resulting in non uniform load distribution

Terms



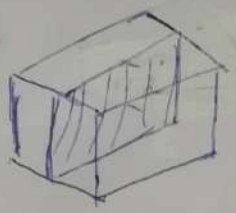




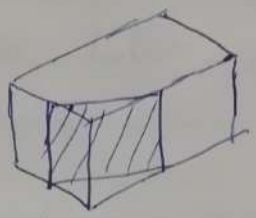
Bat

(Half Bat

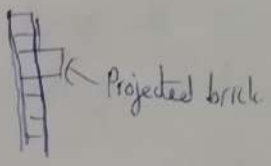
Three Quarter Bat)



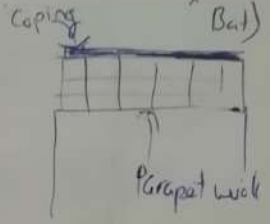
Queen closer



King closers



Cornice, Corbel



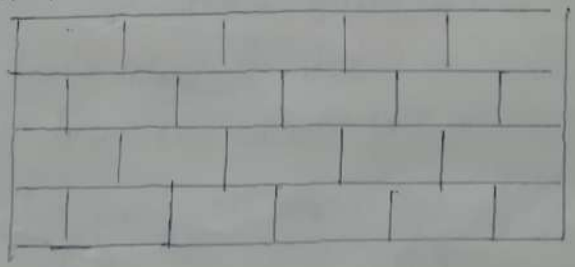
Bonds

1) Stretcher bond

→ All bricks are laid as stretchers (ie) the length of brick is kept parallel to direction of wall

→ This arrangement in applicable for walls having thickness 4cm like partition walls, sleeper walls, division walls (3.5 inch)

→ Used for walls with thickness less than one brick wall



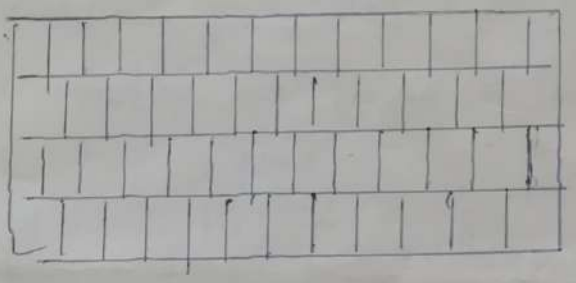
2) Header bond

→ All bricks are laid as headers (ie) the width of the brick is kept parallel to the direction of wall (9 inch)

→ Used for walls with thickness equal to one brick wall (18cm)

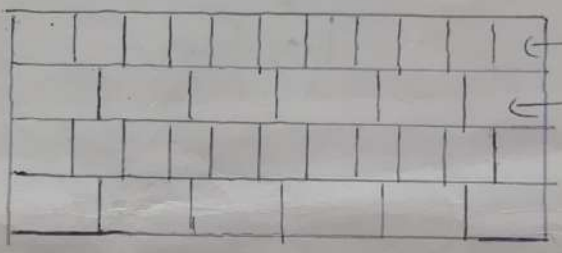
→ Useful for construction of curved walls and footings for better load distribution

→ This bond do not have enough strength to transmit load in the ~~length~~ direction of length of wall and hence it is unsuitable for load bearing walls



3) English Bond

→ Alternate courses of headers and stretchers are laid
→ This is the most common method used for all wall thickness
→ This bond is the strongest

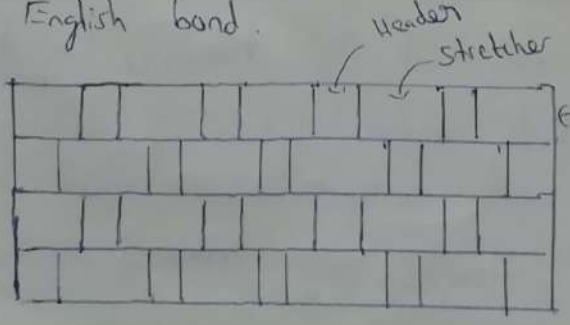


4) Flemish Bond

→ Each course is comprised of alternate headers and stretchers
→ It gives a pleasant appearance
→ Flemish bond are of two types below

Single Flemish bond - Facing consists of Flemish bond while backing consists of English bond. Thus this bond uses strength of English bond and appearance of Flemish bond

Double Flemish bond - Each course in facing and backing is of Flemish bond
- Better in appearance but weaker in strength than English bond.

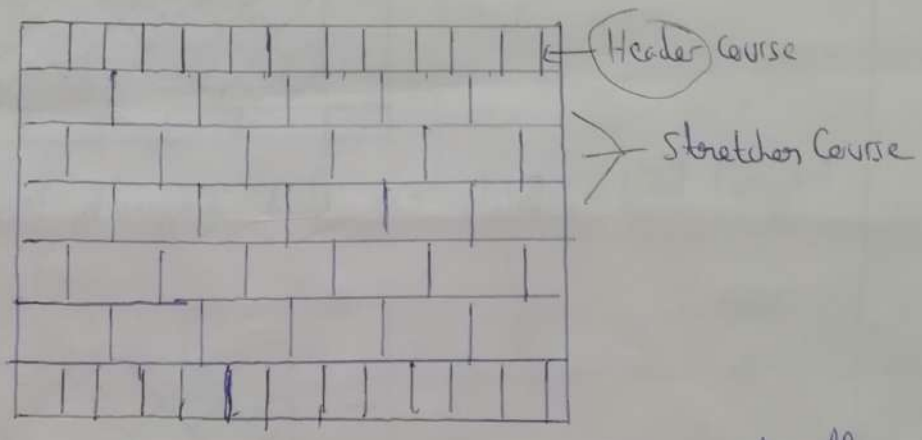


5) Garden wall bond

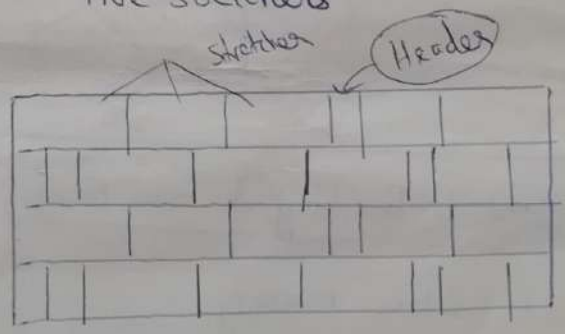
→ This type of bond is used for garden walls, boundary walls etc

→ Garden wall bond can be both English as well as Flemish

English garden wall bond - Comprises one header course to three or five stretcher course



Flemish garden wall bond - Each course comprises one header to three or five stretchers



6) Facing bond

→ Bricks of different thickness are used in facing and backing of wall

→ A header course is placed after several stretcher course

→ Distance between header course is equal to least common multiple of thickness of backing and facing bricks (If thickness of facing brick is 7cm and backing is 10cm, then header course should be placed at 70cm

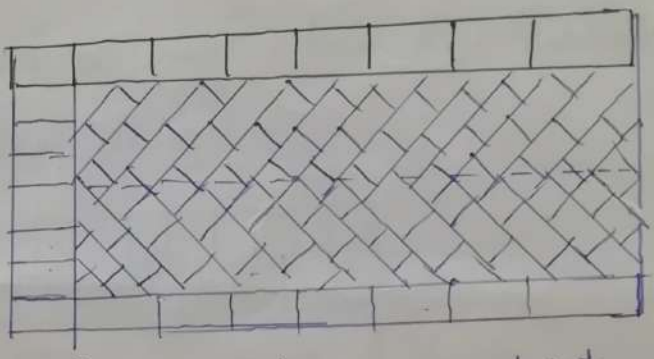
7) Raking bond

→ Alternate courses are placed in different directions to get maximum strength

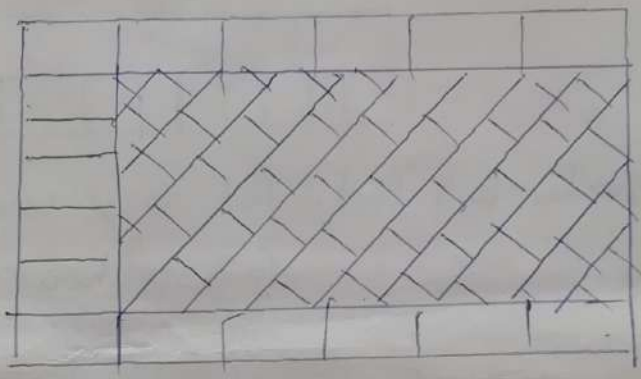
→ Raking bond is laid at certain intervals along the height of the wall

→ Raking course is of following types,

Herring Bone Bond - Bricks are laid at an angle of 45° from central line in both directions



Diagonal Bond - Bricks are laid diagonally in same direction



Comparison between Brick and Stone Masonry

Description	Stone Masonry	Brick Masonry
Uses	Construction of piers, dams, marine structures, residential and monumental buildings	construction of Residential buildings
Strength	High crushing strength	Low crushing strength
Durability	High	High
Appearance	Looks good with age	Requires plastering
Source	Natural	Artificial
Cost / Availability	High cost. Restricted to hilly areas	Less cost. Easy availability
Labour	High Skills	Ordinary skills
Mouldability	Cannot be moulded	Can be moulded to desired shape

Description	Stone Masonry	Brick Masonry
Handling	Requires lifting device	Easy to handle
Fire resistance	Less	More
Dampness	No danger	Causes disintegration
Bonding	Requires time, skilled labour in maintaining proper bond	Regular shape and size results in good bond
Construction of openings	Difficult	Easy

Concrete Hollow Block Masonry

Concrete blocks having void ~~area larger than 25% of gross area~~ or cores ~~or cores~~. ✓ is called concrete hollow block masonry. The cores should be atleast two in number. Net area should be atleast 55 to 60% of gross area. Concrete hollow blocks are used in low cost construction of schools, churches, residential buildings etc. The common sizes adopted are,

- Standard size - 39cm × 19cm × 30cm
- Hollow building tiles - 39cm × 19cm × 20cm
- Partition blocks - 39cm × 19cm × 10cm

Face thickness of these blocks are kept less than 5cm. The blocks are manufactured using 60% fine aggregate and 40% coarse aggregate of size 6 to 12mm with combined fineness modulus 2.9 to 3.6. Mix ratio adopted is 1:6 (cement : combined aggregate). Strength of block is found to be 30kg/cm². The surfaces of blocks can be finished in following ways

- Fine to coarse texture
- Glazed finish
- Slumped finish
- Marble faced
- Coloured finish

Flooring

Floors are horizontal elements of building structure which divide the building into various levels for the purpose of creating m accomodation (occupant, furniture, equipment) within a restricted space. Follow are the types of flooring

1) Mud flooring (25 → 15)

→ Cheap, easy to construct, maintain, impervious
→ Moist earth spread on a well prepared ground for a thickness of 25cm and rammed to a thickness of 15cm
→ In order to avoid cracks while drying, a small quantity of chopped straw is added to moist earth before ramming
→ A thin coat of earth-cowdung or cement cowdung in 1:2 to 1:3 ratio can be applied on top

2) Moorum flooring (25, 15, 2.5)

→ Sub grade is prepared by laying 25cm thick boulders or brick bats and rammed
→ 15cm thick moorum (disintegrated rock) is laid over subgrade
→ over this 2.5cm powdery moorum is spread and water is sprinkled ov
→ The surface is then well rammed
→ Thin coat of earth-cowdung or cement cowdung can be applied on

3) Concrete flooring (15, 15, 2.5-4)

→ Commonly used for residential commercial and industrial buildings
→ Concrete flooring consists of two components,

Base Course - 15cm thick layer of broken stones or bricks are laid
- 15cm thick lime concrete (1:2:4) is laid above it

Topping Concrete - 2.5 to 4cm thick cement concrete (1:2:4) is laid above base co

4) Terazzo flooring (CF → 1:2 cement sand slurry → 1:3 cement marble → polishing)

→ It is a type of floor finish that is laid over concrete flooring
→ It is decorative and has good wearing properties
→ over the cement concrete base, a thin coat of 1:2 cement sand slurry

is spread for 12mm thick
→ over this terrazo surface made of 1:3 cement-marble chips is laid for 6 to 12mm thickness
→ After curing for several days, surface is polished by grinding with carborundum stone

5) Mossaic Flooring (CF → 1:2 cement sand → marble → cement)

→ Concrete base is prepared
→ Cement mortar 1:2 is evenly spread above it
→ Above this, small pieces of china glazed or cement or marble tiles is arranged in definite pattern
→ After this cement is sprinkled on top and surface is rolled so as the joint gets filled.

(CF - 1:3 cement sand → tiles → pieces)

6) Tiled flooring (or) Marble flooring

→ Common flooring in residential, hotel, office and public buildings
→ Over the concrete base, 1:3 cement sand mortar is laid to serve as bedding material and allowed to harden for few hours
→ Then a cement slurry paste is spread over the bedding mortar
→ Then tiles, or marble are laid by gently pressing them into cement mortar with help of wooden mallet to obtain a levelled surface

7) Asphalt flooring

Asphalt is of following types,

Asphalt tiles - - Used in schools, offices, shops, hospitals, restaurants
- Produced from asphalt fibres and pigments
- Square size - 20 to 45cm, Thickness - 3 to 6mm

Asphalt terrazzo - Used in schools, offices, shops, hospitals, restaurants
- Obtained insitu by combining black or coloured asphalt with marble chips in hot condition and then laid

Mastic Asphalt - Used in commercial and industrial buildings like factories, loading platform, swimming pool, dairies, breweries etc
- obtained by mixing filler (stone dust, sand or grit) and coarse aggregate with black bitumen

Asphalt blocks - Used in chemical lab, acid plants, dye houses, storage battery buildings
- Consists of inert crushed rock aggregate bound with acid proof asphalt at high pressure

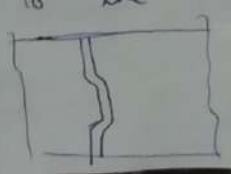
8) Linoleum flooring
→ Floor covering laid over concrete or wooden flooring
→ Linoleum sheet manufactured by mixing oxidised linseed oil with gum, resins, pigments, wood flour, corkdust etc.
→ Available in rolls of width 2 to 4m and thickness 2 to 7mm and used in flo of cinema theatres, office, hospitals etc.

Damp Proof Courses or Water proofing

Damp Proof Courses (DPC) are layer or membranes of water repellan materials such as bitumen felts (roll), mastic asphalt (concrete), plastic sheets, cement con cement mortar, slates, stones etc which are laid on all locations where water entry is suspected. DPC can be used for treatment of
→ Foundations
→ Basements
→ Floors
→ Walls
→ Flat roofs, parapets, copings
→ Pitched roofs

Construction Joints

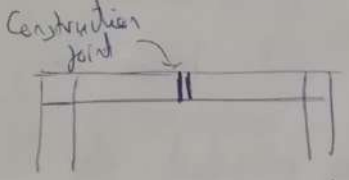
Construction joints are provided at places where placing of concrete has been stopped at the end of day or for any other reason. The provision of construction joints is to ensure proper bo between the old and new concrete. The construction joints may be made of wood, steel, plastic etc. horizontal or vertical for a inclined member the joint should be right angles to the axis of member

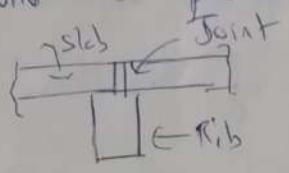


Following are the points to be considered in location of expansion joints.

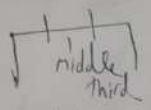
Beams - Construction joint should be placed at a point having minimum shear. Usually joints are located in centre of supports (columns) or within middle third of span. When a cross beam intercepts main beam, the joint should be placed at a offset distance of twice the cross beam.

T and L beams - The ribs (beam) should be filled with concrete first and then the flanges (slab) can be filled upto centre of rib while joint is placed in centre of rib





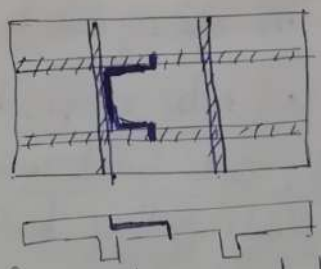
Beams



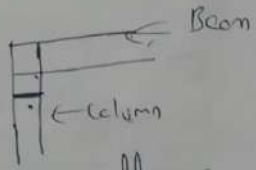
Tbeams, Lbeams

Slabs - One way slabs - Construction Joint is placed at longitudinal centre of supporting wall or beam

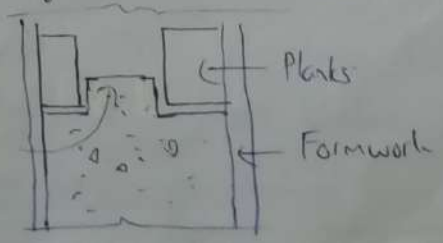
- Continuous slab - Can be placed at middle of supports provided joints should be located for every 15 to 18m length of slab



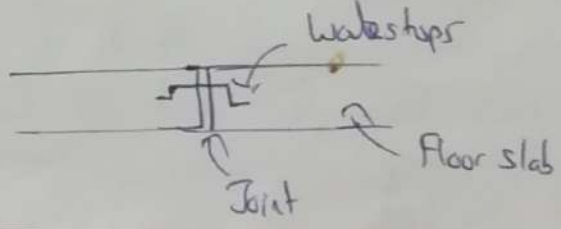
Columns - located a few centimetres below the ~~junction of~~ lowest soffit (bottom) of beam



Rcc wall - Location depends on the convenience of placing formwork and ease of compaction of concrete. Planks should be provided for supporting the joint and removed later



Watertanks - Construction joint is placed in floor or below. Waterstop made of strips of copper, aluminium, GI, PVC, synthetic rubber is used to seal the construction joint water tight



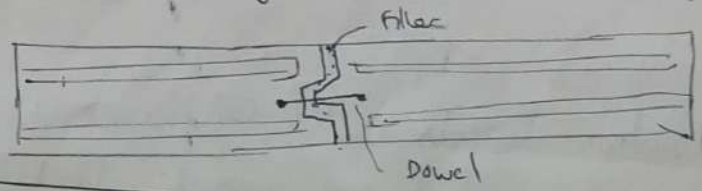
Movement and Expansion Joints (Contraction and Expansion Joints)

These joints permit expansion and contraction. They are provided to allow movement of the structure and hence they can also be called movement joints. Expansion joints are provided for the following reasons.

→ to allow changes in volume of concrete due to temperature
→ to allow changes due to variation in moisture

Expansion joint is provided in buildings with length more than 12m. It consists of

1) Joint filler - Used to fill the space that occur due to expansion joint
   - materials like metal strips, bitumen felt, fibre board, natural cork, cork bound with resin, soft wood are used
   - Joint filler should not be brittle and should be easy to be
2) Dowels or keys - These are metal pins used to transfer load from one part of expansion joint to the



Precast pavements

Precast pavements are concrete blocks designed and laid on a sand bed without mortar but capable of interlocking with each other. The openings (gaps) in blocks are filled with gravel, soil etc.

Building Foundations

Foundation is the part of structure which is in direct contact with the ground. It transfers the load of the structure to the soil. Following are the types of foundations,

- Foundation
  - Shallow foundation
    - Spread footing
    - Combined footing
    - Strap footing
    - Mat foundation
  - Deep foundation
    - Pile foundation
    - Pier foundation
    - Well foundation or caisson

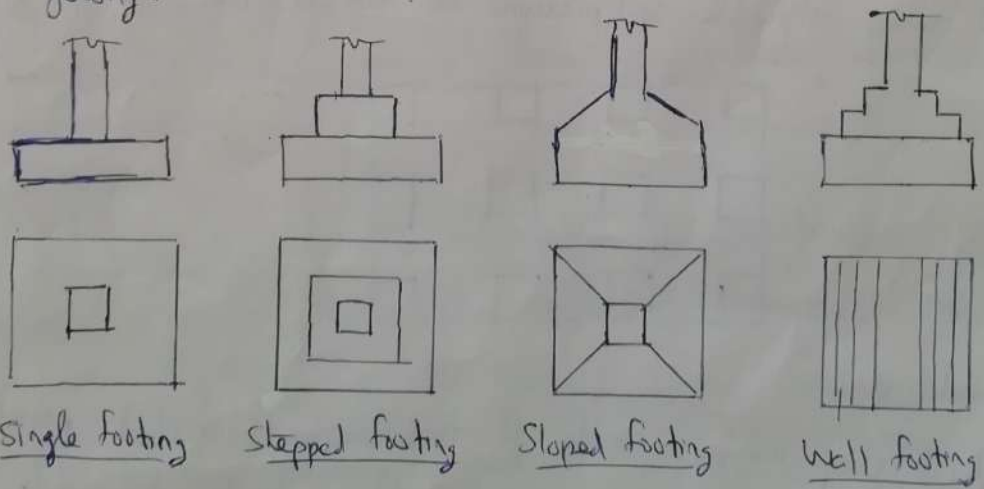
Shallow foundation – If the depth is equal to or less than its width it is called as shallow foundation

Deep foundation – If the depth is greater than its width it is called deep foundation.

Spread footing

→ Footings which spread the load of a column or wall to soil

→ Spread footings are of single footing, stepped footing, sloped footing and wall footing.



Single footing | Stepped footing | Sloped footing | Wall footing

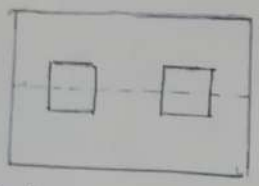
Combined footing

→ A spread footing which supports two or more columns is called combined footing

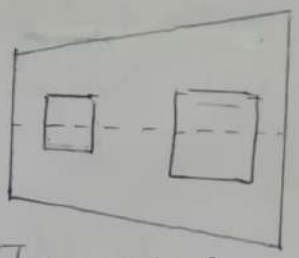
→ Combined footing may be of two shapes.

rectangular – if column carry equal loads

trapezoidal - if column carry unequal loads



Rectangular footing



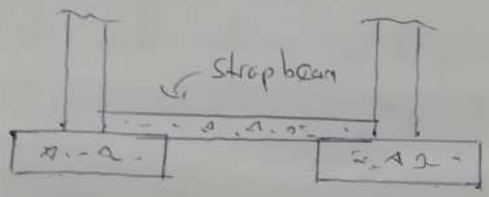
Trapezoidal footing

Strap Footing:

→ If the independent footings of two columns are connected by a beam, it is called strap footing

→ Used when the distance between the columns is so great that the combined trapezoidal footing becomes quite narrow and uneconomical

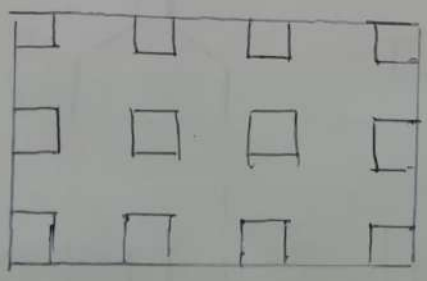
→ The strap beam does not transfer any load to the soil as it is not in contact



Mat foundation

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

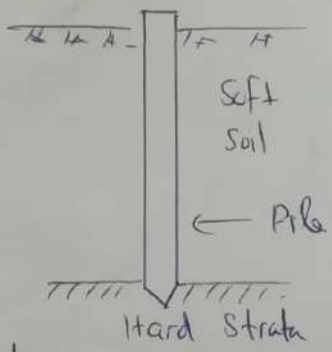
→ Used when allowable soil pressure is low or the building loads are heavy



Pile Foundation

→ Vertical deep members made of timber, concrete or steel provided when the soil below is weak and the loads have to be transfe to a hard strata at greater depth

→ Pile foundation is of types namely bearing piles, friction piles, compaction piles, anchor pile, tension piles, fender piles & dolphi piles, Batter piles

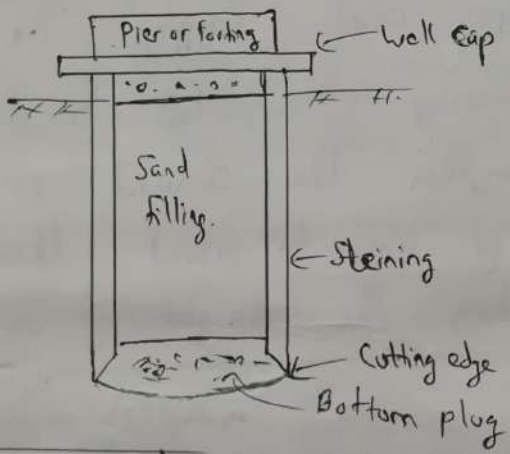


Caissons or well foundation

→ Box like structure circular or rectangular which are sunk into land or water for desired depth

→ It is used for placing a foundation (for bridges) under water (Ex foundation of bridge)

→ Types are box caissons, open caissons, pneumatic caissons



Basements

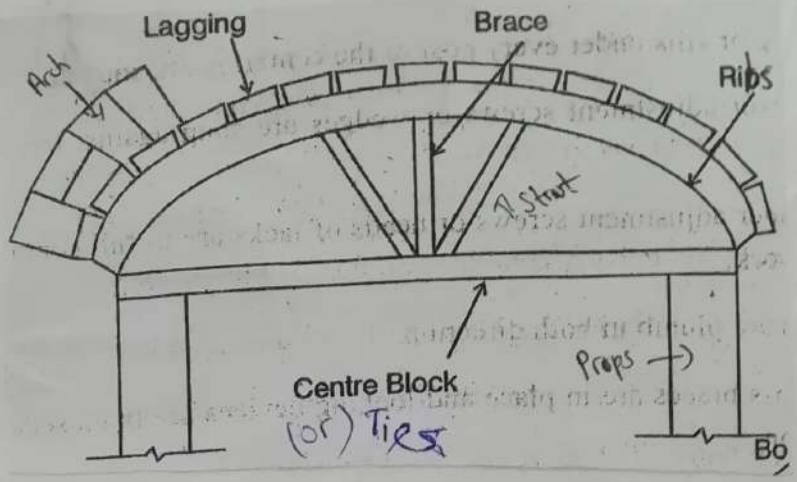
The portion of building between the ground level and the level of floor immediately above ground level is called basement

Temporary shed

Temporary shed is the one which is constructed inside proposed construction site for storing raw materials and for temporary shelter for workers. The shed is constructed using low grade materials

Centering

Centering is the temporary structure required to support brick, stone or concrete arches during their construction till it gains sufficient strength. The upper surface of the centering corresponds to the shape of inner curve intrados of the arch. Following shows centering arrangement,



The centering of arch consists of two parallel boards have their upper edges shaped to required curvature called as 'Ribs'. These boards are connected throughout their curved length by means of narrow wooden strips called 'lagging'. The laggings inturn support the arches. The centering is supported by props at each end. Struts are provided to strengthen the curved portion of ribs and ties provided and ends of ribs to prevent them from spreading & maintain width. Brace is provided to maintain the height of arch. Centre block is provided to maintain width and support

Shuttering or Form Work

wet, fresh. strut, brace

As fresh concrete is in plastic state, it requires to be supported by temporary supports to support the concrete till it gains sufficient strength for self supporting. Shuttering can be of steel, timber or wood, temporary structure

shuttering

Requirements of formwork

- → Strong enough to support the weight of concrete
- → Rigid enough to retain the shape of concrete
- → Must be tight that it does not allow cement paste to leak through it
- → Inside of formwork should be smooth
- → Easy removal and economy

Slipforms

Slipform is a special type of formwork used for construction of tall cylindrical chimneys, rectangular/circular towers for water tanks. Slipforms are also called as climbing forms or sliding forms

Following is the construction sequence using slip forms,

1) The formwork, hydraulic jacks and the access platform are assembled on the concrete base around the component to be constructed
2) The formwork assembly is raised using hydraulic jacks which are mounted on the steel frames. The jacks are supplied with oil under a high pressure by motor
3) ~~As the formwork is raised~~ reinforcements are provided and held in position Concrete is poured in formworks
4) ~~Once the concrete is~~ set, the formwork is raised again and the procedure is repeated

The usual speed of movement is 15 to 25 cm. The frictional force between the concrete and slip forms is taken as $0.4 t/m^2$.

Scaffoldings

Scaffolding is a temporary structure which is used in building operations to support platforms for workmen, structural material and appliances required for construction. Scaffolding may also be useful for maintenance, repair works, demolition in addition to construction. The height of scaffolding can be adjusted with the progress of work.

Components

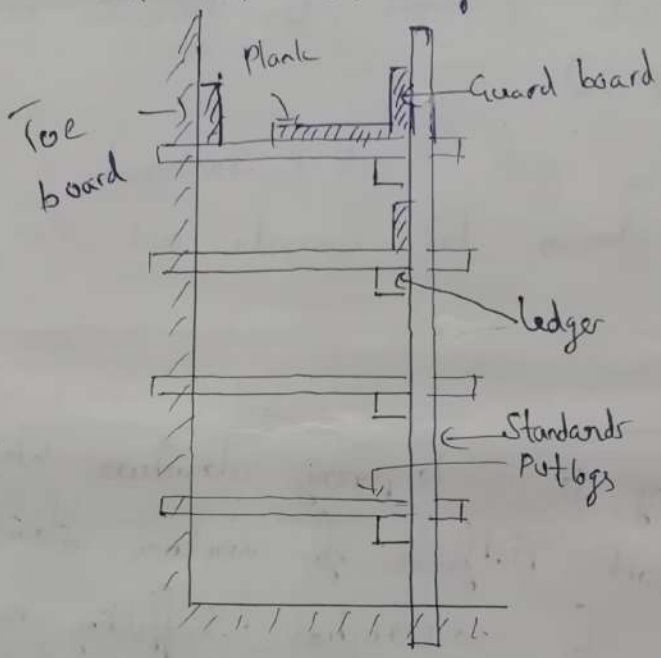
- → Standards - These are vertical members of scaffolding
- → Ledgers - These are horizontal members at right angles to standards and parallel to wall
- → Planks or Boarding - These are horizontal platforms for supporting men, materials and appliances
- → Putlogs - These members are placed on ledgers at right angle to wall one end of putlog is held in wall
- → Guard board - These members are provided at working level (like a ledger) to guard the men working on boarding.

Toe board - Boards placed parallel to ledger near the wall between the putlogs to give protection to workers

Types

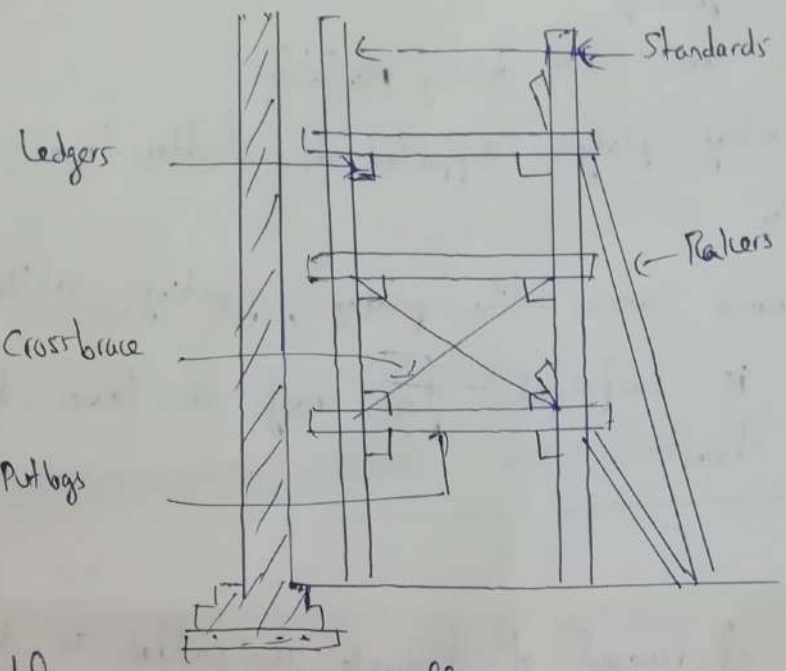
1) Single scaffolding or brick layers scaffolding

→ Most common type and widely used in construction of brickwork.
→ Consists of single framework of standards, ledgers, putlogs etc constructed parallel to wall at a distance of about 1.2m from wall.
→ If it is difficult to fix standards into ground, they may be placed in tubes or barrels filled with sand. Putlogs are inserted into wall



2) Double scaffolding or Mason's scaffolding

→ This system is used for plastering by mason's
→ Similar to single scaffolding except that two rows of standards are used, one close to wall within 15 cm of wall face and other at 1.5m
→ The putlogs are supported on ledgers on both sides and hence no holes are made in wall to support putlogs
→ Cross braces and raker are provided to prevent slipping of scaffolding away from the wall

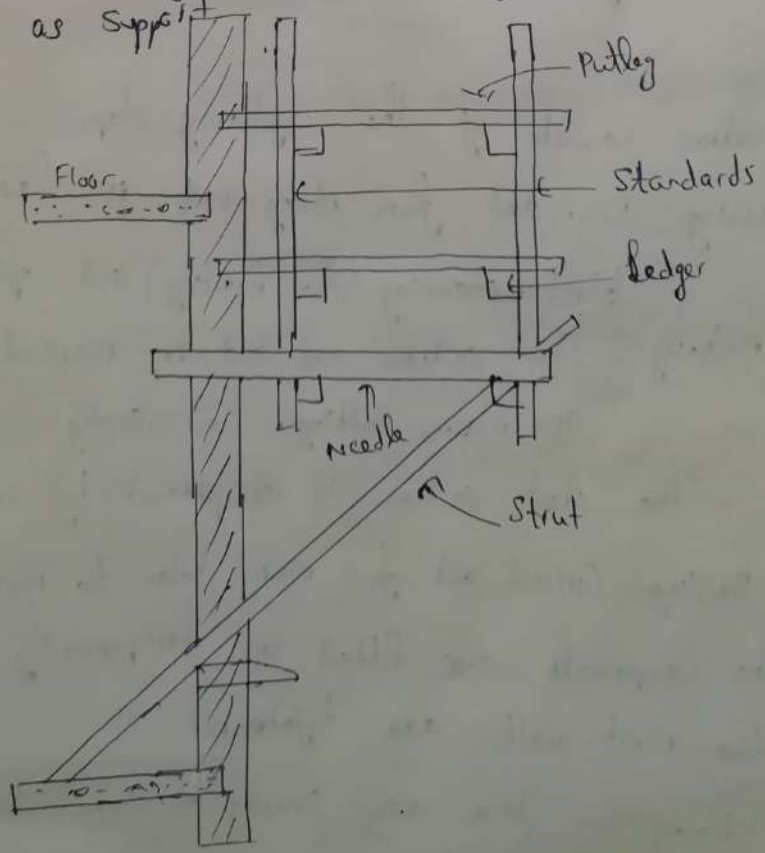


3) Cantilever or Needle Scaffolding

This type of scaffolding used

→ where it is not possible to fix standards into ground
→ when the scaffolding is to be provided at busy road thus eliminating unwanted scaffolding at lower level keeping free space for vechicles
→ when scaffolding is required in upper storeys of tall buildings

It is similar to single or double scaffolding except that the standard is supported by a cantilever projection called needle and strut are provided as support



4) Trestle or ladder scaffolding

-> Used for internal work and usually portable
-> It consists of working platform supported on ladders (two), tripods ch

5) Suspended scaffolding

-> Used for maintenance works like painting, pointing, white washing e
-> Working platform is suspended from roofs or trusses by means of ropes, wires or chains.

Deshuttering forms

The operation of removal of formwork is called as deshuttering forms or stripping. The formwork should be removed only when the concrete has attained sufficient strength. The formwork is removed within 2 to 3 days for vertical member (column) and 10 to 21 days for horizont member (beam, slab)

Fabrication and erection of steel trusses, frames and braced domes

The fabrication and erection are very important in case of steel truss, frames and braced domes.

Fabrication

Fabrication consists of the following steps

Surface cleaning - Raw steel from rolling mills is cleaned using wire brush blast cleaning (shot blasting) and flame cleaning

Cutting and machining - Steel sections are cut to required size by flame cutting arc plasma cutting, cold sawing

Straightening - The steel section is straightened by rolling or gas pressed

Punching and Drilling - Carried out for making holes to receive bolts for connecti

Fitting - The components are fitted up temporarily using rivet, bolts, u

Fastening - The rivet, bolts are tightened.

Finishing - Finishing is done using sawing to remove extra unwanted projecti

Surface Treatment - The steel members are painted.

Erection

Erection is the process of lifting the individual elements like truss, frames, braced domes and placing them in position to form the entire structure. Lifting should be done on nodes (joints) and not on members. Lifting should be done so that the members are balanced on both sides of lifting point. After placing in position, the members are checked for levels and then tightened.

Laying Brick

→ A layer of mortar is spread to cover the full width of the wall for suitable length on lower course
→ The end brick is laid on it with frog up.
→ On completion of laying a course, the vertical joints are filled with mortar from the top.
→ Remove the side bulging mortar so that the face of wall will be level
→ The process is repeated.

Weather and Water Proof roof finishes

Following are the systems used to obtain weather and water proof roofing,

→ ~~Mud phuska terracing~~ Covering with paving brick tiles
→ Laying bituminous products like bitumen paint on bitumen membrane
→ Lime concrete terracing with or without tiles above terracing
→ Application of elastomeric paints directly over concrete floor or tiles laid on concrete floor
→ Application of special chemical slurry compound
→ Thermal insulation combined with waterproofing

Roof Finishes (Roof)

Roof finish is the process of laying a material on roof to enclose the space or building and to protect it from weather like rain, wind, heat, snow etc.

Construction practices to be followed for Acoustics

Following are the factors to be followed in creating good acoustical conditions

1) Site selection and planning

→ Noise survey on the area to be made. Some important sources of objectionable noise are traffic on busy streets, highways, railways, airports, industrial areas.

→ The site should be selected so that the background noise level 40 to 45 dB is achieved within the hall

→ Depending on noise level of surrounding, the orientation and layout of building should be planned.

2) Volume (size and height)

→ The size should be fixed in relation to the number of audience to be seated

→ Volumes of different types of building are given below,

Public lecture halls - 2.8 to 3.7 m^3/person

Theatres - 3.7 to 6.2 m^3/person

Music Halls - 4.2 to 5.6 m^3/person

→ Ceiling height of a room used for speech and music should be kept between 1/3rd to 2/3rd the width of room. (generally 6m for small halls to 25 m for large halls)

3) Shape

→ Shape of a hall is more important as it is the governing factor for correcting defects like echoes, sound foci dead spots etc

→ Generally rectangular, fan shaped, horse shoe, circular, oval shapes are preferred
→ The side walls should be arranged properly to avoid echoes

4) Seats and Seating Arrangement

→ The seats should be arranged in concentric arcs of circles drawn with the centre of curtain line
→ The angle subtended with horizontal at front most observers should not exceed 30°
→ The distance of first row and stage is 3.6m from drama and 4.5m from cinema purposes.
→ The width of seat should be between 45cm and 56 cm
→ The back to back distance between seats should be 45cm
→ The rise in level must be 8cm to 12cm
→ The angle of elevation of inclined floor should not be less than 8 degrees.

5) Treatment of interior surface

→ The auditorium rear wall should be either flat or convex in shape and the side walls may remain reflective
→ False ceiling is coated with reflective material like plaster of paris
→ Concave shaped ceilings in the form of dome or barrel should be avoided

Construction Practices to be followed for Fire Protection

Fire protection of a structure lies in constructing a structure to be ~~Fire proof~~ 'Fire resistant' than being 'Fire Proof'. The fire resistant construction of elements are discussed below,

Walls and Columns

→ The load bearing walls or columns should be thicker in section so that they can resist fire and can act as vertical barriers to passage of heat and fire.

→ Bricks are preferred to stones and RCC frames are preferred to steel frames.
→ The Concrete columns should be covered with fire insulating material such as burnt clay blocks or terra cotta
→ The walls should be of light weight concrete and plastered with fire resistant mortar
→ The partition walls should be of RCC, reinforced brickwork, hollow concrete blocks, burnt clay tiles, reinforced glass, asbestos cement board.
→ Cover of atleast 50mm should be given for columns, main walls and 25mm for partition walls.

Floors and Roofs

→ Flooring should be of concrete, ceramic tiles and brick. Terrazzo, Marble and slate flooring is also satisfactory.
→ Concrete Jack Arch floors with steel joist embedded in concrete, hollow tiled ribbed floor, RCC floors should be used.
→ In case of roofs, flat roof should be preferred to sloping roof or pitched roof.
→ In flat roof ceilings, asbestos cement boards, fibre boards, metal lath should be fixed to avoid fire damage.

Wall openings

→ Openings should be minimum
→ Openings serve as means of fire escape if protected by fire resistant arrangements or else acts as a passage for fire if not protected.
→ Solid timber doors of thickness not less than 4cm should be used
→ Fire proof doors should be used. They are made with steel plate of 6mm thickness (superior quality) or 4cm thick timber panel sandwiched by iron sheets of 3mm on either side (inferior quality)

windows should be provided with fire proof shutters.

All escape doors should be so that they provide free circulation to persons in passages, lobbies, corridors, stairs etc.

Building Fire escape elements

Following are the fire escape elements,

Staircases - Should be located next to outer walls and should be accessible
- Should be of RCC and provided with automatic armoured fire doors
- Straight flight type is preferred having width not less than 75cm with 15 cm threads and 30cm risers and no of risers should be limited to 16.

Corridors, Lobbies - Should be of fire proofing material.
- Have quite large width for exit of persons.

Bearing pile - Load transferred to soil through ends (tips)

Friction pile - " " " through length of piles due to friction

Anchor pile - Piles used to resist uplift forces developed due to hydrostatic pressure or overturning moment.

Tension pile - To resist tension forces.

Fender piles Dolphins - Used in harbours to support platform

Sheet pile - Used to arrest flow of water under

for construction purposes

Batter pile - To resist lateral loads

Compaction pile - while driving a pile, soil around pile gets compacted

Techniques of Box Jacking - Pipe Jacking - Under water construction of diaphragm walls and basement - Tunneling techniques - Piling techniques - well and Caisson - Sinking Cofferdam - Cable anchoring and grouting - Driving diaphragm walls, sheet piles - Shoring for deep cutting - well point - dewatering and stand by Plant equipment for underground open excavation

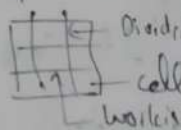
Box Jacking

Box jacking is a process in which a large precast reinforced concrete box is pushed horizontally through the ground usually beneath a road or railway track without any interruption. Box jacking techniques helps in construction of underbridge below existing highways and railway track, pedestrian subways below existing highways and railway tracks, culverts etc.

Installation

→ The box is designed and casted at site or prefabricated in laboratory and transported to the site and placed in position

→ The box is attached with a shield at front. The shield comprises of cutting edges, intermediate working decks and dividing walls. Decks and dividing walls give the shield a cellular configuration

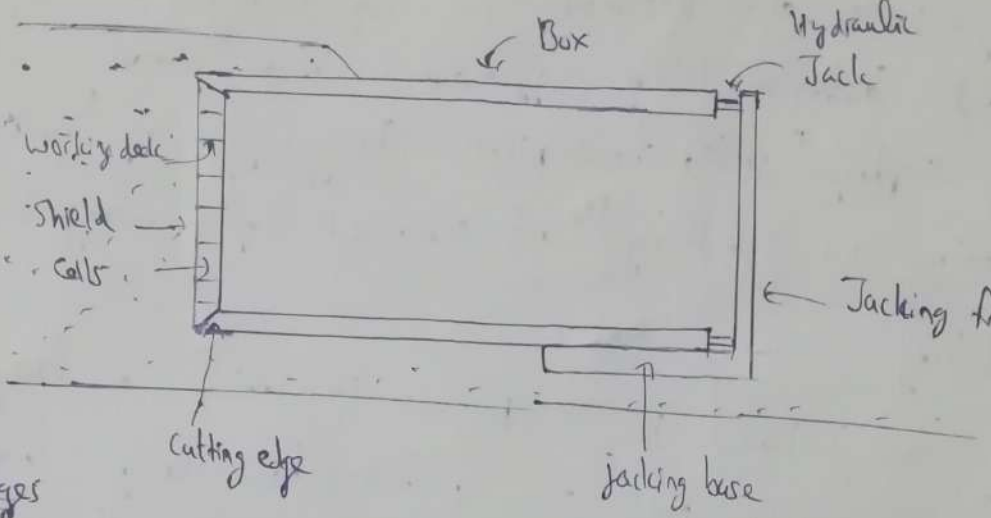


→ On the other side of the box called as jacking frame, hydraulic jacks are provided with necessary jacking base, cross beams, spacer pieces etc. The box is pushed into final position. During this process, the friction between the box and soil is reduced by lubricating with bentonite solution

→ As the box advances, the soil which enters the box through the cellular configuration is excavated

→ Upon completing installation, the box-soil interface is grouted with cement based grouts working from side walls and then roof

→ Finally the shield at front and the arrangements jacking at the back are dismantled. Wing walls, parapets and road way are constructed



Advantages

→ Better quality
→ Economical and speed in construction
→ Saving in man power
→ No traffic disturbance

Disadvantages

→ Needs skilled supervision
→ Caution is important
→ Box should be properly aligned

Pipe Jacking

Pipe jacking is a trenchless method of pipe installation used in construction of sewers, gas and water pipelines, oil pipelines, electricity and telecom cable ducts etc. It consists of driving high strength pipes ~~cylindrical~~ circular in shape, 40cm thick and weighing more than 50 tones beneath the ground.

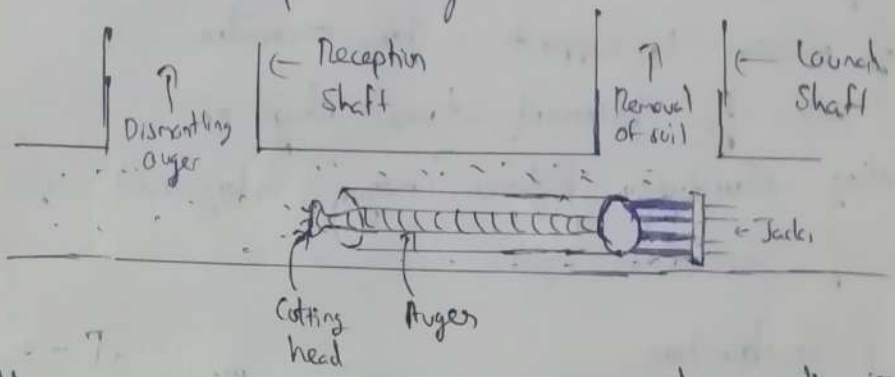
Installation

→ Two vertical shafts namely launch shaft and reception shaft is established vertically into the ground
→ The pipes are placed on the launch shaft with either augers installed inside pipes or with slurry shield at front to excavate soil. Hydraulic jacks are placed on back side of

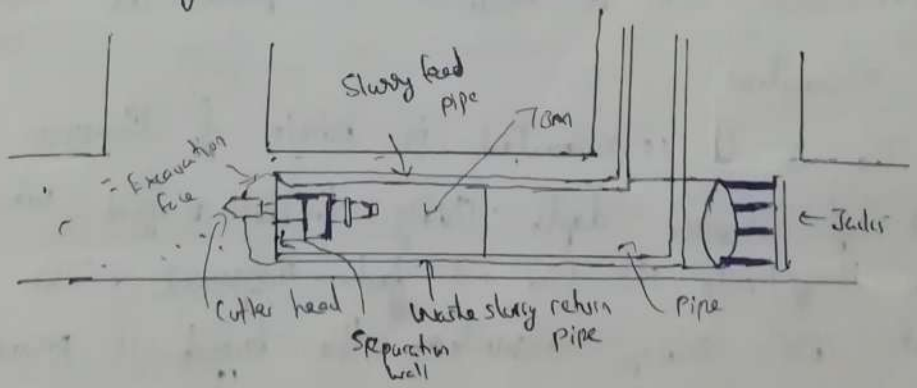
the pipes to push the pipes inside

→ The excavation of soil in front of the pipes is done by

Augers - The augers ~~with cutting head~~ placed inside the pipes with cutting head kept projecting which cuts the soil as the pipe advances. The soil is removed through the pipes, conveyed to ground through the launch shaft. The process proceeds till the pipes reaches the reception shaft where the augers are lifted up



Slurry shield (Tunnel Boring Machine) - In slurry shield jacking a separation wall is placed between the excavation face and the soil disposal setup. The cutter head cuts the soil while slurry or water is forced through the slurry pipes. The excavated soil gets mixed with slurry in the place between the separation wall and excavation face. The waste slurry is pumped out and recycled and separated in treatment plant. The slurry shield is lifted up in reception shaft



Advantages

Same as that of box jacking.

Disadvantages

Same as that of box jacking

Underwater construction of diaphragm walls and basement

Diaphragm walls are underground continuous wall constructed in situ panel by panel. The wall is usually constructed for a greater depth and to provide structural support and water tightness to the structures located underground. Diaphragm wall facilitate the construction activities such as

→ A retaining wall
→ A cutoff provision to support a deep excavation
→ A final wall for basement, tunnel, shaft etc.
→ A separating structure between major underground facilities
→ A form of foundation (pile)

Sequence of Construction

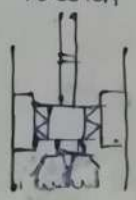
The construction of diaphragm walls is based on a method called slurry trench method discussed below

→ Construction of guide walls

Guide walls are lightly reinforced concrete beams ~~used to maintain~~ constructed horizontally along the side of the walls in order to serve as a guide for the clamshell or grab and to maintain horizontal alignment of sides Some preexcavation will be required to place the guide walls

→ Panel excavation

The trench is excavated in panels of dimensions 50 to 100 cm thick and of required depth using clamshell or grab which excavates soil and keeps it inside its jaw and teeth arrangement. The clamshell can rotate at 180°. During excavation the trench is prevented from collapse by bentonite slurry.

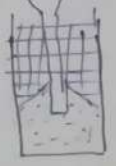


→ Reinforcement

Prior to placing reinforcement, the slurry on sides are cleaned and then the reinforcement is inserted in the form of cage for that particular panel. Guide walls helps in placing the cage in correct position

-> Concreting

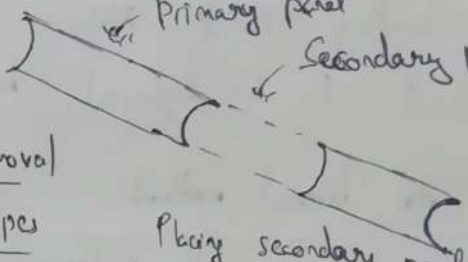
Concreting is done using tremie pipes in order to avoid segregation. Concreting is started from bottom and the tremie pipes are lifted progressively. As concrete is being poured the bentonite slurry which remains on the sides gets displaced due to its lower density and get collected at bottom and can be reused.



-> Joints

Diaphragm walls are usually constructed in alternate panels. Steel pipes called stop end piper are placed at both ends of the primary panels before concreting. The tubes are withdrawn at the same time of concreting so that the concrete takes the shape of stop end pipes

Primary panel with pipes



Primary panel after removal of pipes

Placing secondary panel

After this, the secondary panels are constructed without stop end pipes. This provides good interlocking joints

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Tuneling techniques

Tuneling is defined as ~~creating~~ constructing an artificial underground passage without disturbing the ground surface. Tunel serves as a passage for transport of passengers, water, sewers etc. The various shapes of tunels are circular, egg shaped, horse shoe, vertical walls with arch roof. Following are the techniques of tuneling

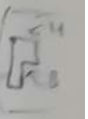
Full face heading

In this technique, the entire face of tunnel is attacked at the same time. ~~It is carried out by~~ drill and shoot by means of ~~pneumatic~~ rock drillers. The entire face is drilled to

make number of holes and then the holes are loaded with explosives and blasted. Another technique is using a rotating tunneling machine with cutter head fitted in front

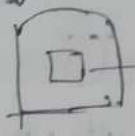
Heading and Benching method

In this technique, top portion called as heading is drilled first and blasted. The lower portion is removed in the shape of benches and such portion is called as benching



Drift method

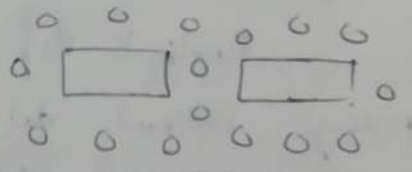
In weak rock it is not possible to drill the full face of a rock. In such situation small tunnels are driven for a portion of length or full length called as drift. Then the surrounding rocks are tested for strength and drilled if it is found to be sufficient to drill



Pilots tunnel method

A small rectangular tunnel located at centre of proposed tunnel is called pilot tunnel. This section is then enlarged by drilling holes along a radial ring pattern around the rectangular tunnel. Then these rings are filled with explosives and blasted

Piling techniques

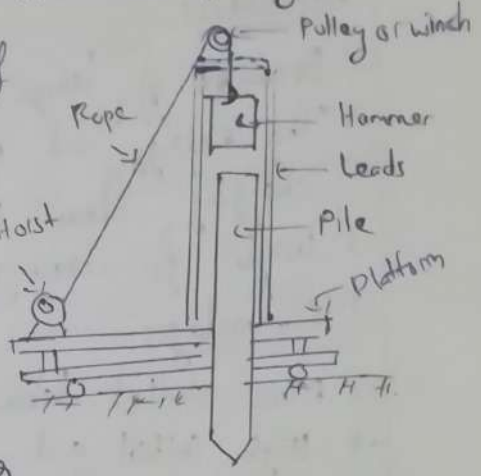


Pile driving or piling techniques is a technique in which the pile is driven into the ground without excavation or boring. Piles are generally driven by means of a hammer supported by a crane or a special device known as pile driver. Following are the hammers used,

1) Drop Hammer

→ A drop hammer is the one in which a hammer is raised and allowed to fall or dropped by gravity on top of the pile. The drop hammer is supported by steel members called leads

along which the hammer slides. The hammer is provided with hook to which rope is attached. The rope runs over pully and gets connected with hoist. The weight of hammer varies from 1/2 to 2 tonnes (5 to 20 KN) and height of fall vary from 1.5 to 3 metres. The number of blows vary from 4 to 8 per minute



Advantages
- Simple to operate and hence no skilled labours
- Energy can be varied by changing height of fall
- Cost is less

Disadvantages
- There is a chance of damage of pile
- Causes vibration to adjoining structure
- Unsuitable for driving piles under water

2) Single acting hammer
- In this the hammer is raised by steam, compressed air, but the hammer is allowed to fall by gravity
- The weight of single acting hammer is 20KN and height of fall is 1M and number of blows vary from 50 to 60 per minute

Advantages
- Speed is increased due to high number of blows per minute
- Height of fall is less and hence less breakage
- Can be used to drive piles under water

Disadvantages
- Skilled labour is essential
- More time is required to install and dismantle.
- Steam boiler or air compressor is required and hence high cost
- High maintenance cost.

3) Double acting hammer
- The double acting hammer consists of using steam or compressed air for lifting and drop
- Weight of such hammer is 30KN and number of blows is 100 to 200 per minute

→ The double acting hammer is completely encased in steel case

Advantages

→ Because of large number of blows, pile driving is quick.
→ The energy per blow and number of blows per minute can be adjusted by changing steam pressure
→ Useful for driving piles under water.

Disadvantages

→ More skilled labour is essential
→ High initial and maintenance cost.
→ Hammer is of light weight and hence unsuitable for driving heavy piles through hard strata

4) Diesel Hammer

→ Small and light in weight
→ Consists of a cylinder, a piston and fuel injection system
→ In diesel hammer explosion takes place at the bottom of piston after the fall and hence the energy is due to energy developed due to explosion and due to impact.

Advantages

→ The hammer can be easily transported
→ Used in remote areas as only diesel is the source of energy.
→ low maintenance cost.
→ Used in cold weather where steam generation is impossible

Disadvantages

→ It is basically single acting and hence high fall is essential
→ Energy per blow varies with driving resistance

Well and Caisson

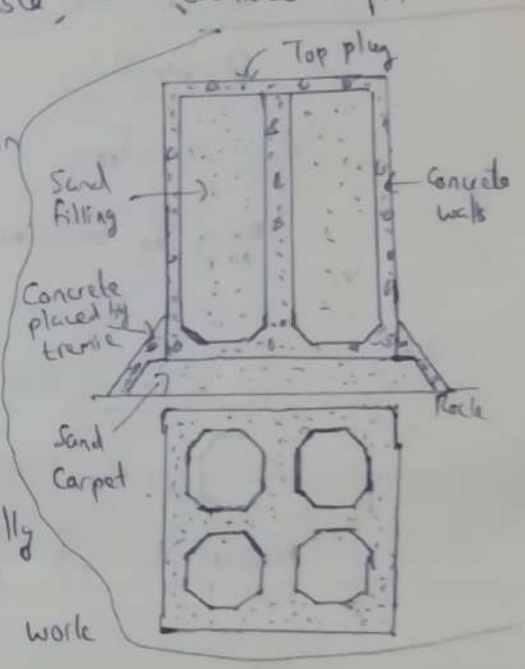
Caisson means a chest or box like structure, round or rectangular, which is constructed above ground and sunk into land or water to required depth for construction of foundations for structures in rivers, lakes, harbours etc. Following are the types of Caissons

→ Box Caisson
→ Open Caisson (or) Wells
→ Pneumatic Caisson

Box Caisson

→ A box caisson is open at top and closed at the bottom and made of timber or reinforced concrete
→ Box caisson is built on land then transported and sunk in position
→ Used in places where bearing strata is available at shallow depth or loads are not heavy
→ Following procedure is adopted on construction of box caisson

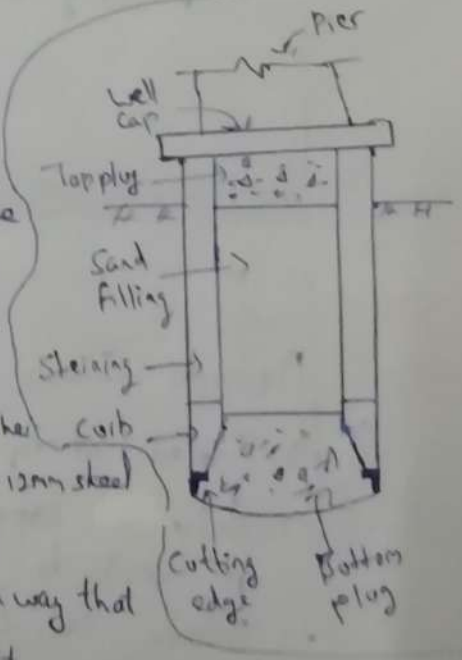
(i) A level surface is prepared to receive the bottom by dredging or by divers. Usually sand filling is done to prepare a level surface
(ii) The caisson is sunk to the required position
(iii) The box is filled with suitable material usually sand or gravel
(iv) The top of caisson is sealed and foundation work is started above the top of caisson.



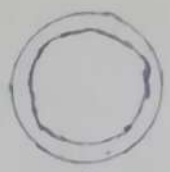
Open Caisson or wells

→ Open caisson is open at top and bottom and made of timber, metal, reinforced concrete or masonry.
→ Following are the components of well

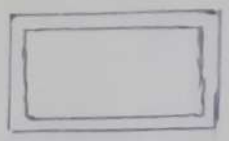
(i) Well curb – Designed for supporting weight of well with partial support at bottom of cutting edge. The well curb should withstand the sand blows as well as light blasting when required
(ii) Cutting edge – Should have sharp edge. It has a angle of 30° or slope inclined to vertical. The lower edge of cutting edge is wrapped with 12mm steel plates anchored to curb by steel stirrups
(iii) Steining – The thickness of steining should be in such a way that the well can sunk under its own weight
(iv) Bottom plug – It is bowl shaped so as to have inverted arch action. Designed for load equal to soil pressure minus self weight of plug and filling



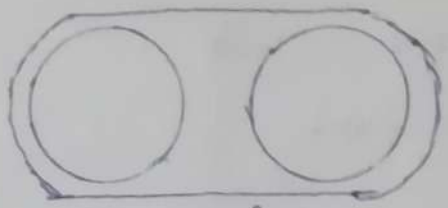
Shapes



Circular

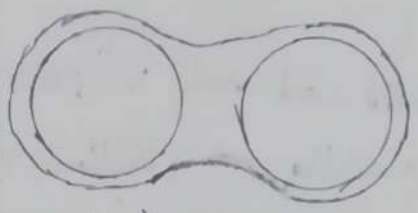


Rectangular

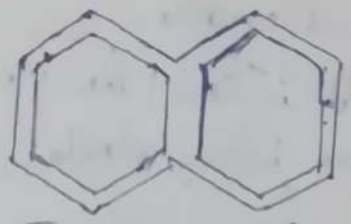


Twin Circular

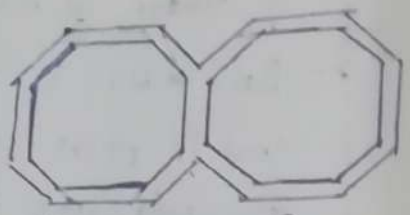
Double D



Dumbwell



Twin Hexagonal



Twin Octagonal

Sinking operations

→ Laying the well curb - If the river bed is dry, excavation is done half a metre above sub soil and well curb is laid. If river water is there, cofferdams are constructed around the site of well outer shuttering is of IS of wood or steel and inner is of brick masonry. Reinforcement is placed and concreting is done

→ Masonry in wall staining - Built in initial short height of 3m and a maximum of 5m at a time and cured for 48 hrs

→ Sinking operations - Done by excavating soil from inside of curb. Excavation is done by workers till the depth of water inside is 1m. After this stage animal, diesel or electric power is used

→ Completion of well - Once the desired depth is reached a concrete seal called bottom plug is provided by concreting with tremie as under water concreting has to be done. The interior space is filled with sand. The well is closed at top by construction top plug. Finally concrete slab called well cap is placed.

Pneumatic Caisson

→ Closed at top and open at bottom

→ Similar to open caisson in construction except that compressed is used to keep the working chamber free from water

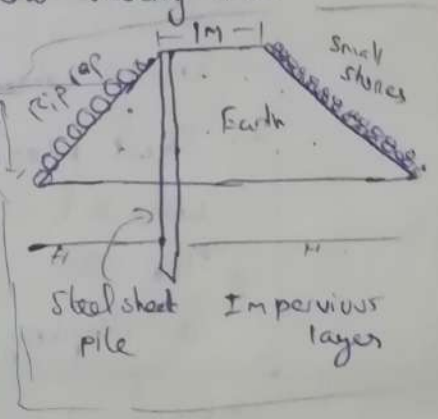
→ Pressure in chamber is kept higher than that of water generally 3.5 kg/cm^3

Cofferdam

Cofferdam is defined as a temporary structure which is usually constructed on river, lake etc to remove water from an area and making it possible to carry on construction works like dams, bridges (piers and abutments). Following are the types of cofferdam

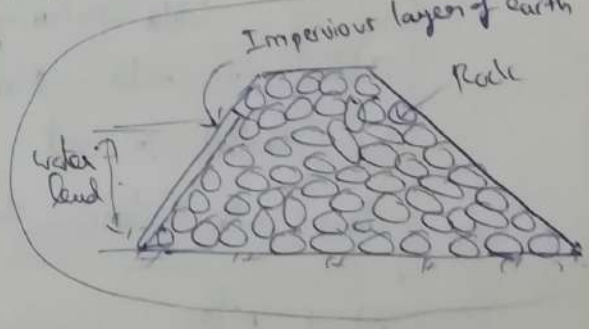
Earth Embankment

→ Simplest form constructed using earth or a mixture of earth & clay.
→ Limited for shallow depth of 1:2 to 1:5m and low velocity flow
→ The top width should not be less than 1m and side slope varies from 1:1 to 1:2
→ The sides are protected by rocks weighing 20N to 200N called as rip rap.
→ After construction the water inside is pumped and made dry



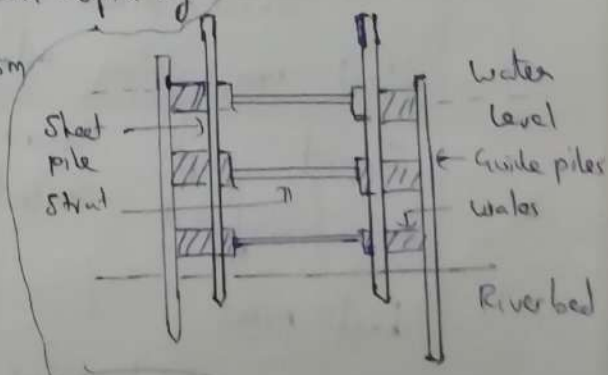
Rockfill Cofferdam

→ Similar to earth embankment but filled with rock and can be used for a depth of 3m
→ Main disadvantage is that it is pervious and hence an impervious layer of earth is introduced on outer face



Single wall cofferdam

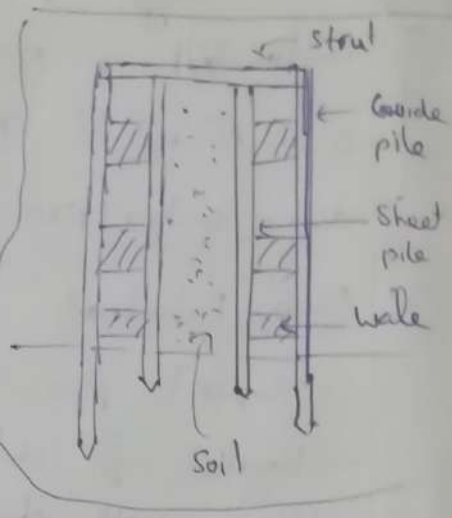
→ Used where workspace is limited and depth of water is more (4.5 to 6m) to a maximum of 25m
→ Guide piles are driven at a distance of 3m They are of timber.
→ Longitudinal runners called wales are bolted to guide piles
→ Sheet piles are bolted to wales
→ The sheet piles are braced by struts.



Double wall cofferdam

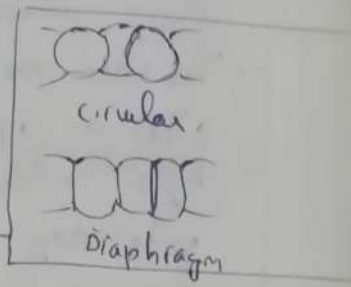
→ Used when the water pressure is high and large struts are required

→ Used for a depth of 15m
→ This consists of two lines of sheet piles with soil in between
→ Guide piles are inserted first to which sheet piles are inserted and bolted to it through wales.
→ The gap between sheet piles is filled with soil and covered with strut at top



Cellular coffer dam

→ Used where depth of water is 18 to 20m
→ Sheet piles are formed as a series of cells which are later filled with soil
→ The cells are interconnected to form circular or diaphragm type structures



Cable anchoring and grouting

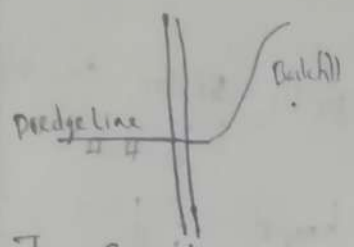
Cable anchoring consist of anchoring high tension resisting cables in rock. For anchoring process the rock or soil needs to be drilled or cut to some extent After that grouting is done to close the cavities in rock or soil.

Sheet piles

Sheet piles are sections of sheet with interlocking edges that are driven into ground to provide earth retention and support for excavation Sheet piles can be of steel, timber or reinforced concrete where steel sheet piles are common

Sheet piles

Sheet piles are temporary structures of sheet type with interlocking arrangements constructed to retain soil in order to build a structure on other side of wall, erosion protection and stabilizing ground slopes



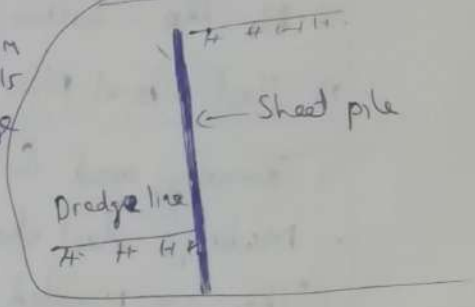
Dredge line - The line at which pile starts penetrating (or) the surface of soil

Backfill - Soil surface or water level on other side

Types (Function)

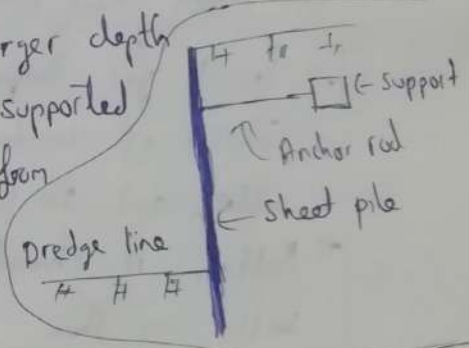
1) Cantilever sheet piles

→ Usually used for walls of height equal to less than 6m from dredge line
→ Useful in highway excavations, retaining walls, diaphragm walls
→ Sheet pile act as wide cantilever beam above dredge line
→ The stability of cantilever wall is obtained from the lateral resistance offered by the soil



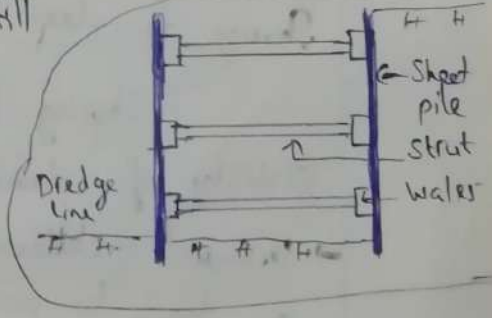
2) Anchored sheet pile

→ When the height exceeds 6m, the deflation of sheet pile will be great and hence the pile should be penetrated to a larger depth
→ To reduce this deflection, the sheet pile should be supported at top using some anchors at a distance of 1-2m from top
→ Anchor installation requires small excavation ~~for installation~~



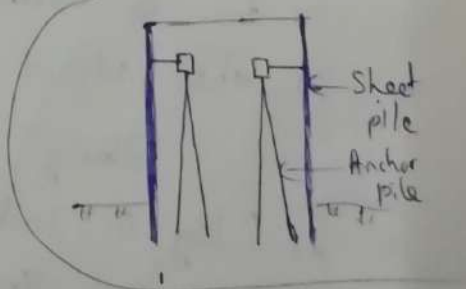
3) Braced sheet pile

→ Braced sheet piles provide a better control on backfill subsidence
→ The piles are held in position by means of struts
→ The struts are bolted with pile through bolts
→ Suitable for clay and sandy soil.



4) Anchored Bulkhead

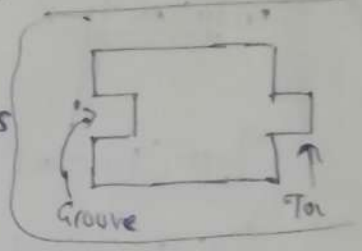
→ Used in docks and harbours
→ Anchored bulkhead provides a vertical wall so that ships may be tied up
→ It also serves as pier of bridge in water
→ Anchor piles are provided as additional support to the sheet piles



Types (materials)

1) Concrete sheet pile

→ Precast, square or rectangular in cross section with sides 500 to 600mm and thickness 200mm to 600mm

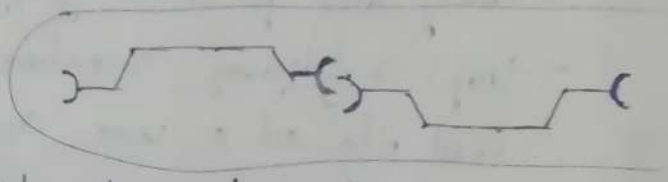


→ Reinforcement is in the form of vertical bars and hoops

→ Concrete sheet piles are provided with tongued grooves for making joints at site

→ At the bottom of pile, steel shoe is provided which helps in penetration

2) Steel sheet pile



→ Commonly used for permanent works

→ Made of steel sheets 200mm to 300mm wide and 4m to 5m long

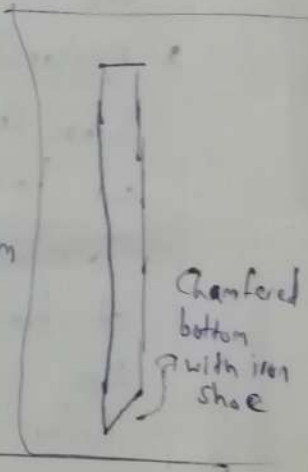
→ They are provided with suitable interlocking arrangements to provide water tight joints

3) Timber sheet pile

→ Used for temporary works like cofferdams

→ Consist of wooden board 80mm to 150mm thick, 200 mm to 300mm wide and 2m to 4m long

→ Bottom is chamfered to form a cutting edge and provided with iron shoe



Shoring for deep cutting

Shoring is means of providing temporary support to attain stability of structure under following circumstances.

→ Unequal settlement of foundation due to removal of adjacent buildings or due to poor workmanship

→ due to alterations in building like remodelling of walls

→ when adjacent structure is dismantled

Following are the types of shores

→ Raking or Inclined shores

→ Flying or Horizontal shores

→ Dead or Vertical shores

(1) Raking or Inclined Shores

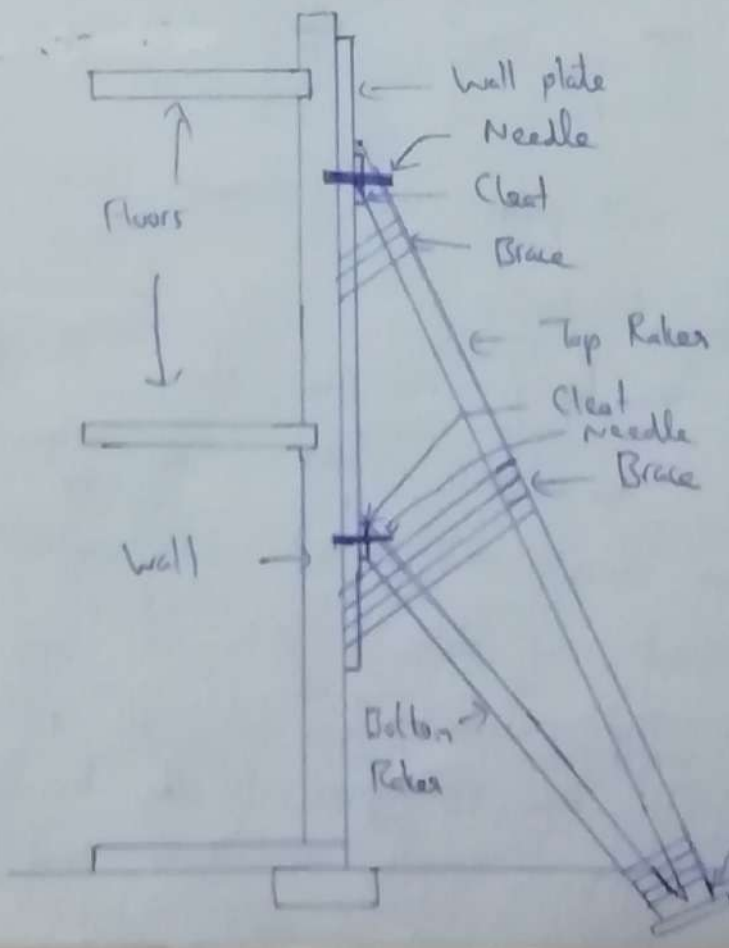
Raking shores is a system of giving temporary support to an unsafe wall through inclined members called rakers. Raking shore must be placed at a spacing of 3 to 4.5m c/c horizontally. The components of raking shores are,

→ Rakers - These are are inclined members, which gives lateral support to wall
- Rakers are inclined at 45° with ground, however the angle may be between 45° and 75°.
- The size of rakers depends on the thrust (push) from wall

→ Sole piece - At the base, the rakers are supported by sole piece embedded into ground in an inclined position

- The rakers are secured to the sole piece by cleats and dogs (⊔-iron)
- In soft ground the area of sole piece is increased to distribute the pressure over large area

→ Wall plate - Wall plate is held against the wall to which the rakers are fixed
- Where possible, the wall plates should be continuous throughout its length.
- The wall plates are secured to the wall using needle and cleats
- The needles are of size 10cm × 7.6cm and penetrates inside wall for a distance of about 10cm
- The needles are strengthened by providing wooden cleats
- Wall plates are of size 23×5cm to 23×7.6cm



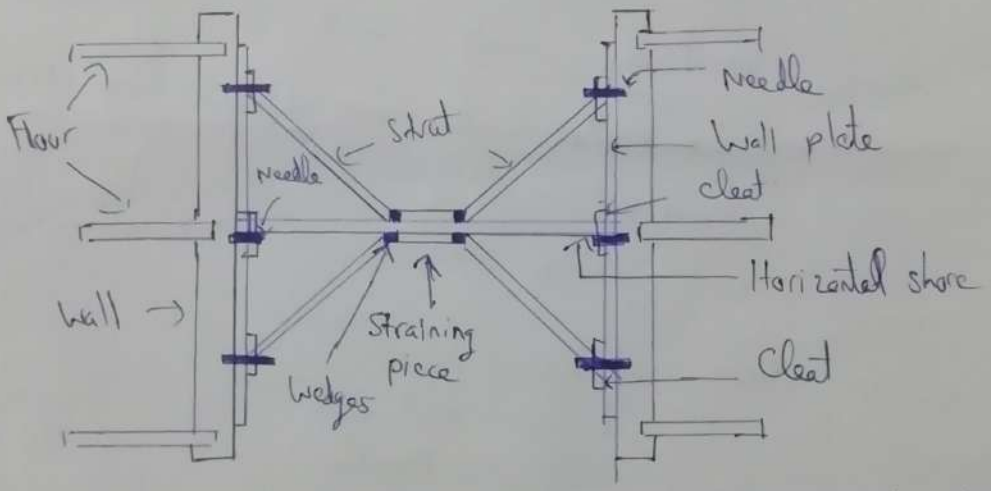
→ Braces (or) Stout - Brace prevents movement of wall plate from wall and also supports the rakers

- Bracing should be provided at regular intervals.

(ii) Flying or horizontal shores

Flying shore is used to support a damaged wall when a adjacent wall can be used as support for the wall to be removed or to support parallel walls of two adjacent buildings which may tend to collapse or damage when one of the adjacent buildings has to be pulled down. A single flying shore consists of

Flying shores provided at spacing of 2.5 to 3.5m



→ Wall plates - Wall plates are secured against wall by cleats and needles (250 mm × 250 mm)

→ Horizontal shore → A horizontal shore is placed in between the wall plates by wedges, needles and cleats

→ Stout - Struts are inclined and supported by needles at wall plates using. one end and straining piece using wedges at other end

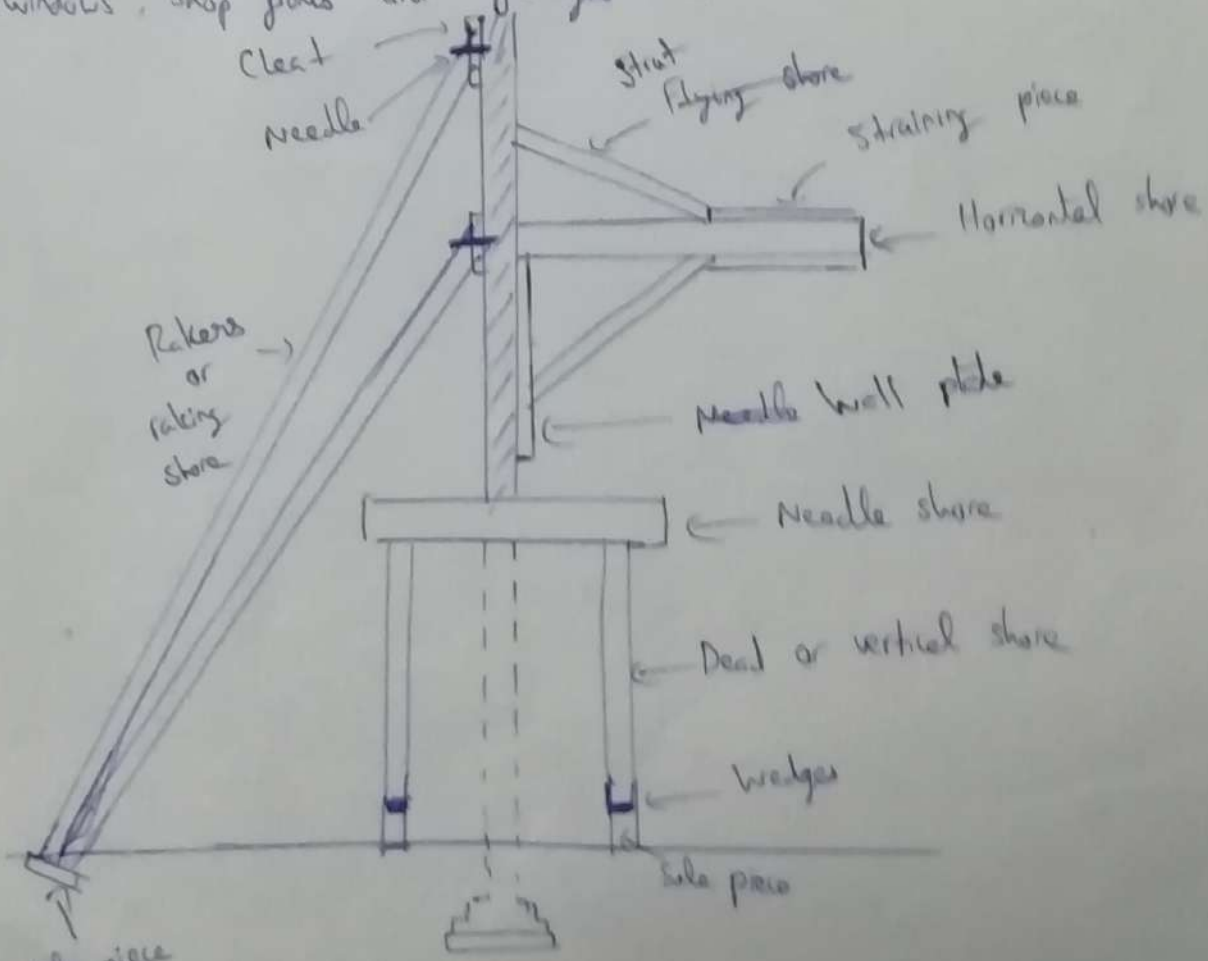
- The struts should be set at an angle not greater than 45 degrees to the horizontal beam
- The struts at opposite ends should be kept apart

→ Straining piece - The straining piece is spiked into horizontal shore using wedges. (150×75mm)
- The length of straining pieces is determined from the length of horizontal shore
- The width of straining piece is same as strut
- Wedges are provided for tightening of straining pieces with strut

(iii) Dead Shores (or) Vertical shores

Dead shores are used to support to walls when provide

→ to rebuild a lower part of a defective load bearing wall in a structure
→ to rebuild or deepen existing foundations which are unsafe
→ to provide large openings in existing walls such as doors, windows, shop fronts and garages at lower level.



Following are the components of dead shores

-> Needle shore - They are made of wood and transfer load to the vertical shores below

-> Vertical shores - The vertical shores inturn transfer loads to foundation below

- They are placed on either side of wall allowing work space when ~~needle~~ shore used

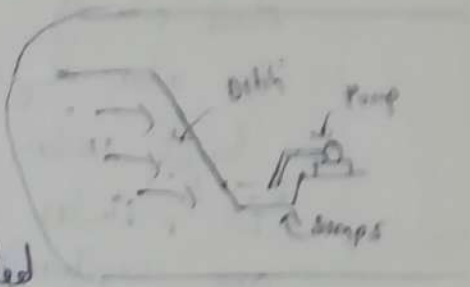
-> Raking shore - These are inclined supports provided for stability during rebuilding work

-> Flying shore - These are horizontal supports

Dewatering

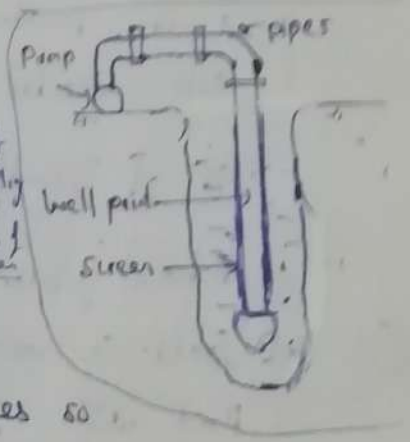
In places having high water table, excavation can be carried out only after dewatering and lowering water table

Ditches and Sumps

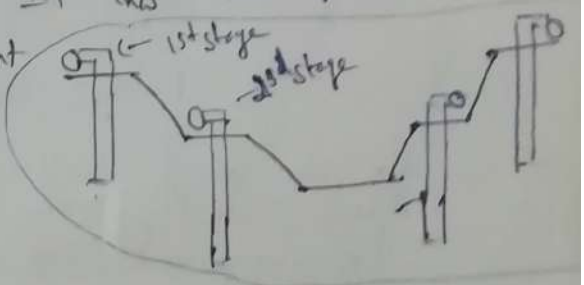


- Used in coarse grained soils and shallow excavations
- Shallow pits called sumps are established along periphery of the ditch
- Water flows from sides under gravity gets collected in sump which can be pumped out

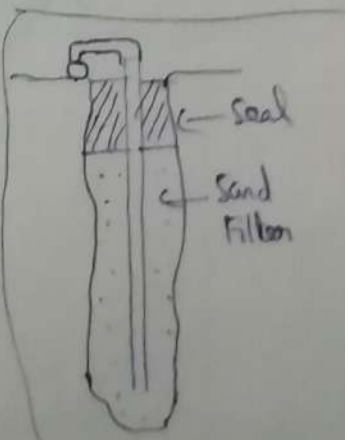
Well Point System



- Commonly used in all ground conditions
- Consist of well point, a perforated pipe 0.5 to 1m long with its end closed or of self jetting type. Predrilling is required in closed type while in self jetting type soil gets loosen due to sprinkling of water
- The well point is covered with screens made of brass or stainless steel mesh, brass or plastic wires to prevent entry of sand into well point
- Jetting type has the advantage of washing away fines so that the coarse particles act as filter media
- The well point is connected to pumps through pipes to pump the water collected in well point
- For dewatering in excavations more than 6m below water table, multistage dewatering well point is used. In this the ground is excavated first and first stage well point is fixed and then excavation is done and second stage is installed

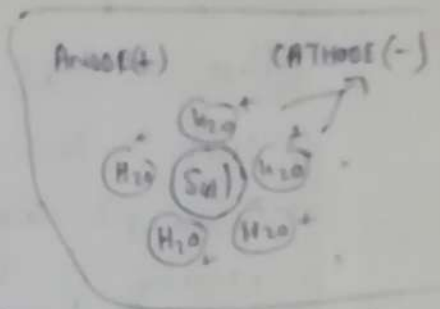


Vacuum Dewatering System



- Used in fine grained soils
- Well point is installed and sealed at top by impervious material
- Vacuum is applied to the pump so that water gets sucked from the surroundings of well point and then the water is pumped out
- The top is sealed to avoid escape of water from excavation to top rather than entering well point

Electro-osmosis
→ Suitable in fine grained cohesive soils
→ Two electrodes are inserted into the soil. The cathode is in the form of well point and the anode is in the form of steel rod, sheet pile etc
→ The outer layer of soil consists of positively charged water particles which are movable and soil particles are ~~negatively charged~~ immovable which are negatively charged



→ When electric potential is applied, the water particles moves towards cathode (well points) and water gets collected which is pumped out

Uses of standby plant equipment for underground open excavation

→ Achieve greater depth
→ Speed in work
→ Avoid risk of collapse of soil or danger of workers
→ Use of less number of workers
→ High efficiency

Launching girders, Bridge decks, offshore platforms - special form of shells - techniques for heavy decks - in situ prestressing in high rise structures, Material handling - erecting light weight components on tall structures - Support structure for heavy equipment and conveyors - Erection of articulated structure, braced domes and space decks

Launching Girders

Launching girders is used in construction of bridges. It is used for placing precast post tensioned concrete bridge segments to form bridges.

A launching girder consists of a lifting frame which consists of two main cantilever beams or trusses fixed to the main structure with a lifting device on top. The lifting device can move horizontally or vertically to lift the bridge segments for assembling. Following is the procedure

→ The lifting frame (girder) is pulled and placed on first two spans (abutment and adjacent pier) with the help of rollers placed on its bottom.

→ After placing girder on position, the seating is checked and rollers are moved to next span

→ The lifting device lifts the bridge segment and places it in position

→ Post tensioning of bridge segments and placing epoxy resin between segments

→ Girder is shifted to next span and process continues

General requirements

→ Before placing the launching girders, the piers and abutments are to be constructed completely including bed blocks

→ Wing walls of the abutment should not be concreted before constructing bridge in order to facilitate the movement of launching girder

→ The tracks for movement of launching girder should be properly welded

→ As this involves lifting devices with mechanical and electrical components it is necessary to have detailed procedures and experienced operators

→ Safety of workers and public should be ensured against hazard

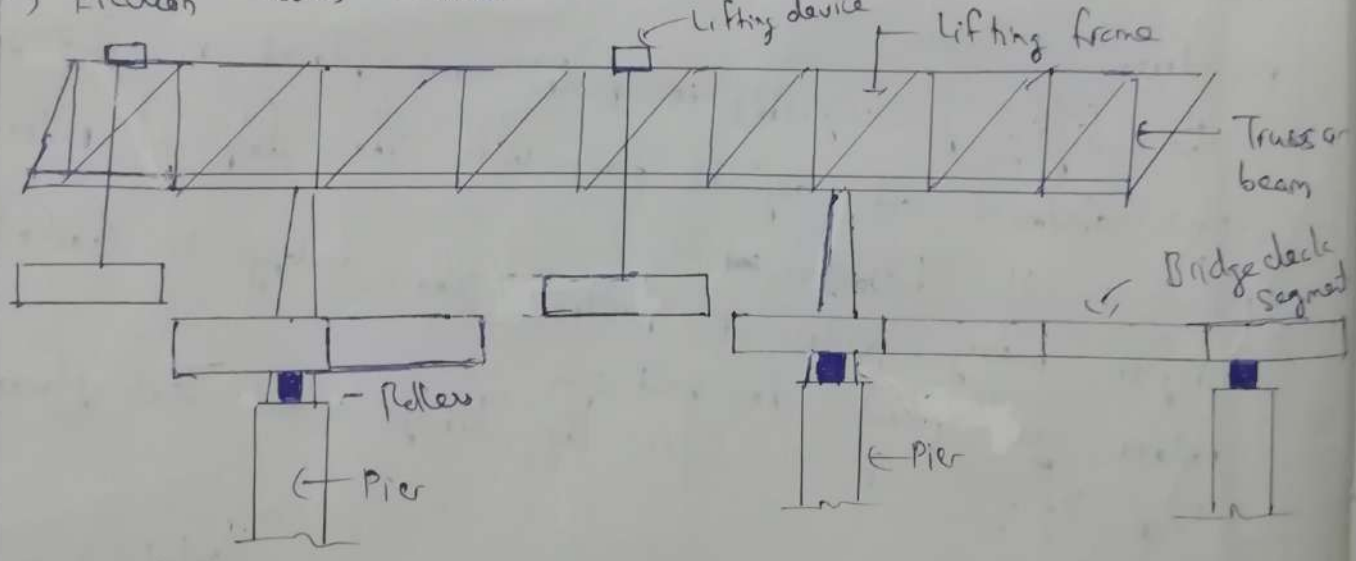
→ Supervising engineers should be appointed for supervising operation

→ Unauthorized movement of persons, equipments on site should be avoided

→ The operations should be carried out during daytime

→ Fail safe brakes should be provided to avoid problems during electrical failures

→ Erection loads should be taken into account in design



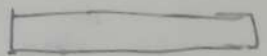
Bridge decks

A bridge deck is the portion of a bridge that acts as the roadway supporting vehicular and pedestrian traffic. It acts as the superstructure of bridge

Types

1) Solid Slab decks

-> Can be used for bridges with span upto 10m and culverts

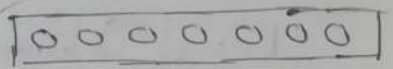


-> Solid slab decks comprises a solid section without voids or beams (the slab directly rests on pier/abutments)

-> The construction of solid slab decks is made on site and it is simple to use formworks or can also be of precast type

Voided Slab deck

-> These slabs have voids within the slabs. The voids are introduced in order to reduce self weight



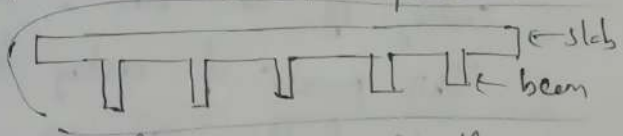
-> The voids are constructed in cylindrical shape using hollow thin walled steel sections within the slab or by introducing spherical balls shape made of polypropylene. The slab with introduction of polypropylene balls is also called as bubble deck slab

-> Care should be taken that the width of the voids should not be greater than 60% of the depth of the deck

Tbeam deck (or) Beam & slab deck (or) Beam deck

-> Consist of a slab supported by longitudinal beams at bottom

-> These decks can be either cast insitu or slab can be precast and beams are cast insitu

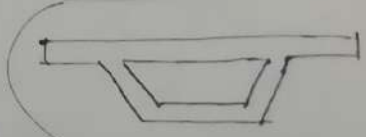


-> Can be used for spans upto 25m

-> Cast insitu beams and slabs decks are generally avoided as the arrangement of formworks is complicated

Box Girder decks

-> Box girder decks is one in which the main beams are in the shape of a hollow box.



-> Box girder decks are usually precast and prestressed because of the reason that for cast insitu decks, the lower slab and webs should be cast at first followed by casting of top slab after some days

-> The common practice is that these decks are provided with a single box while it can be subdivided into two or more if required.

Steel Concrete Composite deck

(38) (39)

→ These decks are more efficient in bearing load, maintenance etc

→ The beams are of steel beams of I cross section and the slab is cast insitu or can be precast

→ Connections between the concrete slab and steel I beam can be achieved by casting the slab with the top flange of I beam embedded into the slab or by using suitable connectors.

Construction techniques of bridge decks

Balanced Cantilever method

→ Most popular method of bridge construction and used for spans from 50 to 250m in length

→ Cost effective method but takes more time for construction

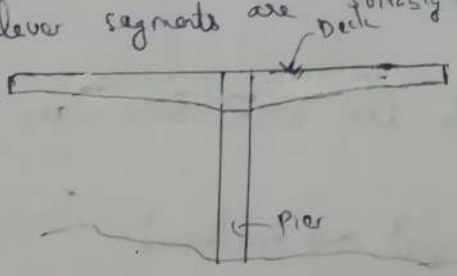
→ In this method ~~the formwork is positioned for construction of pier~~ with a travelling formwork placed at its top of pier for deck construction

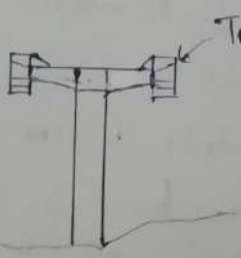
→ Upon ~~the completion of pier~~, it is used as a platform and launching base

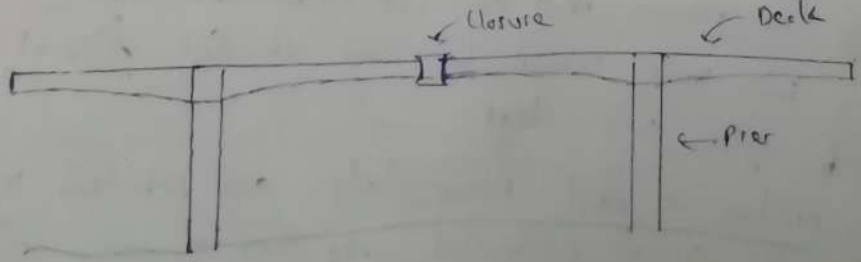
→ With pier as the support, travelling formworks are pushed on its either side with help of hydraulic and casting of deck slab is done

→ This process of casting the deck slab is continued till it reaches half of the span on either side

→ Then the process is carried out in all other piers and finally the cantilever segments are suitably joined







Incremental launching method

-> This method is used for construction of bridges of span more than 25m in length

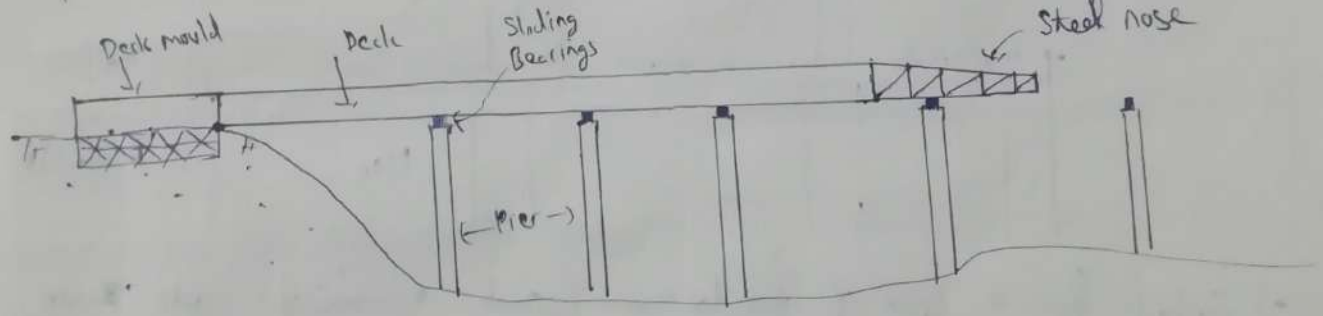
-> This method consists of casting long sections of deck is the 30m in a stationary formwork or deck mould behind the abutment

~~-> once the deck is hardened it is pushed with a end resting on the abutment~~

-> Once the deck is hardened, it is pushed by placing it on sliding bearings on the abutment and pushing it with the help of hydraulic jacks

-> Upon ~~erection~~ placing of first segment, the second segment is cast, pushed behind the first segment and the process is continued.

-> A steel nose is provided at the front of the first segment of bridge deck to keep the bending moment low during construction and to provide necessary cantilever length to avoid slipping of segment.



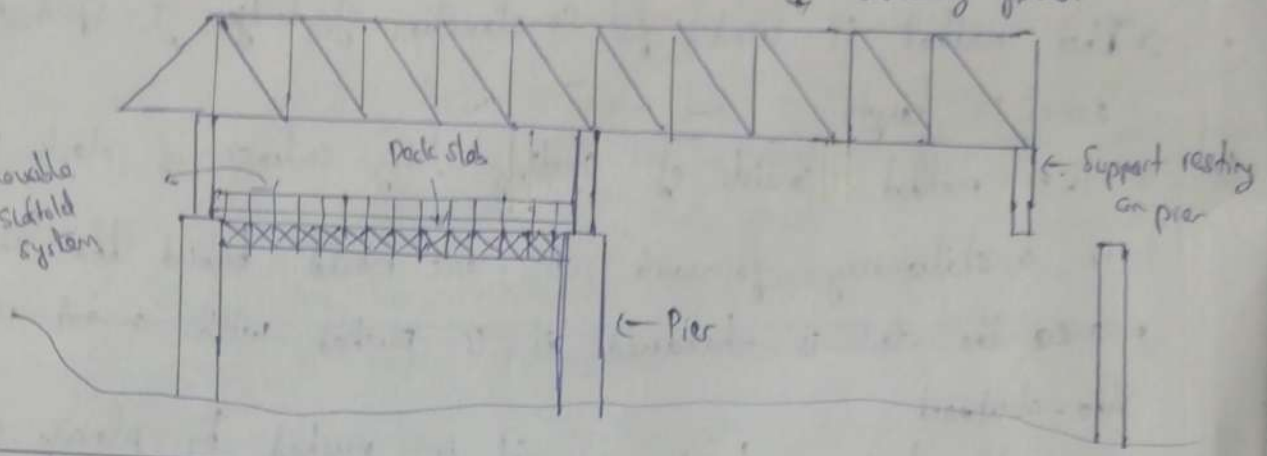
Advanced shoring (or) Movable Scaffold System

-> This method is used where bridges are to be constructed over difficult terrain or water because of providing necessary casting moulds or assembling formwork is not feasible

-> This system consists of a launching girder surrounded with a movable scaffolding system which serves as a platform for casting deck slab.

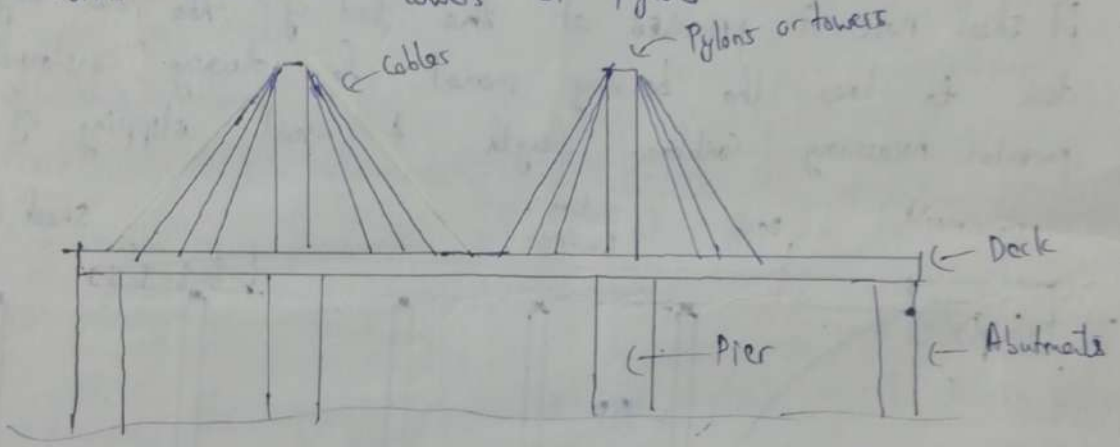
-> The girder gets seated on two adjacent pier such that the movable scaffold system rest between piers. Now the slab is cast in position. After hardening, the scaffold system is shifted to next pier with help of launching girder

-> Decks with a span of 50m can be cast and placed in position accurately



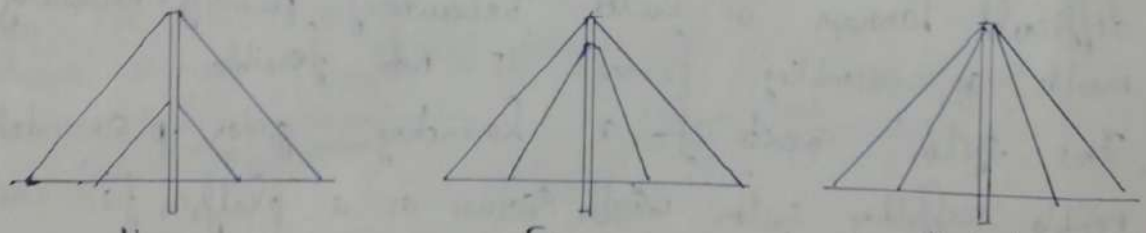
Cable stayed bridges

→ Cable stayed bridges is a bridge in which the bridge deck is suspended by means of cables where the cables are suspended from columns called as towers or pylons



→ Suited for a span of 200 to 400m and economical upto 300m

→ There are three major arrangement of cables namely harp, fan and radial

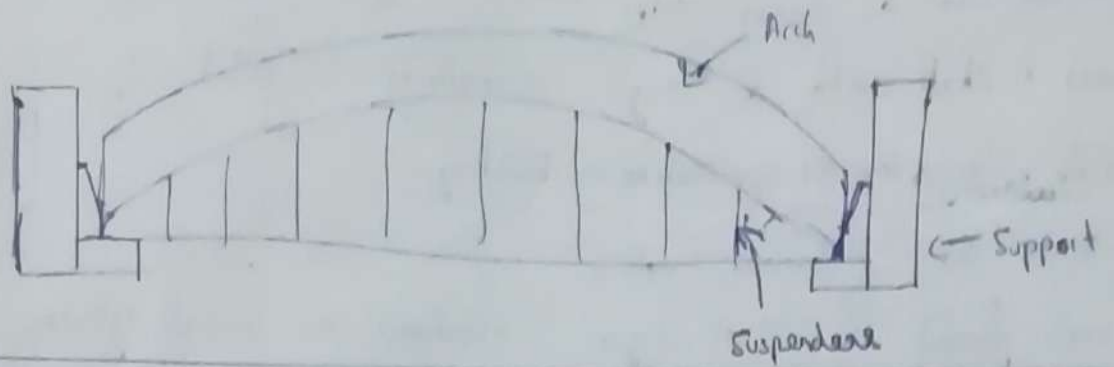


Harp Fan Radial

Bow string Bridge

→ Bow string Bridges consists of two arches which are tied horizontally at its ends. The tie is capable of withstanding horizontal thrust exerted on abutments due to forces on arch

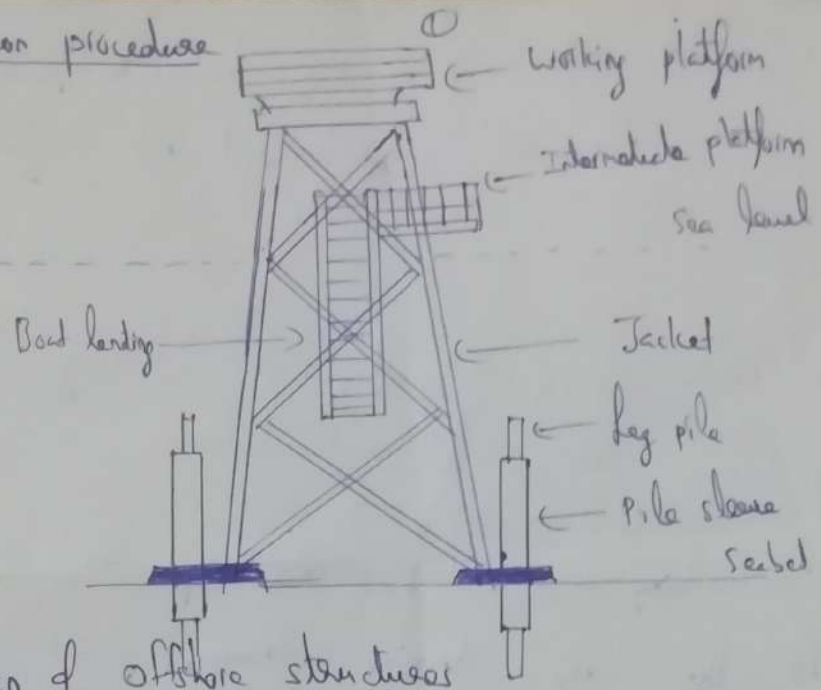
- The deck is suspended from the arch using suspenders (16)



Offshore Platforms

Offshore platforms is a large structure constructed in the ocean to drill wells to extract oil and natural gas and process them or to temporarily store the products until it can be brought to shore for processing. The main use of offshore platform are oil and gas exploration. It also serves as a platform for navigation aid tower, platform for ship loading and unloading. The platform should be located at a higher depth. It can be fixed to the ocean floor, or on a artificial island or any floats.

Installation procedure



1) Design of offshore structures

Since the transportation and installation of offshore platform is a critical activity, design should be made considering the size and power requirments for transpotation and installation should be given due consideration. The structure should be constructed in accordance to design drawings and specifications

2) Fabrication

A high degree of fabrication is required. Fabrication of offshore platform is carried out at locations significantly away from the installation site. The fabrication yard must be well equipped and large in size. The steel plates and structured steel sections should confirm the codal provisions. The components jacket (tower like tubular braced structures) platform and appurtenances are fabricated

3) Load Loadout

Loadout is the movement of the completed structure (platform, jacket and appurtenances into the barge which will transport it Jackets which are fabricated on shore side are usually loaded by skidding the structure into barge by placing the two inner legs on skidways. The friction between the jacket and skidways should by 15 per cent. In some cases the jacket is initially

fabricated above the slideways using hydraulic jacks. Then at time of loadout, the jacket is lowered into slideways

4) Seafastening

Seafastening comprises fitting and welding sufficient ties between the jacket and barge

Seafastening is done to keep the jacket rigidly connected to the barge during transport. It comprises fitting bolts or welding sufficient ties between jacket and barge.

5) Transportation

To perform a transportation analysis, an environmental report showing the worst sea conditions during that time of the year should be available to choose the routes for design.

6) Installation.

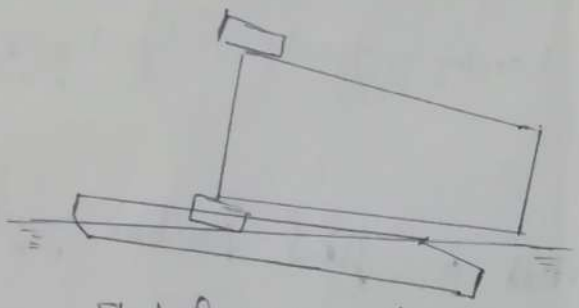
Installation comprises the series of activities required to place the structures in final location. These activities include jacket (launch/lift) upending, positioning, pile installation, jacket levelling and grouting.

(i) (launch / lift)

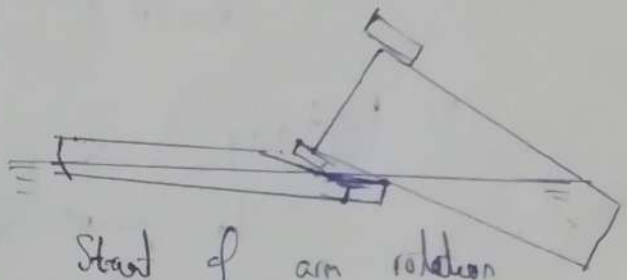
Firstly the jacket must be removed from the barge. There are two basic methods, launch or lift.

Launch – Before launching, the seafastening connecting jacket and barge should be cut off. The jacket is then pulled along

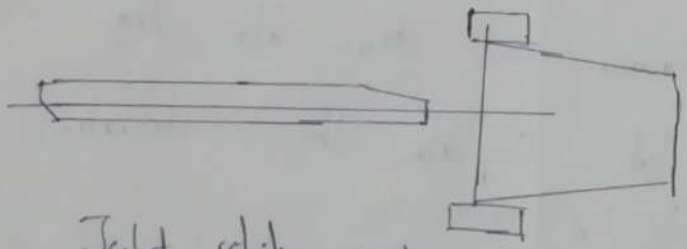
pulled down the barge sideways (used for load out) by winches. As the jacket moves towards the end of the barge, the barge start to tilt and at a time, the jacket self slides. The self floating jacket is under control using lines using tug (boat used for pulling other boats).



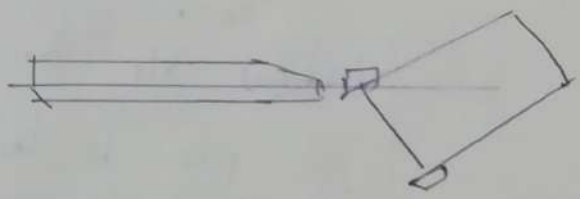
Start of jacket self sliding



Start of arm rotation



Jacket rotating counter clockwise



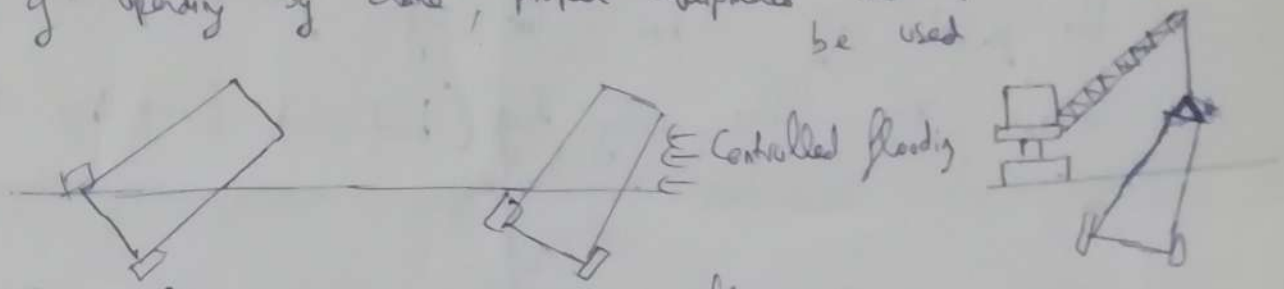
Jacket final floating position

Lift - In dead lift, the jacket is lifted from the barge. In buoyancy lift the barge is flooded and submerged making the jacket to float. lifting is done using derrick barges.

(11) Upending

When jacket is removed from the barge by lifting, upending the jacket may be lifted in vertical position, no upending is required. In case of launched jackets upending is required

Upending may be achieved by controlled flooding of buoyancy tanks, by using a crane vessel or both. In case of flooding, care should be taken to avoid accidental flooding and in case of upending by crane, proper equipments and procedures should be used



Jacked floating position. Upending by flooding Upending by crane

(iii) Positioning

The jacket is placed in final position by flooding till it reaches the sea bed

(iv) Pile installation and grouting

After setting down the jacket, the piles are installed into the sleeves and driven into the sea bed. Fixing the piles to the jacket completes the installation of jacket

(v) Installation of platform & appurtenances -

The piles are open ended, 2m in diameter, driven upto 40 to 80m into the sea bed.

Types —
- Fixed platform
- Compliant Tower
- Sea star
- Floating production system
- Tension leg system
- Sub sea system
- SPAR platform

Shells

Shells are spatial roofs used for long span structures without interior columns. Shells can be defined as very thin slabs curved in shape with their thickness small when compared to their radius of curvature. The strength of shells is due to the membrane forces (tension or compression) called as shell action when compared to the bending action of slabs

Classification according to geometry

1) Rotational shell

Rotational shells are formed by a curve rotating about a central axis. Ex - Circular dome

2) Translational shell

Translational shells are formed by a line or curve moving over another curve. Ex - Cylindrical shells (Barrel vault), Hyperbolic Paraboloids

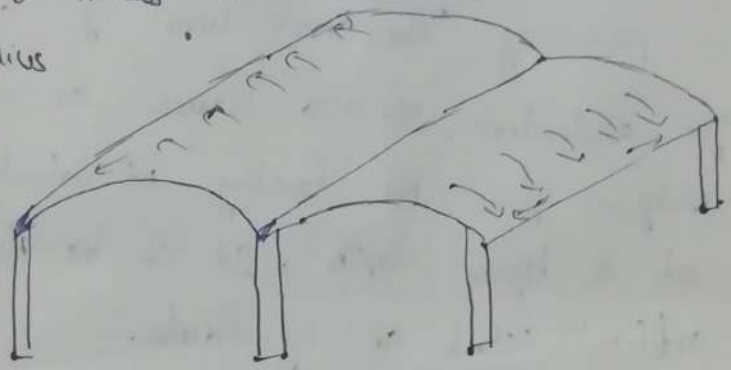
Classification according to application in building

1) Cylindrical shell or barrel vault

→ A shell formed with a single curvature or a cut cylinder is called as cylindrical shell or barrel vault

→ It is a translational shell produced by a line moving over parts of two circles at the ends

→ Classified as long shells or short shells. A long shell has its length large compared to radius while short shell has its axis length small compared to radius

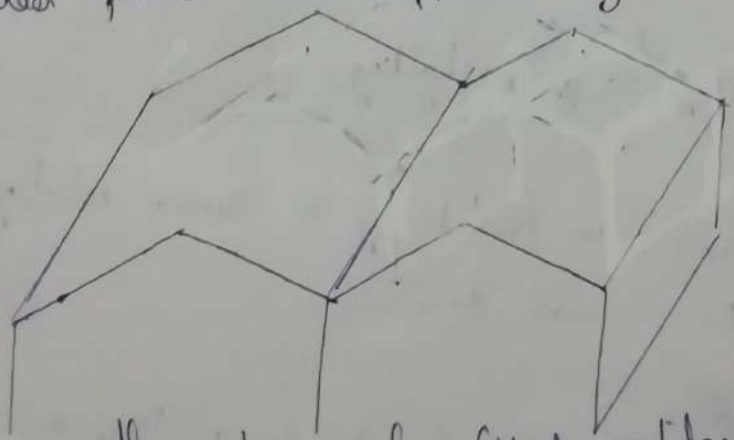


→ Load gets transferred to the supports (as like in arches) through the lower elements

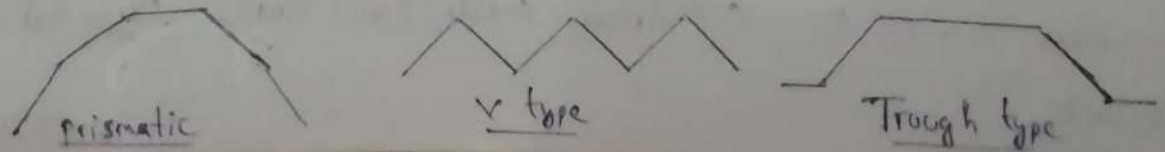
2) Folded plates

→ Similar to that of barrel vault except that the elements have plane surface than a curved surface

→ The folded plates are supported by walls along its entire length



→ Following are the types of folded plates



3) Conoids

translational

→ Conoid is a single curvature shell that can be used as an alternative to barrel vault.

→ The basic shape of conoid is that one edge of the shell is curved while the other edge is kept straight. The straight edge is usually constructed with reinforced concrete or steel beam which serves as a stiffener to prevent shell deformation.

→ It is a translational shell formed by a line moving over a curve at one end and ~~vertical~~ horizontal line at other end.

4) Hyperbolic Paraboloids (or) Saddle shells

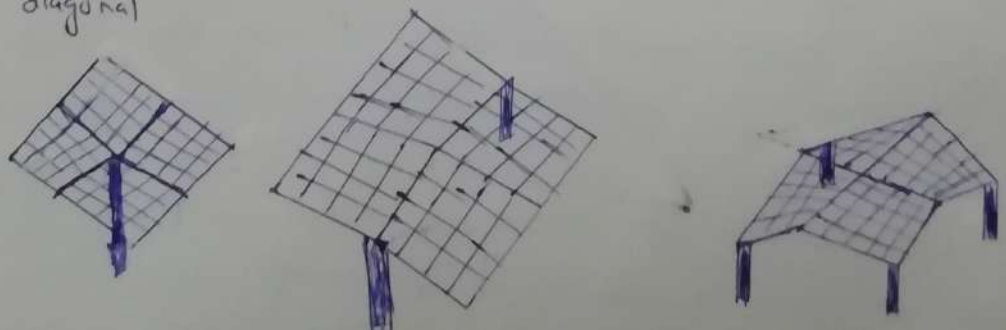
→ These are double curvature translational shells produced by a vertical parabola with upward curvature moving over another parabola with downward curvature.

→ The generated surface is shaped like a horse saddle and it is difficult to construct.

→ This type of shell can be formed by raising or lowering one or more corners of a square or rectangle.

→ Horizontal section of this shell gives hyperbolic shape and vertical section gives parabolic shape

→ For shell action, the rise of diagonal should not be less than 1/5th of length of diagonal



5) Domes

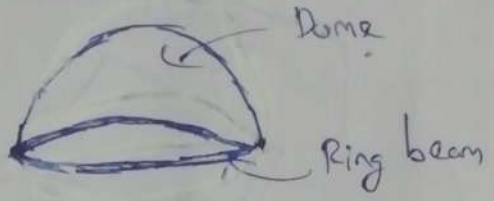
→ Domes are double curvature rotational shell obtained by a curve rotating about a central vertical axis

→ Following are the types of domes

(i) Rotational domes

→ Also known as hemispherical domes (ie) one half of a sphere

→ The dome is constructed over circular ring beam to transfer the forces from dome to walls below

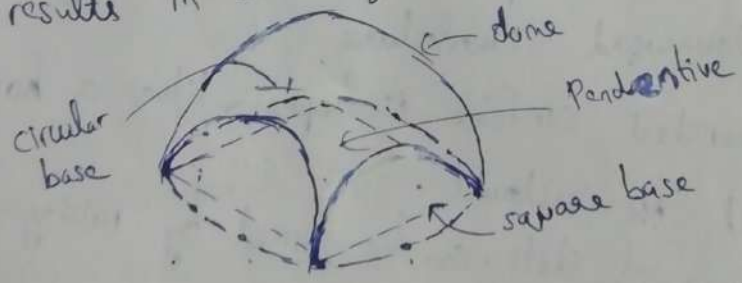


(ii) Pendentive dome

→ The dome in which the dome is placed above a square or rectangular base is called as pendentive dome

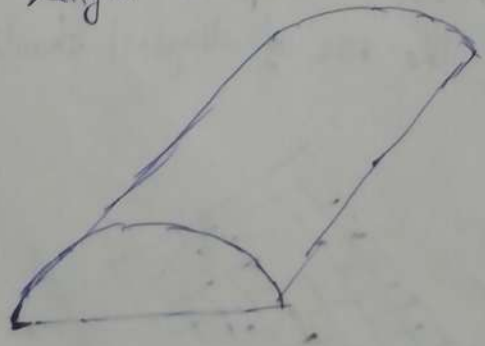
→ The dome have triangular segments taper to a point at bottom and spread at top called as pendentives. These are provided to establish a continuous circular or elliptical base needed for the dome

→ This dome results in a large interior space beneath the dome



(iii) Cylindrical dome

→ Cylindrical dome resembles the upper half of a cylinder placed with its length horizontal



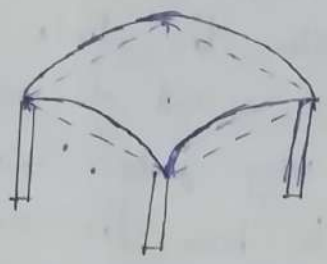
(iv) Translational dome

→ A translational dome is generated when a vertical curve moves along another vertical curve

→ It is a dome set on four arches on each sides

→ The arches have equal radius on all four vertical sides

→ The corner points experiences high tension in this kind of dome



Insitu prestressing in high rise structures

Prestressing is a method of introducing stress (compressive) in a structural member before the loads are applied. For prestressing, tendons made of high strength steel and high strength concrete are used. Following are the two methods of prestressing.

(Pretensioning)

Pretensioning is the method of prestressing in which the the steel tendons are tensioned before the concrete was placed following are the steps involved

→ Tendon is placed at the mould with one end fixed on abutment and other end is pulled using hydraulic jacks

→ Tendons are stressed to about 70% of ultimate strength

→ Concrete is cast into mould and allowed to cure and harden

→ The tendons are now cut. As the tendons are stressed within elastic limit, they will tend to regain its original length (ie) it gets compressed

→ Due to the bonding between the tendon and concrete, the compressive stress in concrete gets transmitted to concrete to bear the external load

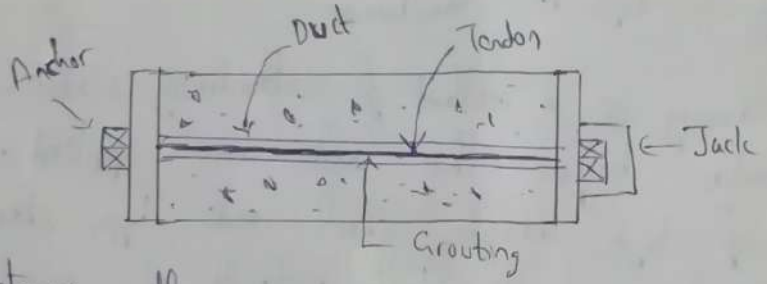
(Post tensioning)

Post tensioning is a method in which the steel tendons are inserted and tensioned after placing the concrete. Following are the steps involved.

→ The portions of tendons are marked and hollow ducts are placed inside the members for inserting the tendon. The duct may be of corrugated steel tube, sheet metal tube, rubber tube etc

→ Concrete is cast and hardened

→ Tendons are inserted into the ducts ~~and the voids between~~ the ~~concrete and tendon~~ and one end of tendon is anchored and the other end is pulled using jacks. This induces compressive stress in concrete to bear the external ~~tensile~~ load.



→ After prestressing, the gap between the tendon and concrete is grouted

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Material handling

Material handling consists of transporting, storage, control and protection of materials used for construction using suitable equipments. Following are the equipments used for material handling

Lifting and lowering device

→ Block and Tackle - oldest and simplest method which uses manpower for lifting using pulley and rope arrangement

→ Winches - Lifts material using rope winded on a drum which is electrically rotated

→ Power hoist - A hook arrangement which is fixed between guide rails making the hoist to move sideways also

→ Elevators - Similar to power hoist but operated in accordance to load

→ Cranes - Generally a overhead crane is used in workshops, industries,

Transporting devices

→ Trolley (or) Skids - Simplest device which uses manpower for transporting. Used to place and lift good from bench. It consist of steel plat form with wheels at bottom for transportation

→ Apeline - Used for transporting fluid materials like oils, gas etc

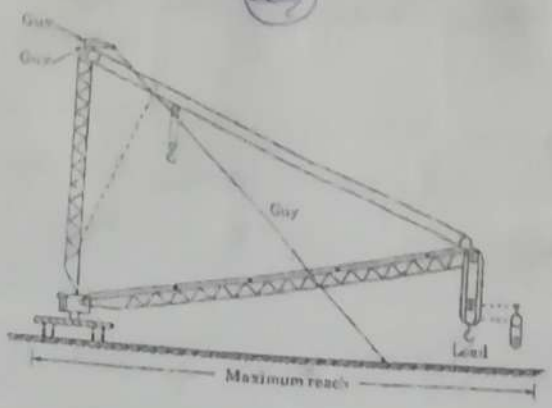
→ Narrow gauge rail road - Little use as it requires tracks to be fitted for transporting materials

→ Belt Conveyors - Used for continuous flow of materials like cement, fertilizers, steel etc Consists of a belt operated with rollers below.

Erecting light weight components on tall structures

Tall structures usually multistoreyed buildings involves the usage of steel elements instead of concrete beams and columns. Light weight blocks are used for walls and slabs. The usage of permanent formworks for concrete and structural steel elements results in rapid speed of construction. The erection of steel elements involves the use of cranes like guyed derrick. Following is the procedure of erection

→ The guy derrick mast is assembled on ground with its base in approximate position.
→ The steel columns are first erected and then beams are erected
→ on having completed frame for a storey height, few slab and walls are erected leaving some strips not erected on position
→ The guyed derrick is lifted to the next floor
→ After shifting, the remaining slab and wall strips of the bottom floor are laid and the bottom floor is completed
→ The process is carried out till the entire structure is erected



Guyed Derrick

Support structure for heavy equipment and conveyor

Support structures is ~~the temporary structure~~ used to provide supports or working platform ~~for equipments~~ for equipment & conveyors or called and ~~temporary storage of materials~~. It should be strong, stable and rigid. Following are the support structures used for heavy equipments.

Heavy equipments

1) Self supported equipments

Some special heavy equipments are ~~equ~~ equipped with self supporting accessories which ~~supp~~ provides a supporting platform at the bottom. It is ~~generally~~ used in soil with less bearing capacity

2) Beam structures

1) Self supporting equipments

Some special heavy equipments are equipped with a self supporting frame with legs at bottom to support the equipment. These equipments are used for leveling the ground, transporting elements etc in soil with less bearing capacity with the help of legs

2) Beam structures

It is generally possible to locate heavy equipments above the structural beam (steel or concrete). Example - Concrete beam can be used as a support for equipments and workers in overhead water tanks,

Steel gantry girder (beams) are used as support for overhead travelling crane.

3) Support towers

Used for supporting steel structures like silos, hopper bin (storing coal), bucket elevators in earth moving equipment. The towers are made of square or circular rods. For supporting workers and movement of workers, platforms and stairs are provided. This allows to work horizontally and vertically.

4) Truss spans

Used to support equipments like conveyors, used to support in ~~launching girders~~ lifting device in launching girders. Truss spans are made of steel elements either square or tubular. Truss consists of top and bottom chord members, tie and strut.

5) Curbs

Curbs are used to support earth moving equipments on rail. They are also called as equipment support rails in which the equipments are supported over rails. The rails can be installed on ground level or top ~~of the rail~~, wherever necessary.

Following are the support structures used for conveyors,

1) Dog House structure

When a conveyor travel path penetrates an elevated ~~the silo~~ or used for supporting conveyor is dog house structure. The conveyor belt runs inside a dog house shaped structure. The conveyor travels overhead inside the building the sides provided with guard rails. It is economic but subjected to wind, rain etc outside the structure which affects the interior when the belt travels inside of the structure. It provides impact on walls of structure

2) Open Gantry structure

This structures are used in exterior of buildings and where the span between supports are excessive. This conveyor support structures becomes inefficient if lift is greater than 30m? As this structure is of open type, they are subjected to wind, rain etc

3) Partially closed Box Gantry structure

Similar to open box gantry girder except that the box is closed on its sides. This structure provides a reasonable weather protection but there is spillage problems

4) Closed Box Gantry structures

Developed to overcome the disadvantages in open gantry girders. Here the conveyor is enclosed on all the four sides. Even the smallest gaps are closed in order to avoid animal or bird entry. In case of transport of fine materials, there is a tendency for the dust to coat the inside of the gantry. Hence it is required to wash the structure periodically and the structure gets subjected to corrosion

4) Closed concrete gantry structures

Provision of closed concrete gantry support structures for conveyor results in combination of both advantages of weather protection and corrosion resistance, however it requires high amount for installation and production and installation of closed concrete gantry structures

5) Triangular gantry structure

Triangular gantry structures have a base with sides joined at top in the form of triangular cross section. They are mainly made of steel pipe sections. They are of low cost and looks architecturally pleasing.

Erection of articulated structures (10a) (10b)

Or (Articulated structures is a structure in which relative motion is allowed to occur between parts, usually by means of hinged or sliding joints)

Articulated structures (Truss) is a structure composed of bars connected by frictionless pins at joint which allows relative motion (sliding) and arranged so that the area enclosed within the boundaries of the structure is sub divided by the bars into geometrical figures usually triangles

Erection

Erection of articulated structures involves lifting and assembling the members together to form the completed structure. The erection process should be planned so as to avoid storage requirements of the members. Erection can be made safe and accurate if temporary support, falsework etc are used. Following are the sequence of erection activities,

→ Equipments like guyed derrick crane used for erection is assembled on a level and strong ground
→ The fabricated structures are unloaded and kept in storage yard till the time of erection. They are stored on basis of erection sequence
→ Shifting of the structures or components from storage yard to site of erection by using trucks or trailers
→ Temporary supports are established
→ Based on markings, lifting and placing of the structure using crane is carried out. It should be ensured that the members are placed exactly and in correct position
→ The structure is aligned and levelled
→ The members are then connected using pins, bolts etc to establish sliding joints
→ Application of final coat of painting.

Erection of braced domes

Domes are shell structures which resembles upper half of a sphere. Following is the erection sequence,

→ Guyed derrick crane is assembled on a level ground outside the place where dome to be erected

→ A careful survey was made to determine accurately the centre point of dome, periphery of ring beam and other support columns (exterior)

→ The support columns are constructed

→ Tubular scaffolding towers are erected along the circumference of the ring beam at a certain interval to support the ring beam

→ Segments of ring beam are placed simultaneously by two team of workers in clockwise and anticlockwise direction - The position of ring beam is checked by measuring included angles, radius and levels as the work proceeds

→ All the ring beam segments are welded with each other after leveling and connected by bolts at location of columns

→ Tubular steel scaffolding towers are located inside the dome for erection of dome ribs at required intersections

Dome ribs are erected such that they are aligned in north south direction. Erection was started from crown working in both directions

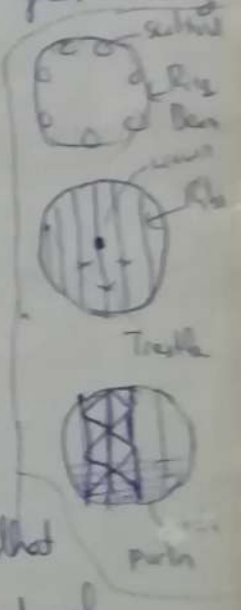
→ The ribs are connected at ends with ring beam by placing the ribs at underside of beam and bolting

→ Upon completing main ribs, secondary ribs are laid such that triangles are formed between two parallel main ribs. The points of intersection are connected using gusset plates

→ Once completion of ribs, tubular bracings can be provided in between the ribs. These are located below the ribs

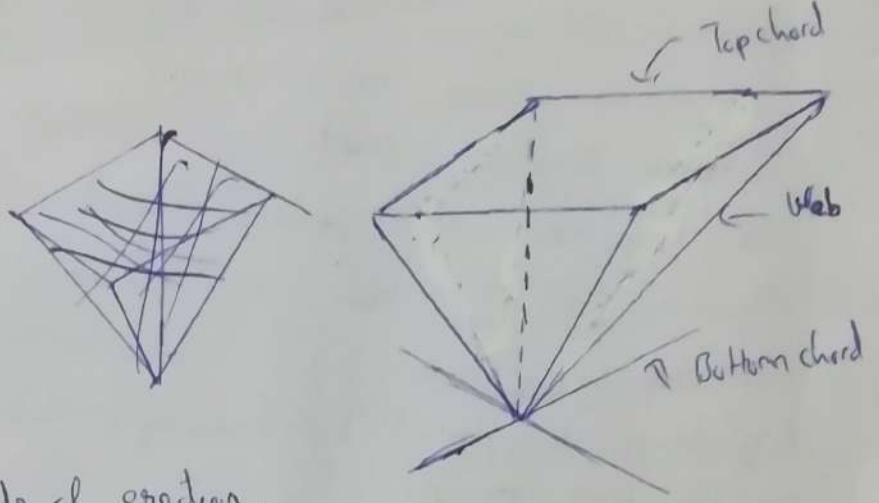
→ Purlins can be provided at top of the ribs to hold the roof sheets

→ Finally the sheets are laid over the ribs or purlin in the form of panels and connected with ribs or purlin



Erection of space decks

Space decks are the structures used to form a double layer roof construction, by assembling and connecting factory produced steel pyramid structures. The pyramid structures are provided with bottom chord members in order to establish connection with adjacent pyramid element



Following are the methods of erection,

Cantilever method

→ In this method the structure is erected from a starting point
→ The strips (each pyramid) are erected to span between two supports, with the help of movable scaffolding
→ Once a part of structure is completed, the rest of the strips are added to the existing strips

→ Connection between the strips are achieved by bolting. Bottom chord members are also connected at bottom
→ more effective when the strips are of heavy weight.

Lift slab method

→ In this method the entire spatial structure is assembled on ground and lifted up using heavy cranes and placed in position
→ This method is used to erect double or triple layers with span upto 300ft
→ Used where the site has enough place for assembling

Sub assembly erection method

→ This method is a combination of above two methods. Part of the structure is first assembled on ground and lifted and placed in position
→ Subsequent sections are lifted, placed and connected with previous parts.
→ Advantage of this method is less labour and small cranes can be used.

Unit V - Construction Equipment

Selection of equipment for earthwork - Earth moving operations - types of earthwork equipment - tractors, motor graders, scrapers, front end loaders, earth movers - Equipment for foundation and pile driving. Equipment for compaction, batching, mixing and concreting - Equipment for material handling and erection of structures - Equipment for dredging, trenching and tunneling.

Factors to be considered for selecting equipment

-> Scope of work
-> Type, size and availability of equipment
-> Cost and usage of equipment
-> Availability of skilled operators
-> Useful life of equipment if it is purchased
-> Duration of work

Earthmoving operations (~~Excavation~~)

This operation involves removal of soil and moving them to another place. Following are the equipments used for earthwork Tractors, bull dozers, single dozers, ~~scrapers, power shovels,~~ draglines, ~~clamshells, hoes, dredgers, ripper cat~~ motor grade. The selection of equipment depends on nature of job, distance and method of disposal, construction time etc.

1) Tractors

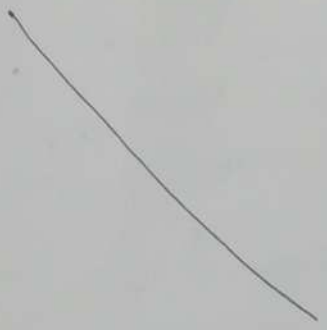
-> It is an important equipment for earth movement - It converts engine energy into tractive energy which generates a powerful tractive (pulling) force for pulling other machines.

-> Tractors are either of,

Crawler or track type - Crawler type moves on endless chain at a speed of 13kmph
- Used for uneven and rough ground
- Best operates on earth or gravel ~~at speed of~~ 13kmph

Wheel or Pneumatic tyre – Moves on tyres at a speed of 50 kmph (110)
– They best operates on smooth road

→ Tractors have energy to pull or push various attachments such as dozer blades, scraper, harrow, plough etc



2) Motor Graders

→ Motor graders are used to level and finish earthwork
→ It consists of 3 to 4m long angled blade supported on frame work mounted on wheels.
→ The various operations that can be performed by motor grader are grading, spreading, side cutting, road crowning, bank dressing etc
→ Motor graders are of
~~Towed motor grader – Self propelled type~~
Motorised grader – self propelled type
Towed grader – Towed by tractor
'pulled with rope

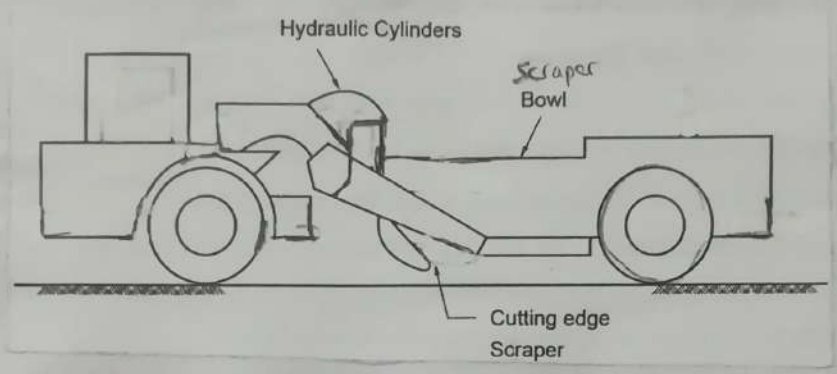
3) Scrapers

→ It is a self sufficient machine which can dig, load, haul and disch the material in uniformly thick layers usually site levelling
→ It consists of a bucket called scrapper bowl with a blade at botto which cuts the soil, excavate and ~~transpo~~ transports the collected soil. The bowl is emptied by raising the rear portion and spreading the soil
→ The scraper is operated using a power unit at front
→ The scrapers are mounted on pneumatic wheels (~~two or~~ four)
→ Following are the basic types, air ~~op~~ bowl attached to power unit
Crawler drawn scraper – Consists of four wheeled scraper, with bowl capacity 5 to 50 m^3

- Speed varies from 3km/h to 8km/h

Two axle scraper - less rolling resistance
- Consists of two axles which has a two wheeled bowl pulled by two wheeled power unit

Three axle scraper - Able to use at its full speed more frequently
- Easy to control as it has three axles.



SCRAPER

g) Front end wavers or loaders

→ Front end wavers are also called front end loader, bucket loader, scoop loader etc.

→ It is machine usually mounted on rubber tire wheel or tracks and used for moving loose earth from one place

→ It consists of large bucket in front connected to the machine and using two booms or lift arms, the lift arms being activated by a hydraulic system

→ The large bucket can be replaced by attachments like forks to lift loads or a backhoe to excavate trenches. Following are the three types

→ Wheel front end loader - mounted on large rubber tires and hence can move from site to other places easily

→ Skid steer loader - similar to wheel front end loader except that left side wheels are independent of right side wheel and hence it can rotate in place

→ Crawler mounted front end loader - Instead of tires, it has chain type crawlers. Hence it can move easily even in inaccessible areas

5) Bulldozers

→ These are high powered tractors with a blade at front for stripping excavations by pushing the loosened material into it
→ Excavates upto a depth of 400mm, the blade being 1.2 to 4m wide 1.2 m high, 6 to 20 tonnes in weight
→ If the blade attached at front is other than 90° (usually then it is called angle dozer

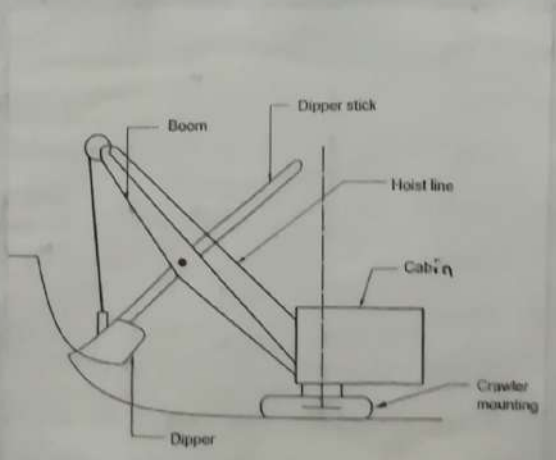
Excavation equipments

An excavator is a machine which removes earth using a digging unit while the main unit is stationary. The range of excavator is limited to the reach of boom carrying bucket at its end. The boom is capable of moving the bucket both horizontally and vertically. The excavators can be mounted on crawler or pneumatic wheels. Following are the examples.

Crawler type - Possess low travel speed. Can be operated on soft ground - Power shovel
Pneumatic wheel type - Possess high speed and suitable for hard ground.

1) Power Shovel

→ Consists of six parts boom, cabin, dipper with stick, hoist line, crawler mounting power system
→ Power shovel is moved to required position with dipper lowered to required ground
→ Force is applied to the dipper stick and the dipper with teeth excavates the soil and placed in trucks, dumpers etc.



POWER SHOVEL

Output of Power shovel - Quantity of material excavated in unit period of time and expressed in m^3/hr

- Volume of excavated material / Time take for one cycle × No of cycles

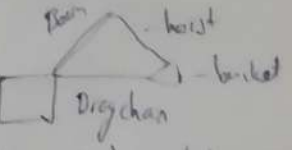
2) Draglines

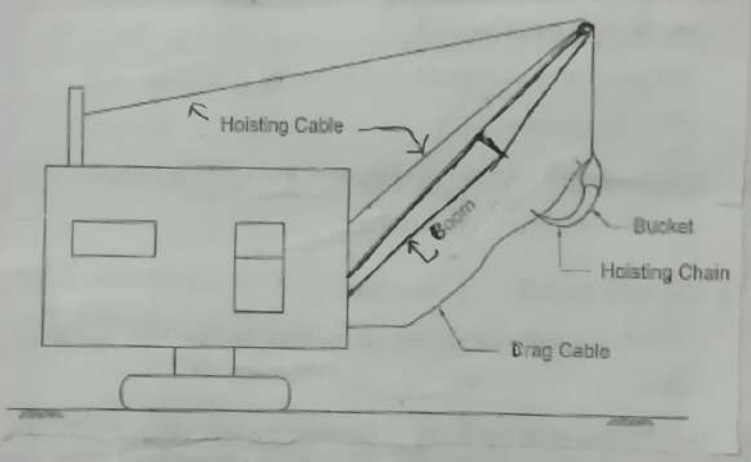
-) Consists of boom, cabin, ~~drum~~ cable, drag chain and bucket, hoist line, crawler mounting

-) Empty bucket is brought to position using drag chain and hoist lines,

=) When the bucket is pulled towards the machine, it excavates the soil

-) Once the bucket is filled up, the drag chain is released and the hoist lines is pulled up by which the bucket is brought up and placed in trucks, dumpers etc





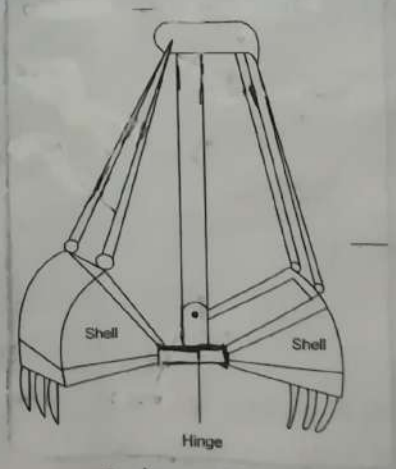
DRAGLINE

3) Clam shell

-) Consists of a bucket made of two halves which are hinged at top with jaws with teeth arranged

-) The bucket is attached to crane. ~~closed~~

-) The bucket excavates the material and as being lifted, it closes entrapping the soil into it



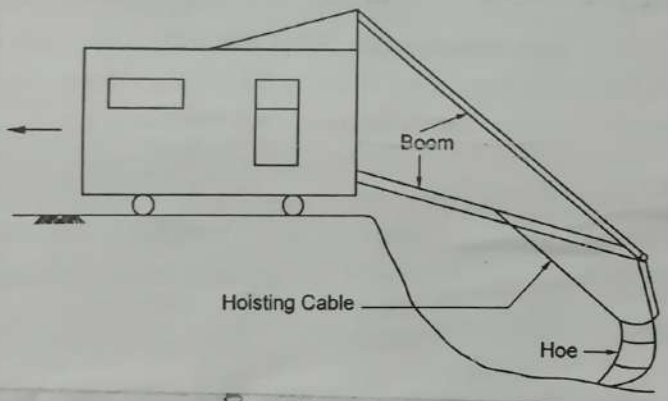
CLAMSHELL

4) Trenches or Ditchers

-> Used for excavating trenches of width 250 to 450mm and depth upto
-> Consists of a conveyor having series of cutting buckets supported a boom that is lowered into ground for required depth
-> The soil was dug by bucket, comes up due to conveyor and deposited along side of trench.

5) Backator

-> Also called as back trench hoe excavators
-> Commonly used in buildings for excavating basements, trenches, pits etc
-> Consists of boom to which a bucket or hoe is attached
-> Ground is excavated using power units or by hydraulic means and the soil is disposed
-> The operating cabin is capable of revolving in all angles and direction



BACKATOR

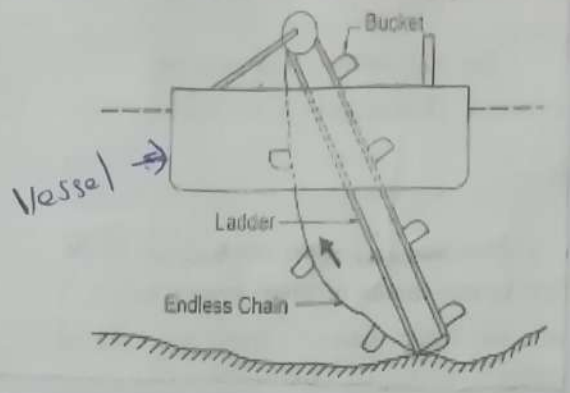
Dredging

Dredging is the method of providing deepening the bed of river, lake or sea. It is an important operation used in navigation canals, harbours, dams etc.

Bucket-ladder dredgers

-> Consists of an endless chain of buckets mounted on a ladder
-> The buckets are provided with suitable cutting edge for the purpose of digging
-> The material brought up by the buckets is either directly dropped into hopper provided on vessel or conveyed to

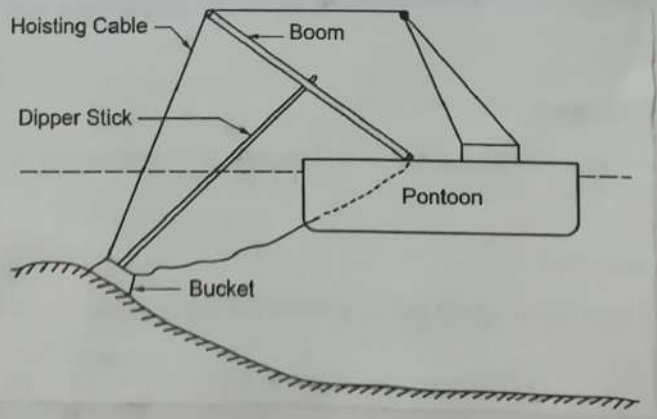
barges standing alongside of vessel.



BUCKET LADDER DREDGER

Dipper dredger

→ Dipper dredger consists of a pontoon carrying a frame in which a revolving boom is fixed
→ To the boom, dipper stick is attached. The other end of dipper stick is provided with bucket.
→ The soil is dredged using the bucket by releasing and pulling the hoist cable.
→ Used for all underwater soil and can excavate upto $50m^3/hr$
→ They can operate upto 20m to 35m.



DIPPER DREDGER

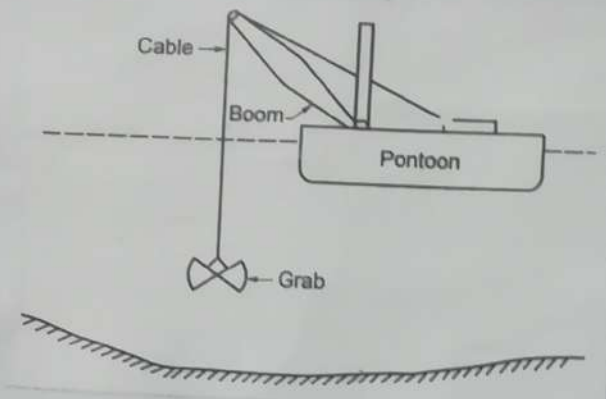
Grab Dredger

→ Grab dredger consists of a grab suspended from cable attached to boom of pontoon
→ The grab in the shape of quadrant of circle is open in normal position
→ On being lowered, the grab digs into mud, and by suitable

arrangement it gets closed (22) (110)

→ The grab is lifted up and the soil is disposed

→ Used for dredging sand, clay, mud



GRAB DREDGER

Suction or Hydraulic dredger

→ Consists of a heavy duty, suction pump mounted on a vessel or barge

→ The pump is supported using ladder upto river bed which can be raised or lowered with the help of winches.

→ The soil is removed with the help of suction pump and a cutter may be provided at end of pipe in case of removing hard material

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Trenching

Trenching is the process of digging trenches for laying gas and electrical and telecommunication cables. It is a form of excavation but differs from the view that a trench is an excavation with length which greatly exceeds the depth.

Wheel trencher (or) Rockwheels

→ Consists of a power driven wheel with cutting teeth mounted along its circumference.

→ The cutting teeth may be 6 to 8 depending on diameter and they are placed in ~~semi-spherical configuration~~ bucket shape to increase the ability to remove the materials from trench

→ Maximum cutting depth is 3m and width 30cm to 150cm

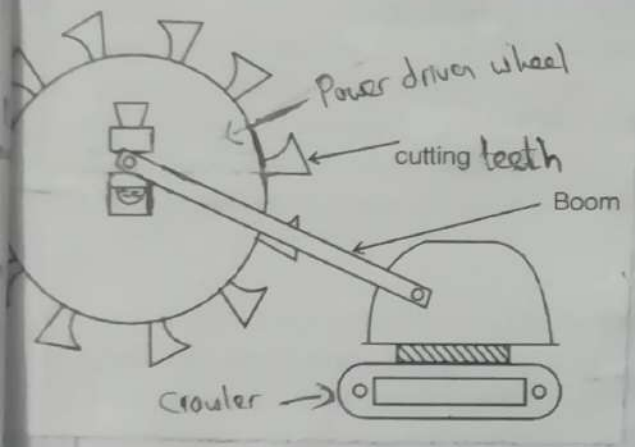
Chain trencher

→ This trencher uses a digging chain or belt to cut the soil

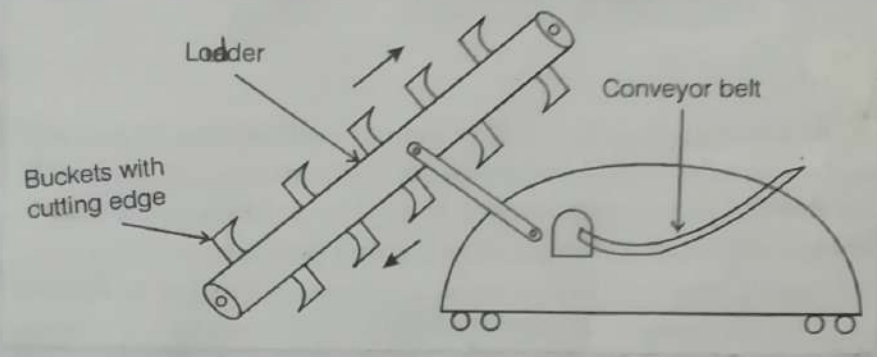
→ The chain or belt is driven around a metal frame or ladder, the angle of which can be adjusted to control the cut depth

→ Chain trenchers are used to cut hard ground and for digging trenches in rural areas for telecommunication cables, electrical cables, water, gas pipes etc.

→ The excavated materials can be removed by conveyor belt provided on either side of the trencher



WHEEL TRENCHER

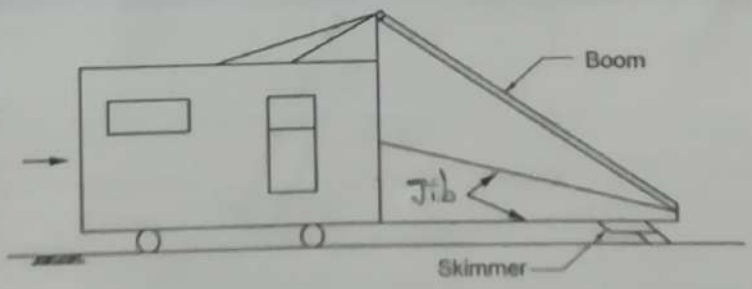


CHAIN TRENCHER

Skimmers

→ Skimmer consists of a bucket sliding along a horizontal jib. The bucket slides along the jib digging away from the machine

→ Trenches upto a depth of 300mm can be made at a removal rate of 50 bucket loads per hour



SKIMMER

Micro trenches

-> Micro trencher is a small wheel trencher used for excavating narrow trenches usually in roads for maintenance without disturb traffic during the process.
-> Micro trench widths range between 30 to 130mm with a depth 500mm
-> It can cut harder than a chain trencher including cutting through stones.

Portable trenches

-> Portable trencher is a small size chain trencher and ~~operate~~ driven manually
-> Used by landscapers and lawn care specialist for carrying a landscape works and digging irrigation lines

Trador mount trencher

-> They are a type of chain trencher pulled using gear tra
-> The tractor should be able to move slowly as that of trenching speed

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Tunelling

-> Tunelling is the process of digging a passage underground for the purpose of pedestrian way, railways, highway military purposes, wildlife crossings etc.

Road Headers machine

-> It consist of a boom with cutting head mounted on a cra mounted machine
-> It is extremely powerful in cutting rocks and hydraulically operate
-> The cutting head is capable of rotating perpendicular to the boom
-> It is also called as boom type road headers

Tunnel Boring Machine (TBM)

-> TBM also known as 'mole' is a equipment used to excavate tunnels of circular cross section.
-> Used for tunelling in soils or rocks with complex geological environment, swelling grounds, shear and fault zones, grounds with high water pressure etc
-> The TBM is of three types,

Slurry method - Soil is cut using cutter head and the loosened soil is washed off using slurry and removed through pipes
pressure

Earth balance method - Similar to above method, but the loosened soil is removed through the conveyor set up placed within the tunnel boring machine. The excavated earth is also used for balancing the soil from immediate collapse.

Equipments for material handling

Material handling involves moving of materials from one place to another inside site of work. Using equipments for material handling is economic and less time consuming when compared to that of manual material handling

Dumpers

-> Most suitable for horizontal movement of materials such as bricks, aggregate, wet concrete, sanitary fittings, scaffolding etc
-> They are diesel powered vechicles having suitable collecting and transporting facilities

Elevators

-> They are endless belt used for transporting aggregates and concrete in large sites, raising bricks or tiles to the fixing position
-> Elevators are used for moving materials in vertical direction and transverse strips are provided at suitable spacings (max-7m)

Conveyors

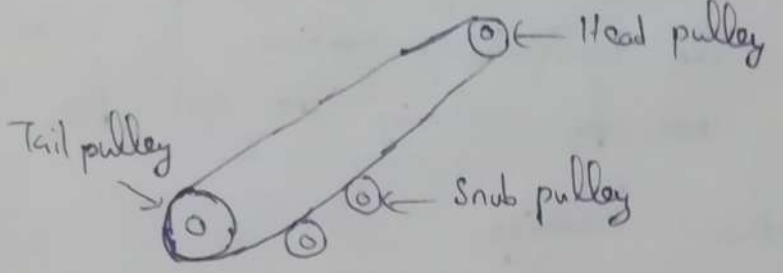
→ These are endless belt transporting materials in horizontal direction

→ Following are the various types

1) Belt Conveyor

→ These are used to convey materials such as sand, cement, aggregate Concrete etc

→ It consists of a continuous belt which is driven using pulleys which are installed at head called head pulley, at tail called tail pulley, at intermediate called snub pulley. The pulleys may be supported by electric power, diesel engine etc

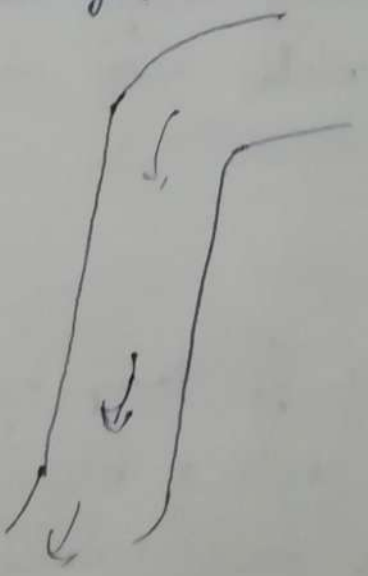


2) Chute Conveyor

→ Mainly used to convey materials between two material handling or between two floors

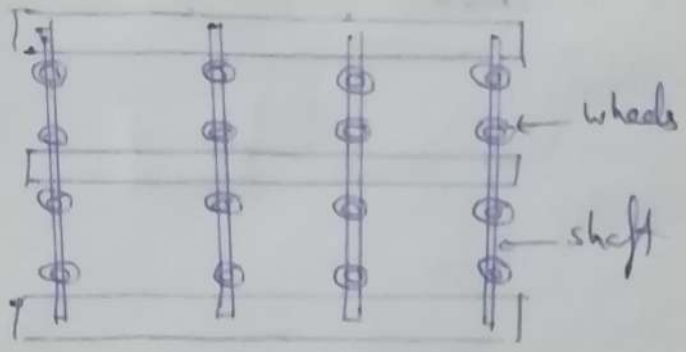
→ This conveyor works on the principle that the material gets conveyed due to gravity

→ This method is inexpensive while there is a lack of control over the materials conveyed



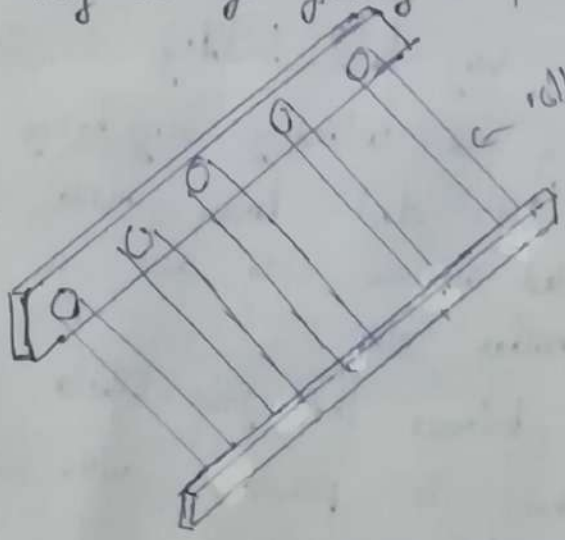
3) Wheel Conveyor

→ Consists of series of steele wheels mounted on axles or shaft run by motor
→ The spacing of wheels and shaft depends on the weight of the material to be conveyed
→ Best suitable for transporting large size light weight materials



4) Roller Conveyor

→ Consists of parallel rollers supported by frames and the material with large size are kept on it and transported
→ Roller conveyor may be of gravity or powered type



Erection

This consists of lifting heavy loads or materials and to shift them from one place to another. It also includes placing or erecting heavy prefabricated components in position to form the entire structure.

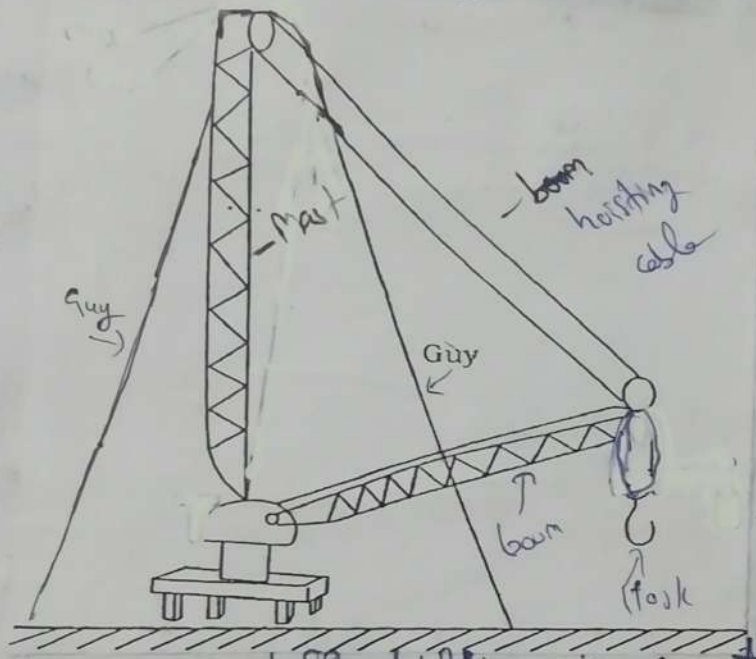
Following are the types of crane used for erection

Guy Derrick

→ This consists of a mast supported by a number of guys (rope which provides stability

→ The crane is provided with a jib or boom which is provid with a hoisting cable for lifting materials

→ The crane is capable of rotating 360° without any obstruct



Tower Cranes

→ Used for erecting very tall buildings in congested area

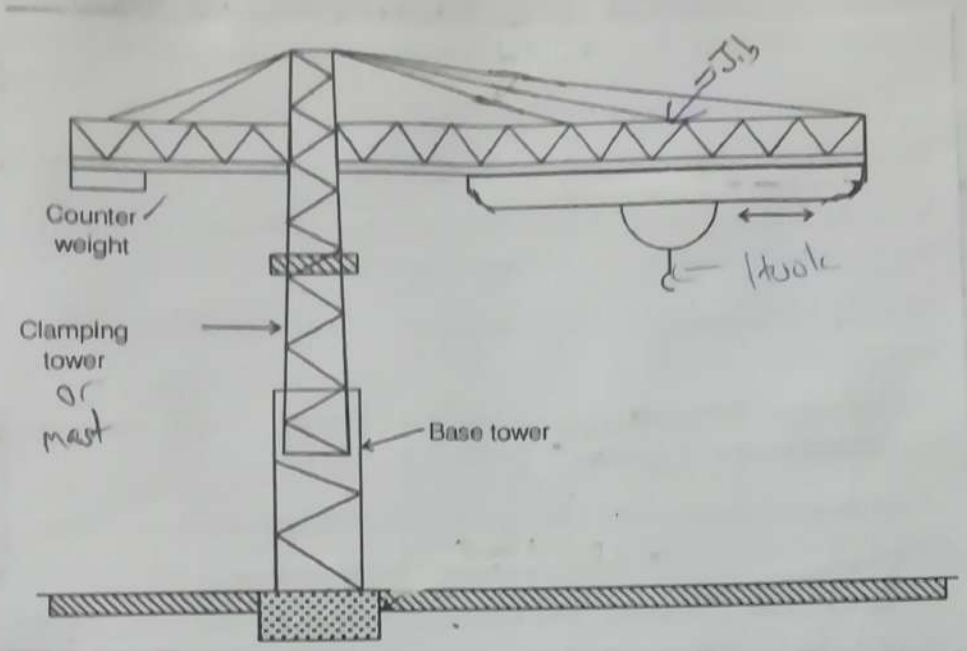
→ Used for loading and unloading very heavy structural members

→ Consists of a high steel tower made of truss to which a jib is provided on one side and a counter weight is provided on another side.

→ The counter weight balances the jib while lifting of elements

→ Sometimes the tower is provided with mast which extends the height

→ The types of tower crane are fixed or static mast tower crane, climbing crane, rotating crane etc



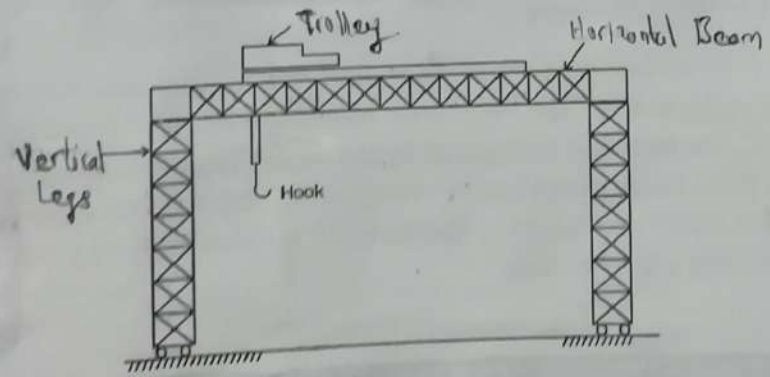
Gantry Crane

→ These are cranes mounted on rail and used for lifting materials in between the tracks (lifting from storage yards)

→ This crane consists of two vertical legs and a horizontal beam

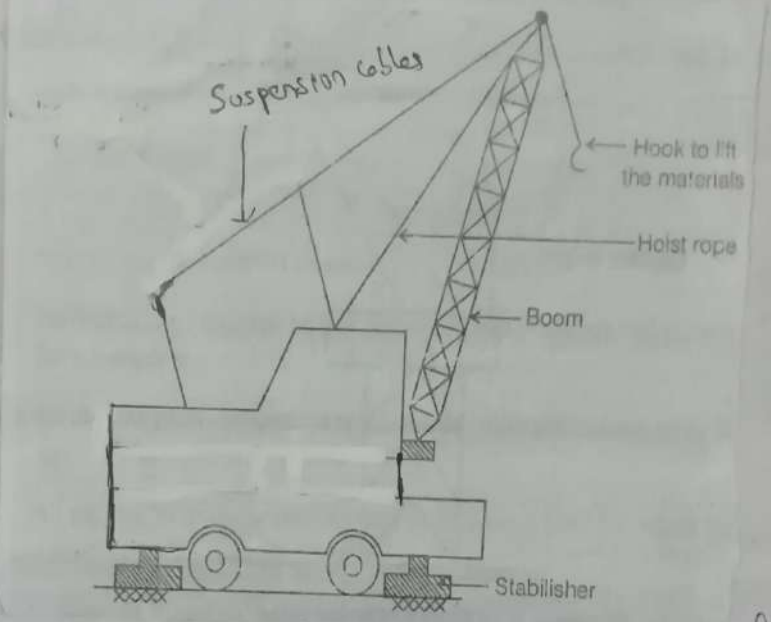
→ The horizontal beam carries a moving trolley with hook for lifting elements.

→ Used mainly in harbours, steel workshops, prefabricating workshops etc and can lift load upto 840 tons to a height of 70 metres



Mobile Cranes (or) Crawler mounted crane or crawler

-> These are cranes mounted on wheels, which can lift upto 10 T
-> These crane consists of boom to which the hook is suspe
-> The boom is supported using suspension cables attached to th back of the wheel mounted vechicle
-> The vechicle has stabilizers at bottom to rest on soil and at a speed of 30km/h.

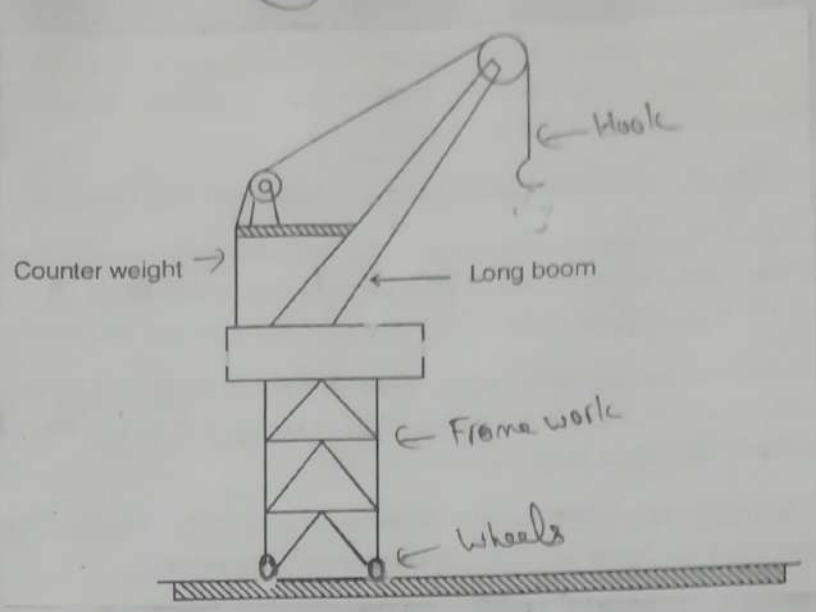


Whirler Cranes

-> This crane is a combination of stationary and mobile unit
-> It combines the advantage of boom of guy derrick and mobility of mobile cranes
-> The lifting mechanism is supported on a frame work which is capable of rotating or moving. The boom is attached to front end of frame
-> Counter weight is provided at the rear end which provides support to the boom
-> Two separate motors are provided for movement of the frame work

Truck mounted crane

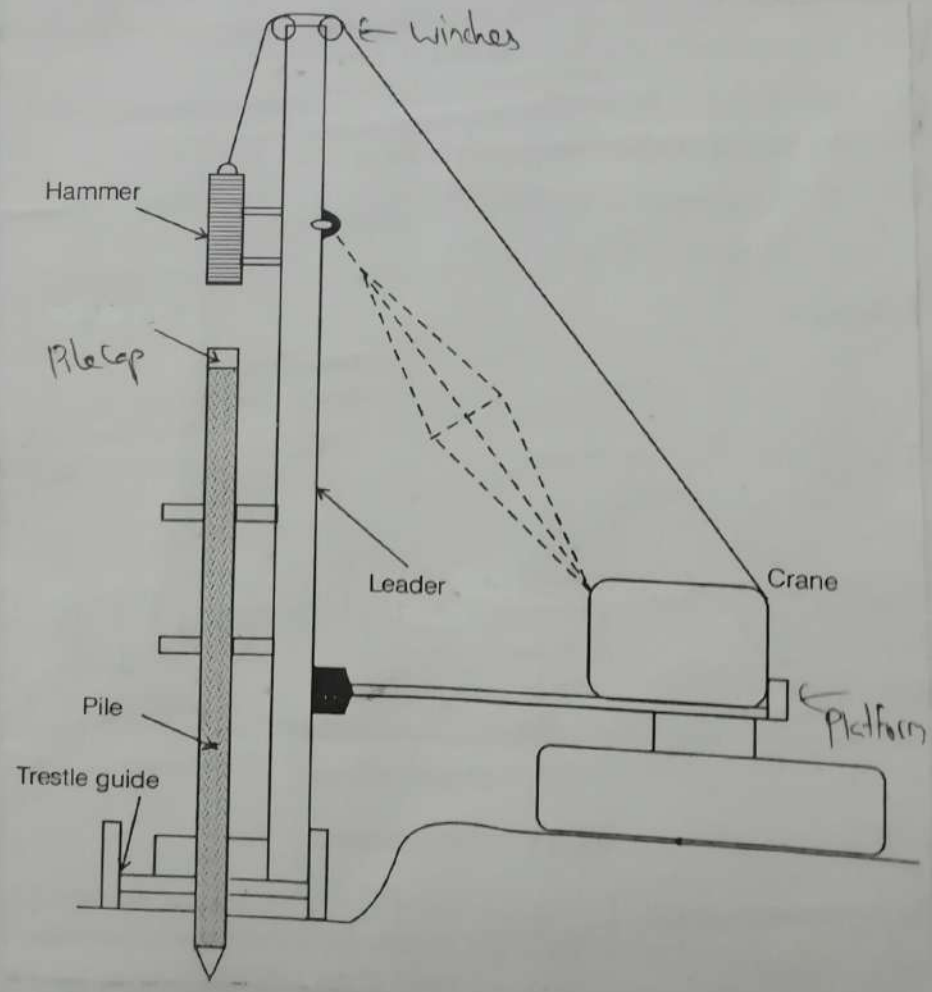
-> These cranes are mounted on a truck with its own operating cabin to which boom is attached
-> Hooks attached on the boom which is used to lift elements



WHIRLER CRANE

Equipments for Pile Driving

The process of inserting a pile into ground is called pile driving. The piles should be driven vertically while a eccentricity of 2% is permissible. Following are the equipments used,



Pile Frames

→ Generally made of steel of height 10 to 25m, light in weight

→ It composes the leader which supports the pile and a horizontal platform for supporting drivers, engines, winches etc

→ Pile frame consists of,

* Leader - Vertical element which supports the pile and gives perfect alignment. It also carries the hammer attached to it through winches (rope winded over rotating drum). The leader is of steel and can be solid, channel, box or tubular in cross section

* Platform - Horizontal elemet provided for supporting drivers, engines

Trestle Guide

→ Moveable structure used at ground level made of wood or steel

→ Trestle guide have holes through which the pile is held in required position.

→ This is usually provided to maintain the alignment of pile.

Pile Hammer

→ The fuction of pile hammer is to impart energy to drive the p into the soil

→ These hammers are guided with the help of leader and winch

→ Following are the types of hammer used

Write the types of hammers in unit II

Miscellaneous

→ The other equipments used in addition the main equipments are

Pile Cap - Transfers energy from hammer to pile without

creating damage to pile

Pile extractors - Used to extract previously driven steel piles without any damage to pile

Jetting equipments - Used to spray water to make pile to be driven easier

Followers or ~~cushions~~ - kept in between hammer and pile to transfer energy while driving underwater

Equipment for compaction, batching, mixing and conveting (Nov Dec 16)

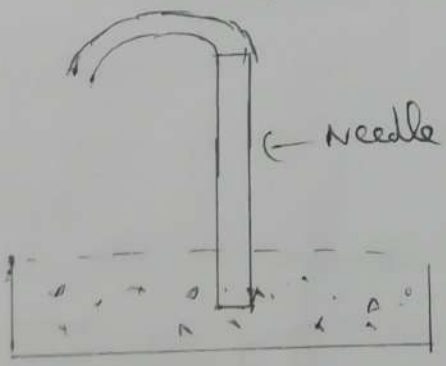
Compaction - Hand Compaction or vibration (internal, external, table, platform)

Batching - Gauge box, weighing balance, Automatic batching plants

Mixing - Pan type, Drum type

Conveting - mortar pan, Wheel barrow, Bucket, Skip and hoist, (Apr 18) Chute, Conveyor, Transit mixer)

Internal Vibrator or Needle Vibrator



External or Formwork Vibrator

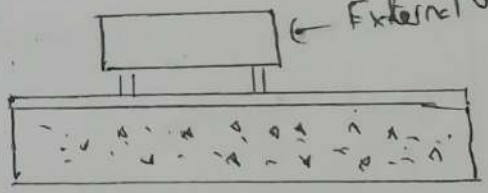
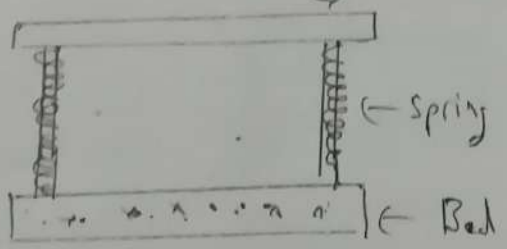
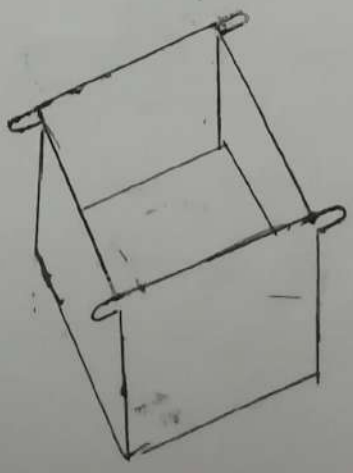


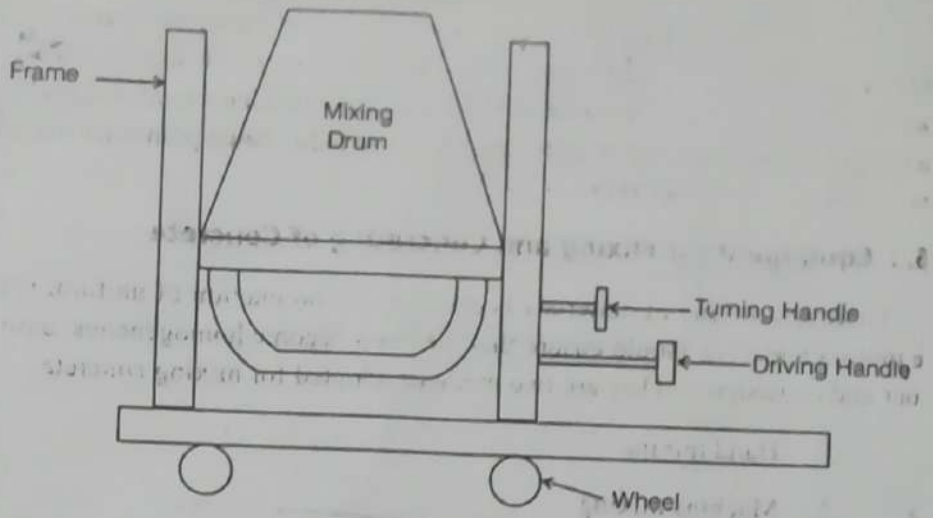
Table vibrator



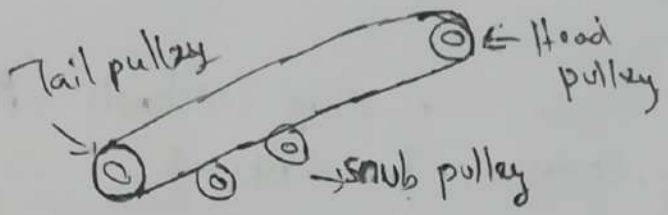
Gauge box



Tilting Drum Mixer

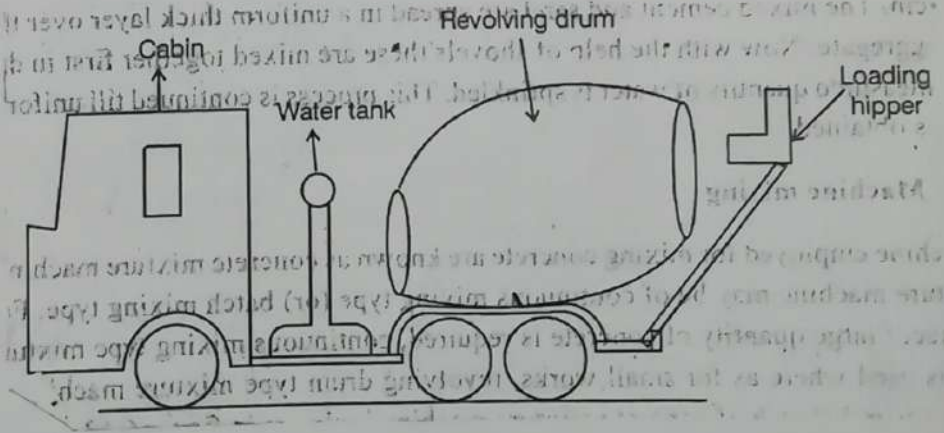


Conveyor



Chutes

Transit Mixer



Manufacturing of Concrete (Apr May 18) (Nov Dec 17) (Nov Dec 16)

Batching

The measurement of materials for making concrete is called batching. There are two methods of batching, namely volume batching and weigh batching

1) Volume batching

→ Used for small jobs because volume batching is not a good method as there is a difficulty in measuring granular materials (volume of moist and dry sand differs)

→ Cement is always measured in weight. Generally for a batch, one bag of cement is used. Volume of one bag of cement is 3.5 litres

→ Gauge boxes are used for measuring fine and coarse aggregate. The volume of box is equal to volume of one bag of cement or its multiple

→ Water is measured in either weight or volume (1kg or 1l)

2) Weight batching

→ Correct method of batching due to its accuracy and flexibility

→ For smaller jobs, weighing arrangement consists of two buckets mounted on a shaft about which they can rotate. Thus one can be loaded while the other can be discharged at the same time. The buckets are connected to levers which indicates load

→ For larger works, hopper are used which discharges the materials directly to mixer. Weighing is made through a lever arm system and two interlinked beams and jockey weights

→ Automatic batching plants are available in which buttons are used for motion and cut off of material flow.

Mixing

Mixing should be done such that the mass becomes homogeneous uniform in colour and consistent. There are two methods namely hand mixing and machine mixing

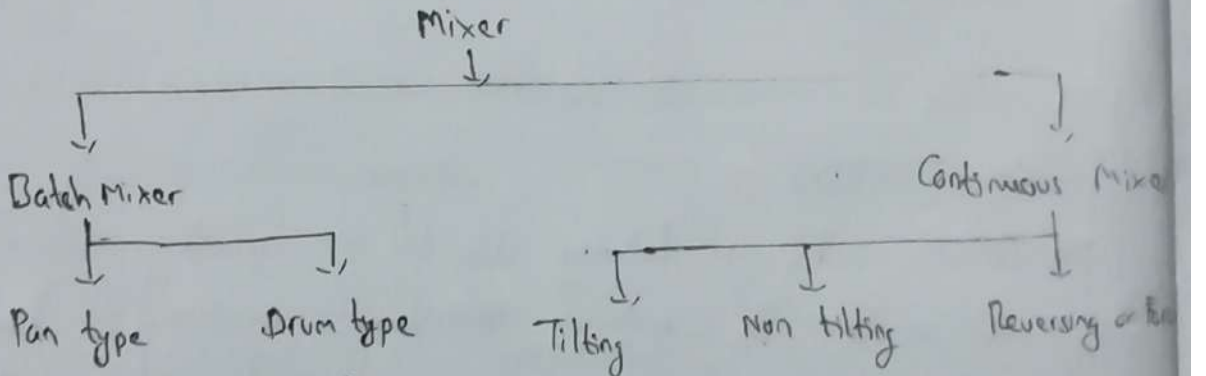
1) Hand Mixing

→ Hand mixing should be done on impervious floor
→ Spread out measured quantity of coarse and fine aggregate in alternate layers
→ Pour cement on top of it and mix by shovel turning the mixture over and over again till uniform colour is achieved.
→ The mixture is spread out for a thickness of 20cm
→ Water is sprinkled over the mixture and simultaneously turned over and mixed till uniform mix is achieved

2) Machine mixing

Carried out for mass concrete works. Following are the types of mixer

Batch mixer → Produce batch by batch with time interval
Continuous mixer → Produce continuously without stoppage till the plant is working



Batch mixer → Produce batch by batch with time interval
Continuous mixer → Produce continuously without stoppage till the plant is working

Pan and Drum type mixer → Has revolving blades for mixing
Tilting type mixer → The drum of mixer can be tilted
Non tilting type mixer → Drum revolves about a horizontal axis and cannot be tilted
Reversing type mixer → Rotates in one direction for mixing & another for discharging

Transporting

During transportation of concrete, the homogenity obtained at time of mixing should be maintained while being transported to final place of concreting. Following are the methods of transportation

1) Mortar Pan - Common method
   - No segregation
   - Gets dry as greater surface area is exposed
2) Wheel barrow - Used for transporting concrete at ground level
   - Used for transporting long distances (concrete road construction)
   - Possibilities of segregation due to vibration that occurs
3) Crane, Bucket and Ropeway - Right method for transporting concrete at ground level
   - Crane moves horizontally and vertically to which buckets are attached though ropes.
4) Trucks or Dumper - Capacity was 2 to 4 m^3
   - Before loading, inside of trucks should be wetted
   - Tarpaulins or cover should be used to avoid evaporation
5) Belt Conveyor - Have limited application as there is possibilities of segregation and evaporation when subjected to hot weather.
6) Chute - Used for transporting concrete from higher to lower level (gravity)
   - Inside of chute is lined with metal and slope 1:2½ is provided
7) Skip and Hoist - Used for transporting concrete vertically in multistoreyed buildings
   - Mixer discharges concrete into skip or wheel barrow
   - The skip or wheel barrow is transported to the platform which can be hoisted.
8) Transit mixer - Used to transport concrete to long distances particularly in Ready Mixed Concrete (RMC) works
   - It is a truck with revolving drum at rate of 2 to 6 revolutions per minute with capacity 4 to 7 m^3
9) Pumps and pipeline - Contains hopper, inlet and outlet value, cylinder and piston
   - Piston located in cylinder pulled up while concrete enters cylinder due to pressure (suction)
   - After that, inlet value is closed and outlet valve is opened

Placing

The process of depositing the exact quantity of concrete in its desired position is called placing. Care must be taken while pla concrete in the following situations

→ Placing concrete within a mould (Foundation Concrete for wall or
→ Placing concrete in large earth or timber mould (Road slab)
→ Placing concrete in layers within timber or steel structure (Pier, A
→ Placing concrete in formwork (Column, Beam, Floor)
→ Placing concrete under water

Compaction

Compaction is the process of expelling the entrapped air from concrete and to obtain a homogeneous dense mass. Following are the methods of compaction

1) Hand Compaction

Hand compaction is adopted in case of small works. Following are the hand compaction methods

→ Rodding - Poking (Applying thrust) the concrete with 2m long 16mm diameter rod to compa the concrete between reinforcement and sharp corners and edges and then compacting over the entire area

→ Ramming - Done in unreinforced concrete work with heavy flat bottomed rammer. The surface is rammed till a thin film of mortar appe on the surface

→ Tamping - Usually adopted for slab or road pavements. It consists of bea the top surface by wooden beam of cross section 100×100 m Since tamping bar is long it also levels the top surface.

2) Compaction by Vibration

High strength can be obtained by proper compaction which is possible using mechanically operated vibrators. Following are the different types of vibrators

Internal Vibrator - Also called needle vibrator, immersion vibrator
- Needle of diameter 20mm to 75mm and length 25cm to 90cm is used
- Vibration of needle is caused by power from air compressor

→ External Vibrator - Also called formwork vibrator
- Machine is clamped to the external surface of formwork
- As the formwork gets vibrated, the concrete inside the formwork also gets vibrated

→ Table Vibrator - Commonly used for vibrating concrete cubes in laboratories
- Table is mounted on springs which are vibrated using power from motor and the vibration gets transferred to table through springs.

→ Platform Vibrator - It is a table vibrator large in size
- Used for vibrating electric poles, railway sleepers, prefabricated roofs

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Curing (Apr May 17) What are the objectives & types of curing.

Curing is the process of keeping the concrete moist and warm enough so that hydration of cement gets completed. A water cement ratio of 0.38 (0.23 for hydration and 0.15 for filling pores) is enough for hydration but this water cement ratio cannot be preserved in atmospheric conditions present. Hence curing is done. Following are the methods of curing.

1) Water Curing

It is the best and easy method of curing. Water curing can be done by following ways,

Immersion - Immersing concrete specimens in water tanks for curing

Ponding - Slabs can be cured by making small pond of water.

Wet covering - Gunny bags, hessian cloth, jute matting, straw also can be laid

Spraying - Water can also be sprayed in case of wall, columns etc

2) Membrane Curing - Used in places where there is shortage of water
- Concrete is covered with membranes like bituminous compounds (Tar, Asphalt), Clear compounds (paraffin, wax resin, vegetable oil), water proof paper in order to avoid evaporation of water
- Hence curing takes place due to sufficient w/c ratio

3) Application of Heat

When concrete is subjected to high temperature it enhances the hydration process. However concrete cannot be subjected to dry heat as water is required for curing. Following are the types.

Steam curing - Applicable for precast members
- The members are placed in a chamber and steam is passed either under ordinary or high pressure

Curing by Infra red radiation - Infra red radiation is passed under a temperature 90°C

Electrical curing - Applied in cold climatic regions. Electrodes are fixed in concrete and alternating current is passed

4) Other methods

Calcium chloride ($CaCl_2$) - Can be used as surface coating medium

Sodium silicate ($NaSiO_3$) - Sprayed in solution form on concrete surface

Finishing

Finishing is the last operation in making concrete It is done to make the concrete surface to be pleasant in appearance. It may not be important for beams whereas for road pavements, flooring of a building careful finishing is essential.