CE8401 CONSTRUCTION TECHNIQUES AND PRACTICES

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 SYSTEMS:

A system is an assemblage formed to satisfy specific objectives and subjected to constraints and restrictions and consisting of two or more components that are interacted and compatible. Each component being essential to the required performance of the system. The group of components of a system may also be a system; such a group is called a subsystem.

LOAD BEARING STRUCTURE:

In load bearing structure, the whole load supported & transferred by masonry wall. Load bearing masonry construction was the most widely used form of construction for large buildings from the 1700s to the mid 1900s. it is so very rarely used today for large buildings. But for small residential buildings it consists of thick heavy masonry walls of bricks or stones that support the entire structure including the horizontal floor slabs.

FRAMED STRUCTURE:

In RCC framed structure, the whole load supported on beams and slabs and then transferred from columns to footings.

LOAD TRANSFER MECHANISM:

Any structure is made up of structural elements and non-structural elements. The structural elements put together constitute the structural system. Its function is to resists effectively the action of gravitational and environmental loads and to transmit the resisting forces to the supporting ground without significantly disturbing the geometry, integrity and serviceability of the structure. Most of the structural element may be considered from the viewpoint of simplified analysis as one dimensional elements. A few structural elements may require more rigorous analysis.

Floor system:

Load bearing construction is most appropriately used for building in which the floor area is subdivided into a relatively large number of rooms of small to medium size in which the floor plan is repeated on each storey throughout the height of the building. These considerations give ample opportunity for disposing load bearing walls which are continous from foundation to roof level and because of the moderate floor spans, are not called upon to carry unduly heavy concentration of vertical loads. A cellular arrangement is one in which both internal and external walls are load bearing and in which the walls form a cellular pattern in plan.

DEVELOPMENT OF CONSTRUCTION TECHNIQUES:

- Conventional construction using locally available materials such as clay wood and bamboo.
- Stone masonry construction of structure.
- Brick masonry construction of structures.
- Construction of timber structures.
- Concrete masonry construction of structure.
- Concrete structures with cast in-situ and prefabricated structures.

HIGH RISE BUILDING TECHNOLOGY:

- Structural systems for tall buildings
- Rigid frame system
- Braced frame and shear walled frame systems
- Outrigger systems
- Framed tube system
- Braced tube system
- Bundled tube systems

RIGID FRAME SYSTEMS:

Rigid frame systems are utilized in both steel and reinforced concrete construction. Rigid frame systems for resisting lateral and vertical loads have long been accepted for the design of the buildings. Rigid framing namely moment framing is based on the fact that beam-to-column connections have enough rigidity to hold the nearly unchanged intersecting components.

BRACED FRAME AND SHEAR WALLED FRAME SYSTEMS:

Rigid frame systems are not efficient for buildings taller than 30 storey's because lateral deflection due to the bending of columns causes the drift to be too large on the other hand steel bracing or shear walls with or without rigid frame increases the total rigidity of the building and the resulting system is named as braced frame or shear walled frame system.

SEISMIC EFFECT

An earthquake is defined as natural vibration of earth crust produced by seismic forces. The focus is the place beneath the earth's surface from where an earthquake originates and the point on the earth's surface immediately above the focus is called epicenter. On the basis of depth the earthquake focus are generally distributed in three general depth ranges.

1. Shallow earthquakes – 60kms
2. Intermediate earthquakes – 60-300kms
3. Deep sea earthquakes - <300kms

The type and extent of damage to structures to structures during earthquakes depends on only the intensity, depth of focus, duration and location of epicentre but also on the strength of building materials, structural systems, joint details of members etc., quality of workmanship, proper anchorage of secondary elements to the main structure and soil conditions.

Summary of main sources of Earthquakes:

- Organic movements such as mountain building.
- Subduction and plate convection followed geothermal and mechanical disturbances.
- Volcanic activity.
- Land erosion.

EARTHQUAKE EFFECTS:

Direct Effects:

- Ground Shaking
- Ground Cracking
- Differential ground settlement
- Soil liquefaction
- Lateral Spreading
- Land slides
- Rockfalls

Indirect Effects:

- Landslide
- Tsunami
- Avalanches
- Rockfalls
- Floods Fires
- Toxic Contamination

During the earthquake effect on individual would be thrown out of bed at night, be unable to stand upright and be forced to kneel on the ground, fall downstairs, or even be tossed out of the swimming pool by the violent sloshing of the water.

ENVIRONMENTAL IMPACT OF MATERIALS:

Materials efficiency

Building materials typically considered to be green include rapidly renewable materials like bamboo. Total energy consumed in the life cycle of a product includes following process.

- Extraction
- Processing
- Transportation
- Disposal

Material	Embodied energy
Concrete	1.10
Steel	40.00
Stainless steel	57.00
Clay bricks	3.00
Terrazo Tiles	1.40
Ceramic Tiles	12.0
Aluminium	230.00

RESPONSIBLE SOURCING:

The construction sector is an important part of the economy having contributed about 8% to the national GDP over last 5 years. It also provides employment to 18 million people directly. The downside of this sector is its enormous resource and energy footprint. The impact is only set to increase with an estimated shortage of about 60 million hours during the twelfth five-year period of 2012-2017.

ECO-BUILDING:

Green Building: Buildings designed considering the concepts of sustainable design and reduction of environmental impacts due to site selection, water use, energy use materials and resources the buildings impact on the environment, and indoor air quality.

FOCUS ON GREEN BUILDING:

- Efficient utilization of resources, energy, water & building.
- Protection of occupants health and enhancement of employee productivity.
- Reducing waste, pollution and environment degradation as compared to conventional building.

MATERIALS USED:

The selection criteria for green building material shall be based broadly on

- Resource efficiency
- Indoor air quality
- Energy efficiency
- Water conservation
- Affordability
- Some green building materials
- Fly as bricks
- Autoclaved aerated concrete terrazzo tiles
- UPVC windows

- Bamboo jute composite doors
- Calcium silicate tiles

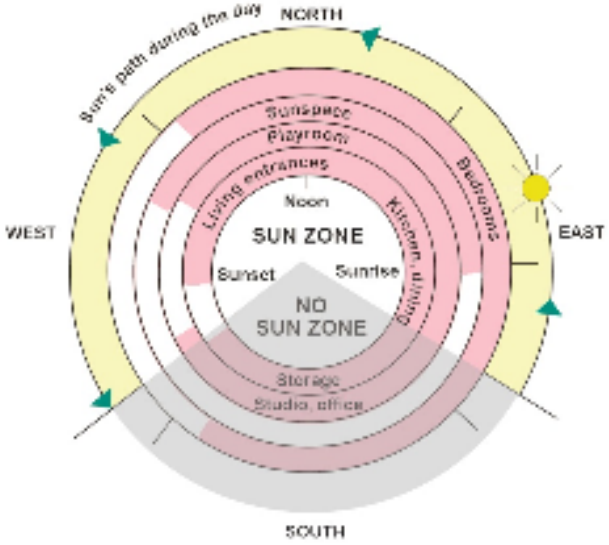
Construction Materials:

In this heading new definitions and attitudes about industrialization are presented by review of new related researches with an explanatory and analytical method to extract new directions in building industrialization included economical and social trends and sustainable approach.

The points regarding economy factory production and consistency are as followings:

- General organization of continuous production of a product applying similar knowledge and experience instead of new group formation for each project.
- Simplicity of process and reduction of the some of the consumed energy in each production project.
- Working in factory leads to avoid of loss of time arising from climate conditions.

NATURAL BUILDING:



CREATIVE COURTYARDS:

- They date back to the Harappan civilization.
- They are used for socializing, religious matters and family meetings.
- The purpose of the courtyard varied based on the occupation of the family as well. In large homes, there may be as many as five or six courtyards and each had a different function.

Home is where health is. Rural huts are usually not more than one room big. As soon as you enter such a house the first thing you will notice will be the most important part of the house the kitchen. Cooking and eating takes place on the floor, with entire family sitting together for meals. They use cow dung cakes wood and bio gas. Utensils are neatly stacked and are usually of terracotta steel or copper.

Pretty Puducherry

Puducherry is famous for the colonial French and franco-tamil architecture. The French styled architecture is suited for this town because of the weather with its long and huge windows with helical vertical cast iron bars as grills ornate balconies large courtyards, circular arched gates and stucco designs. They have flat roofs an inner courtyard with garden and colonnaded portions that serve a double function of protection from the sun and rain.

PASSIVE BUILDINGS

Basic principles:

Basic principles of passive design-I

The objective of this class is to find out the method of passive heating using solar geometry study the process of passive cooling and shading as one of its methods help understand the importance of the day lighting in design as a primary element is to study the importance of materials in sustainable design as well as the crucial element of indirect lightening.

Basic principle of passive design – 2

What does passive cooling mean? As much as possible passive cooling uses natural forces energies and heat sink since the goal is to create thermal comfort during the summer we can either cool the building by removing heat from the building by finding a heat sink or by raising the comfort zone sufficiently to include the higher indoor temperature by increasing air velocity so that the comfort zone shift to higher temperature.

INTELLIGENT BUILDINGS:

In addition to incorporating the major system previously described, intelligent buildings through the use of computers and communication equipment have the ability to control the total building environment the equipment & operating personal can be stationed in a so-called control center or the equipment can be monitored and controlled remotely via a computer, modem and telephone line.

Various sensors and communication devices feeding information to and from the control center are located in key areas throughout the building for the purpose of analyzing and adjusting the environment delivery messages during emergencies and dispatching repair personal and security guards as needed. To conserve energy lighting may be operated by sensors that detect people movement HVAC may be adjusted in accordance with temperature changes. Elevators may be programmed for efficient handling of variations in traffic patterns and may be equipped with voice synthesizers to announce floor steps and give advice in emergencies.

SECURITY CENTRE IN INTELLIGENT BUILDING

- Detect a break in attempt and sound an alarm.
- Identify the point of intrusion.
- Turn on light.
- Display the intruder on card reader.
- Notify the police.

- Limit entry to specific spaces only to approved personal and only at permitted time.
- Change locks automatically.

MEANING OF SMART BUILDING:

Smart building components distinguishes a “smart building” from normal and makes it smart.

BUILDING AUTOMATION (BA SYSTEM)

BA system consists of system installed in building that controls and monitors building services responsible for heating, cooling ventilation, air conditioning lighting, shading, life safety alarm security system and many more. ABAS aims at automating task in technologically enabled environments coordinating a number of electrical and mechanical devices interconnected in a distributed manner by means of underlying control networks.

SMART SOLUTIONS:

- Are not able to inter operate with other vendors solutions without additional overheads locking customers to specific product lines a major issue if such lines get discontinuous
- Are too complex to be used by non specialized personnel whether they are end-users or system developers.
- Only perform satisfactorily in the exact conditions they were tailored for not performing so well if the working environment changes thus lacking flexibility and
- Do not cover all the desired functionalities expected in a BAS.

ENERGY EFFICIENT BUILDINGS FOR VARIOUS ZONES

- Climate zone map of India
- Cold climate
- Composite climate

- Warm and humid climate
- Hot and dry climate
- Moderate climate

Orientation of the building in various climate zones.

Orientation of the building is generally used to refer to solar orientation which is the planning of building with respect to solar access. It is guided by natural elements like sunlight and its intensity, direction of the wind, seasons of the year and temperature variations. Size specific planning is very crucial for a nature friendly building and it should be oriented appropriate to the regions climate.

A building may have to take need of multiple orientation factors depending on functional requirements.

DESIGN STRATEGIES FOR VARIOUS CLIMATE ZONES

Design strategies in a cold climate

- Design according to the side slopes and orientation should preferably be in North-South direction.
- Glazing windows upto 25% floor area may be provided. Double glazing is preferable to avoid heat losses during nights.
- Adopt trombe walls as they are a very useful passive heating system. They require little or no effort no operate and are ideal for cold climates.

Design strategies in a composite climate:

- Plan or site plan the building to increase the cross ventilation of the internal rooms by providing them around the courtyard.
- Plan water bodies on the bigger sides which and wherever possible so that hot air can pass over them. Provision of cavity walls, terrace gardens, green roofs, light shelves to be increased in building planning.

- Design strategies in a hot and dry climate:
- Longer walls of building should face north and south. Non habitat rooms can be located on outer faces to act as thermal barrier. Preferably, the kitchen should be located on leeward side of the building to avoid circulation of hot air and smell from the kitchen.
- The day lighting of architectural space utilizes diffuse light from the sky dome direct beam orientation from the sun and reflected light from opening on west side.

CASE STUDIES OF RESIDENTIAL, OFFICE BUILDINGS AND OTHER BUILDING IN EACH ZONES:

Redevelopment of property at civil lines Delhi.

Design Features:

- Orientation of the building to cut off solar insulation during summer and let in winter sun.
- Design of sections to let in winter sun into the first floor rooms on the north side of the house.
- Terraces with skylights that admit winter sun.
- Insulated walls using innovative construction sandwich.
- Roof finished with china mosaic and is insulated using 30mm thick polyurethane board insulation above the RCC slab.

DESIGN FEATURES:

- Air heating panels designed as an integral part of the south wall
- Provide effective heat gain. Distribution of heat gain in the building through a connective loop that utilizes the stairwall as a means of distributing heated air.
- Double glazed windows with proper sealing to minimize infiltration.
- Insulated RCC diaphragm walls on the north to prevent heat loss and solar chimney.
- Specially designed solarium on south for heat gain.

UNIT II CONSTRUCTION PRACTICES

Specifications, 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 – pre cast 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.

Specification for construction

Specifications describe the materials and workmanship required for a development. They do not include cost, quantity or drawn information, and so need to be read alongside other information such as quantities, schedules and drawings. Specifications vary considerably depending on the stage to which the design has been developed, ranging from performance specifications (open specifications) that require further design work to be carried out, to prescriptive specifications (closed specifications) where the design is already complete.

Having a prescriptive specification when a contract is tendered gives the client more certainty about the end product, whereas a performance specification gives suppliers more scope to innovate, and adopt cost effective methods of work, potentially offering better value for money. Typically, performance specifications are written on projects that are straight-forward and are well-known building types, whereas prescriptive specifications are written for more complex buildings, or buildings where the client has requirements that might not be familiar to suppliers and where certainty regarding the exact nature of the completed development is more important to the client.

An exception to this might be a repeat client such as a large retailer, where a specific, branded end result is required and so whilst the building type is well known, the specification is likely to be prescriptive.

Most projects will involve a combination of performance and prescriptive specifications. Items crucial to the design will be specified prescriptively (such as external cladding) whilst less critical items are specified only by performance (such as service lifts).

Key to deciding whether to specify a building component prescriptively or not, is considering who is most likely to achieve best value, the client, the designers or the contractor.

Large clients may be able to procure certain products at competitive rates themselves (for example the government).

Some designers may have particular experience of using a specific product (although some clients may not allow designers to specify particular products as they believe it restricts competition and innovation and may relieve the contractor of their liability for 'fitness for purpose').

The contractor may be best placed to specify products that affect buildability.

Specifications should be developed alongside the design, increasing in level of detail as the design progresses. They should not be left until the preparation of production information. By tender they should describe every aspect of the building in such a way that there is no uncertainty about what the contractor is pricing.

Aspects of the works are generally specified by:

Products (by standard, a description of attributes, naming (perhaps allowing equivalent alternatives) or by nominating suppliers).

Workmanship (by compliance with manufacturers requirements, reference to a code of practice or standards, or by approval of samples or by testing).

It should be possible to verify standards of products and workmanship by testing, inspection, mock-ups and samples, and documentation such as manufacturers certificates.

Specifications should be structured according to work packages mirroring the separation of the works into sub-contracts. This makes it easier for the contractor to price and so may result in a more accurate tender. A standard classification system should be followed such as Uni-class.

The Building Sequence

It's fairly self-evident that to successfully build a home, you need to know not only the parts involved, but just as important, how they all go together . . . and in what order! Here then is a description, in broad terms, of the actual construction sequence for a typical home.

An important disclaimer is in order here.

Many things including, among others, the area of the country where it is being built, the design of the home, the availability of subs and materials, and the preference of the contractor, i.e. you, determine the actual sequence of construction.

1. STAKE LOT

This will usually involve a surveyor who will come out and accurately drive stakes to locate your home on the lot. They will be used by the excavators and foundation subcontractors to guide their work.

2. TEMPORARY UTILITIES

You will need to have water, electric power, and toilet facilities available during the construction process.

3. CLEAR AND ROUGH GRADE

Clearing is the removal of trees and undergrowth from the actual construction site and yard areas.

Rough grading is moving the dirt around to establish the approximate drainage patterns, yard areas, drive and walk levels, etc. that you hope to achieve.

4. WELL

If you are going to have a well, you might as well dig it up front so that you will have the water available for construction.

5. EXCAVATE

This is where a piece of earth-moving equipment digs the hole for your foundation, and, if you will have one, your basement.

6. FOOTINGS

This is the structure where the house interfaces with the earth that supports it. All of the weight of the home rests on the footings.

7. FOUNDATION

The foundation is the wall on which the first floor rests. It may be short - if you will have a crawl space, or tall - if you will have a basement.

8. WATERPROOFING AND FOUNDATION DRAIN

A waterproofing material or membrane (or both) is applied to the foundation walls which will be below grade to minimize water accumulating in the basement or in the crawl space. Foundation drains run along the footings and remove water accumulating in that area.

9. SEWER AND WATER TAPS

If you are connecting to municipal water and sewer, this is where the pipes are laid to the house and actually connected (tapped into) the water and sewer mains.

10. BACKFILL

Pushing the excavated dirt into the hole next to the foundation wall around the house (inside and out). This is a good time to establish the necessary drainage away from the house at the foundation wall.

11. SLAB PLUMBING

Any plumbing that needs to go into the basement floor is installed here.

12. SLAB OR BASEMENT FLOOR

The “slab” is the concrete basement floor. It is poured at this point. In some parts of the country, plans may call for a “structural wood floor” (more on this later). Now is when it would be installed.

13. FRAMING, WINDOWS, AND EXTERIOR DOORS

This is where it starts to look like a house! The floors, walls, ceiling, and roof are the focus of this construction activity. The framer usually installs the windows and exterior doors.

14. EXTERIOR SIDING AND TRIM

Whatever you are using - brick veneer, siding, stucco, etc.- here is where it gets done.

15. GARAGE DOOR AND EXTERIOR LOCKS

Some people wait until the end to get the garage door in. But we think having it in place creates a good place to store materials and equipment during construction. Installing the exterior locks means that the whole house is secure.

16. BACK-OUT FRAMING

This is a general category that includes partition walls that have not been installed, pillars, soffits for wall cabinets, and drywall nailers.

17. FIREPLACE AND CHIMNEY

A prefabricated fireplace should be installed before the roughs (below). A prefab will have a framed chimney. A masonry fireplace and chimney can be installed before the brick veneer.

18. STAIRS

Get these in now so that the subs working inside can get from one floor to the other without depending on ladders.

19. ROUGH HVAC

The HVAC (heating, ventilation, air conditioning) sub is the first of the three "mechanical" subs (plumbing, electrical, HVAC) to come to the job. He will install the duct work for your HVAC system and possibly the furnace. He comes first because the stuff he puts into the walls is the biggest and most inflexible.

20. ROUGH PLUMBING

Next comes the plumber to install his pipes.

21. ROOFING

With plumbing and HVAC vent pipes through the roof, the roofer can install the roofing.

22. ROUGH ELECTRICAL

Codes call for the house to be "dried in" before the wiring is installed. With the exterior windows and doors in place and the roof on, it's time. For roughs, the electrician will put in the boxes (switch, outlet, and lighting) and will pull the wires into them. Cable, telephone, speakerwires, etc. are also installed at this point.

23. ELECTRIC & GAS METER SET

You will need these in place to get some heat in the house for the drywall installation.

24. GUTTERS AND DOWNSPOUTS

Its good to get the water away from the house as soon as possible.

25. EXTERIOR PAINT

Many surfaces on the outside need to be protected from the elements. So you‟ll want to paint as soon as is practical.

26. INSULATION

Once everything else is in the walls and rough inspections are completed, it‟s time to insulated your home.

27. TEMPORARY HEAT

With the meters set (above), the HVAC sub can get some temporary heat in the house. This will be critical for getting the drywall joint compound (mud) to dry in a timely fashion. The carpet sub also needs a warm home so that the carpet is installed at a temperature comparable to normal living conditions.

28. DRYWALL

Sometimes called "Sheetrock." This will be "hung" (nailed or screwed to the wall studs and ceiling joists), taped (at the joints), and "mudded" (joint compound applied) after the in-wall plumbing, HVAC, electricals, and insulation have been inspected!

29. CABINETS

Base and wall.

30. INTERIOR DOORS AND TRIM

The trim materials installed here may include the door casing, base mould, window stool and apron, window casing, chair rail, crown mould, built-in cabinets, stair railing parts, and others.

31. PAINT AND WALLPAPER

The first coat of paint is usually sprayed. Get it in before the hard wood floors are installed.

32. HARDWOOD FLOORS

Now its time to install your hardwood floors.

33. COUNTER TOPS

Counter tops are next. This may involve a different sub than the one who installed the cabinets.

34. VINYL AND CERAMIC TILE

Vinyl floor coverings and ceramic tile are installed. Two different subs. Probably should have made these two different steps, but I was trying to make it come out to an even 50!

35. SAND AND FINISH WOOD FLOORS

This is the first of two finishes. The last is done just before you move in.

36. APPLIANCES AND SPECIAL EQUIPMENT

This would include all of your major appliances - washer, dryer, range, oven, refrigerator, as well as any other special equipment you have specified.

37. FINISH ELECTRICAL

Here is where the electrician comes back to install the switches, outlets, light fixtures, ceiling fans, door bells, etc. He will also hook up the appliances, furnace, air conditioner, doorbell, and so forth.

38. FINISH PLUMBING

The plumber will install the sinks, lavatories, toilets, and all the faucets.

39. FINISH HVAC & FINAL HEAT

Your heating sub will install the registers and get the furnace and air conditioning running properly.

40. SHOWER DOORS AND MIRRORS

Install shower doors. Hang mirrors.

41. CARPET

Now its starting to feel like home!

42. HARDWARE AND SCREENS

Typically, this is door, window, and closet hardware. Window screens.

43. DRYWALL REPAIRS

You may need to get the drywall subcontractor back out to patch some dings caused by the other sub work. This is normal.

44. CLEAN UP

This is the final interior clean up.

45. FINAL PAINT

Touching up drywall repairs and so forth.

46. FINAL WOOD FLOOR FINISH

This should be your last inside job before moving in.

47. RETAINING WALLS

These outside jobs can be going on while the work proceeds inside. You should not have these going on while the outside is being painted.

48. WALKS, DRIVES, AND PATIOS

You should wait until the drywall has been delivered to the home, because the drywall truck is VERY heavy, and could damage your flat work

49. SEPTIC TANK AND DRAIN FIELD

Same as above on the timing with regard to the drywall delivery. The tank holds the waste and allows microbic action on the solids. The drain field is where the effluent leaches into the soil.

50. FINISH GRADING AND LANDSCAPING

The final finished grades are established to ensure proper drainage away from the home, and to prepare the yard for landscaping. Trees, shrubs, grass, etc. are installed.

CONSTRUCTION CO ORDINATION:

Coordination can be seen as a process of managing resources in an organized manner so that a higher degree of operational efficiency can be achieved for a given project.

Two coordination methods have been identified as appropriate to be used in the design process, namely, direct contact and meetings.

Direct contact

Direct contact has been identified as the simplest form, and one that involves minimal cost among the methods of coordination .Two types of direct contacts are used in projects: direct formal contact and direct informal contact. Each method encompasses different approaches in gathering useful information. A combination of these methods could send reasonably accurate messages quickly in all directions, and could be able to deal with all the major uncertainties that arise within the project organization. Because of the iterative nature of the design process, the number of participants and the fragmentation of building systems, the increased use of direct contact is critically required.

Direct formal contact

Direct formal contact refers to the documented information that could be obtained by letters, memos and reports. This approach is more formal, and is widely used as a means of communication among the different organisations that are involved in a project. Direct formal contact has been identified as one of the means used by designers for obtaining design information.

In managing a risky project, proper documents are always needed to protect the participants involved. Formal documents could be used for litigation or as evidence in any contract dispute, such as variation claims in projects. Therefore, it is important to use direct formal contact in handling uncertainty in the refurbishment design, such as in design changes.

Direct informal contact

Any information obtained using informal conversations such as telephone calls or discussions is categorized under direct informal contact. As the design process has a large number of participants and a high degree of interdependence of building design, the demand for informal contact is increased. The uncertain nature of refurbishment projects requires an approach that is more flexible.

One of the advantages of using direct informal contact is that information can be gathered quickly without the need for any formal procedure. Informal contact provides clearer information in a short time, and hence is useful in confirming certain issues pertaining to the design process.

The refurbishment design process involves a large amount of information flow. Therefore, direct informal contact could resolve the problem of inefficiency in flow of design information, especially when design changes occur during the construction stage.

Meeting

The purpose of meetings is to keep key participants informed, and to handle shared problems arising in the projects. Meetings are one way to increase the amount of information in construction projects, as a meeting mostly covers the current issues of the design.

All the feedback and comments from the design team's participants could be discussed instantly in the meeting. The design process normally involves participants from different organisations, who form a group known as a design team. Meetings are seen as a medium to increase interaction among the design team members. There are two types of meetings in construction projects: scheduled and unscheduled meetings. Both types are important in achieving better integration in the management of the refurbishment design process.

Scheduled meeting

Scheduled meetings for the design process are conducted at intervals of one a week to report on the progress of the design work and to discuss any issues that arise. The scheduled meeting for design diminishes slowly once the construction stage starts. A scheduled meeting can transform into an unscheduled meeting if any problems crop up during the construction stage. The functions of a scheduled meeting are to coordinate and to act as a means of conveying information about current progress of work and recent design changes. In a construction project, the scheduled meeting is an appropriate venue and suitable time for the project participants to discuss any issues related to the project. Problems in design could be discussed and finalized during the meeting, which could lead to a reduction in design errors during the construction stage.

Unscheduled meetings in the design process

An unscheduled meeting would be held if there was any urgent need to solve current issues related to design. This type of meeting normally takes over from a scheduled meeting in the design process when work has started onsite or between the intervals of scheduled meetings.

Problems arising onsite, such as discrepancies in drawings that need to be solved urgently, are typical situations when an unscheduled meeting would be called. However,

the need to attend unscheduled meetings requires the participants in refurbishment projects to be flexible and responsive. They may need to forgo their routine activities in order to attend unscheduled meetings for refurbishment projects. The allocation of time and overhead cost for refurbishment design works tends to increase if there are many unscheduled meetings during the construction stage. The need for unscheduled meetings increases during the construction stage, as many unknown items start to be discovered. The unscheduled meeting is probably suitable to cater to the uncertainty of design information in refurbishment projects. The unscheduled meeting would be least important if there were no urgent decisions to be confirmed. Minor design problems that arise could be discussed at the next scheduled meeting of the project.

Site clearance

Site clearance involves the removal of walls, hedges, ditches, and trees, other vegetation and services from the site. It can also involve the clearance of fly-tipped materials.

Carbon reduction and business efficiency

Buying sustainable goods & services

Emergency response

Environmental Damage
Spills at construction sites

Land: Construction

Archaeology at construction sites
Nature conservation and affecting public rights of way in construction
Site investigation and sampling to assess contamination
Soils and soil stripping at construction sites

Land: General

Contaminated Land
Japanese knotweed, giant hogweed and other invasive weeds

Materials and equipment: Construction

Generators at construction sites
Plant maintenance at construction sites
Road sweepers at construction sites

Materials and equipment: Hazardous

Chemical storage
Fuelling and fuel storage
Oil storage

Nuisances

Dust from construction sites
Noise from construction sites
Noise, odour and all nuisances

Permits and licences

Permits and licences - an overview

Trade associations and BSOs

Construction trade associations

Transport
Vehicle movements and deliveries at construction sites
Waste: Storage handling and transport
Duty of care – your waste responsibilities
Site waste management plans
Waste storage and transport
Waste: Waste materials
Asbestos
Fly-tipped material
Hazardous/special waste
Tyres
Waste oil
Waste: Waste treatment
Burning construction and demolition wastes
Chipping wood and other plant material
Crushing bricks, tiles, concrete and other materials
Recycling construction materials
Water
Bunds at construction sites
Controlling surface water run-off
Dewatering during construction
Discharges to water and sewer
Settlement tanks
Trade effluent – discharges to sewers
Water use and abstraction
Wheel washing at construction sites
Working close to rivers - const
What is setting out?

A definition of setting out, often used, is that it is the reverse of surveying. Whereas surveying is a process for forming maps and plans of a particular site or area, setting out begins with plans and ends with the various elements of a particular plan correctly positioned on site.

However most techniques and equipment used in surveying are also used in setting out i.e. while surveying may be the opposite of setting out, the processes and instruments are almost identical.

The International Organisation for Standardisation (ISO) define setting out as:
Setting out is the establishment of the marks and lines to define the position and level of the elements for the construction work so that works may proceed with reference to them. This process may be contrasted with the purpose of surveying which is to determine by measurement the position of existing features. Setting out is one application of surveying
Most of the techniques and equipment used in surveying are also used in setting out
Mistakes in setting out can be costly
For setting out to be undertaken successfully good work practices should be employed.

There are three parties involved in the construction procedures: the employer, the engineer and the contractor
Although the engineer checks the work, the setting out is the responsibility of the contractor
The cost of correcting any errors in the setting out has to be paid for by the Contractor, provided the engineer has supplies reliable information in writing

Earthworks are engineering works created through the moving or processing of parts of the earth's surface involving quantities of soil or unformed rock. The earth may be moved to another location and formed into a desired shape for a purpose. Much of earthworks involves machine excavation and fill or backfill

Types of excavation

Excavation may be classified by type of material:
Topsoil excavation
Earth excavation
Rock excavation
Muck excavation - this usually contains excess water and unsuitable soil
Unclassified excavation - this is any combination of material types
Excavation may be classified by the purpose:
Stripping
Roadway excavation
Drainage or structure excavation
Bridge excavation
Channel excavation
Footing excavation
Borrow excavation
Dredge excavation
Underground Excavation

Masonry:

It is the building of structures from individual units laid in and bound together by mortar; the term *masonry* can also refer to the units themselves. The common materials of masonry construction are brick , stone , marble , granite , travertine , limestone , cast stone , concrete block , glass block, stucco , tile , and cob. Masonry is generally a highly durable form of construction.

However, the materials used, the quality of the mortar and workmanship, and the pattern in which the units are assembled can significantly affect the durability of the overall masonry construction. A person who constructs masonry is called a **mason** or **bricklayer**.

Applications

Masonry is commonly used for the walls of buildings, retaining walls and buildings. Brick and concrete block are the most common types of masonry in use in industrialized nations and may be either weight-bearing or a veneer. Concrete blocks, especially those with hollow cores, offer various possibilities in masonry construction.

They generally provide great compressive strength, and are best suited to structures with light transverse loading when the cores remain unfilled.

Filling some or all of the cores with concrete or concrete with steel reinforcement (typically rebar) offers much greater tensile and lateral strength to structures.

Advantages

The use of material such as bricks and stones can increase the thermal mass of a building and can protect the building from fire.

Most types of masonry typically will not require painting and so can provide a structure with reduced life-cycle costs.

Masonry is non-combustible product.

Masonry walls are more resistant to projectiles, such as debris from hurricanes or tornadoes.

Masonry structures built in compression preferably with lime mortar can have a useful life of more than 500 years as compared to 30 to 100 for structures of steel or reinforced concrete.

Disadvantages

Extreme weather, under certain circumstances, can cause degradation of masonry wall surfaces due to frost damage.

Masonry tends to be heavy and must be built upon a strong foundation, such as reinforced concrete, to avoid settling and cracking.

Other than concrete, masonry construction does not lend itself well to mechanization, and requires more skilled labor than stick-framing.

Masonry consists of loose components and has a low tolerance to oscillation as compared to other materials such as reinforced concrete, plastics, wood, or metals.

Stone Masonry and brick stone masonry

Types of Stone Masonry:

Stone masonry may be broadly classified into the following two types:

1. Rubble Masonry
2. Ashlar Masonry

1. Rubble Masonry:

The stone masonry in which either undressed or roughly dressed stone are laid in a suitable mortar is called rubble masonry. In this masonry the joints are not of uniform thickness. Rubble masonry is further sub-divided into the following three types:

1. Random rubble masonry
2. Squared rubble masonry
3. Dry rubble masonry

1. **Random rubble masonry:**

The rubble masonry in which either undressed or hammer dressed stones are used is called random rubble masonry. Further random rubble masonry is also divided into the following three types:

Un coursed random rubble masonry:

The random rubble masonry in which stones are laid without forming courses is known as uncoursed random rubble masonry. This is the roughest and cheapest

type of masonry and is of varying appearance. The stones used in this masonry are of different sizes and shapes before lying, all projecting corners of stones are slightly knocked off. Vertical joints are not plumbed, joints are filled and flushed. Large stones are used at corners and at jambs to increase their strength. Once "through stone" is used for every square meter of the face area for joining faces and backing.

Suitability: Used for construction of walls of low height in case of ordinary buildings.

Coursed random rubble masonry:

The random rubble masonry in which stones are laid in layers of equal height is called random rubble masonry. In this masonry, the stones are laid in somewhat level courses. Headers of one coursed height are placed at certain intervals. The stones are hammer dressed.

Suitability: Used for construction of residential buildings, go downs, boundary walls etc.

1. **Squared rubble masonry:**

   The rubble masonry in which the face stones are squared on all joints and beds by hammer dressing or chisel dressing before their actual laying, is called squared rubble masonry. There are two types of squared rubble masonry.

Coursed Square rubble masonry: The square rubble masonry in which chisel dressed stones laid in courses is called coarse square rubble masonry. This is a superior variety of rubble masonry. It consists of stones, which are squared on all joints and laid in courses. The stones are to be laid in courses of equal layers. and the joints should also be uniform.

Suitability: Used for construction of public buildings, hospitals, schools, markets, modern residential buildings etc and in hilly areas where good quality of stone is easily available.

Bonds:

In brick masonry, there are many techniques to stack bricks. These different arrangements are known as bricks bonds. Each bond has its own characteristics.

Following are the commonly used bricks bonds.

1. Stretcher Bond
2. English Bond
3. Flemish Bond
4. Common/American/English Garden Wall Bond
5. Flemish Garden Wall Bond
6. Herringbone Bond

and there are many other brick bonds which a designer can design for custom requirements

1. Stretcher Bond

Easiest bond to lay & it minimizes the amount of cutting required.

Originally used for single brick walls.

It is used for cavity walls as less cutting is required.

Walls are half brick wide.

No two adjacent vertical joints should be in line.

2. English Bond

Alternative courses of headers and stretchers.

One header placed centrally above each stretcher.

This is a very strong bond when the wall is 1 brick thick (or more thicker).

One of the strongest brickwork patterns.

3. Flemish Bond

Alternate bricks are placed as header and stretcher in every course.

Each header is placed centrally between the stretcher immediately above and below. This is not a strong as the English bond at 1 brick thick.

It can be successfully applied in cavity wall.

4. Common/American/English Garden Wall Bond

A pattern made like Stretcher bond but with a row of headers replacing every nth course (n is usually odd).

5. Flemish Garden Wall Bond

In this variant of Flemish bond, one header is placed at every third stretcher.

6. Herringbone Bond

It is a purely decorative bond. It is used in floor and wall panels

Concrete Masonry Blocks

Concrete masonry blocks have been in existence for centuries. Revolutionary changes in manufacturing technology and material sciences have made multi sized, shaped, colours and textured blocks a reality. They are used as both structural and non-structural components and have been the preferred building blocks in the western world. They are fast replacing traditional bricks and other masonry products in India too.

Concrete Masonry Blocks can either be

- Hollow or Solid
- Load Bearing or Non-load Bearing
- Light weight or Dense

Shield concrete blocks are used in low and high rise buildings, for basements, exterior and interior walls and partitions.

Applications

Shopping Malls, Multiplexes, Multifunctional Complexes such as IT Parks, Institutional Building, Independent Residences, Farmhouses, Villas, Residential Complexes, Hotels, Resorts, Schools, Colleges, Hospitals, Ports, Airports, Mass Transport Stations, Factory Buildings, Warehouses, Sports Stadiums

FLOORING

Concrete Flooring

Concrete floor finishes are typically only used in basements and garages. The floor should slope down to a floor drain in basements and other areas where water may accumulate.

In modern construction, a four to six inch gravel base below the 3-inch thick floor slab allows water below the slab to drain away. Moisture barriers (plastic sheets) may also be provided under the slab, and in energy efficient construction or slab-on-grade

construction, rigid insulation may be used below the floor. In older construction, concrete floor slabs were as thin as 1/2 inch.

These are prone to impact damage, heaving and break-up.

This is a cosmetic issue and may be a trip hazard. Most concrete floors are not part of the structure. Basement floors are typically installed after the home is completed, and their main function is to keep our feet out of the mud.

Concrete basement floors can be overlaid with finished flooring. Since almost every house with a basement has water on the basement floor at some point, water-resistant floors make sense. In slab-on-grade construction, the concrete floors provide a substrate for floor finishes.

Concrete Floor

FLOOR, CERAMIC TILE
FLOOR, CONCRETE SLAB CHOICES
FLOOR DAMAGE DIAGNOSIS
FLOOR, ENGINEERED WOOD, LAMINATES INSTALL
FLOOR FRAMING & SUBFLOOR for TILE
FLOOR, KITCHEN & BATH OPTIONS
FLOOR, LAMINATE PLASTIC
FLOOR, CONCRETE POURED FINISH

Kitchen & Bath Floor Options

FLOOR, KITCHEN & BATH OPTIONS

Laminate Flooring, (Plastic Laminate Floors and Engineered Wood floors)

In recent years, laminate flooring has become very popular, especially among do-it-yourselfers.

Laminate floor planks (or tiles) have several layers. The top layer is generally a clear laminate that is bonded to a decorative layer below, often creating the look of a wood floor. These layers are bonded to a wood- or fiber-based core. The bottom layer may be a paper or melamine backing. The product is similar to resilient countertops. A complete floor is created by either snapping planks together with specially-designed fasteners along the edges, or by gluing planks together along traditional tongue and groove edges.

Laminate flooring is not secured to the subfloor beneath it. Instead, it is installed as a floating floor, allowing it to expand and contract. A sheet of cushioning foam is installed between the laminate flooring and the subfloor. There may also be a sheet of plastic below the foam to act as a moisture barrier and to allow the floor to slide as it expands. A gap is required between the flooring and the walls to allow for expansion. This gap is covered by trim. Laminate flooring cannot be sanded, stained, or otherwise refinished, although damaged planks can be replaced.

Laminate flooring is resistant to small amounts of water, such as quickly wiped-up spills, but precautions should be taken in kitchens or bathrooms including applying a sealant around the perimeter. This is not visible during a home inspection. Laminate flooring should not be installed in damp basement areas.

List of Non-Resilient & Resilient Floor Coverings Used in buildings.

Definitions of Non-resilient Flooring & Resilient Flooring

Non-resilient floor coverings used in buildings that can assist in determining the age of a structure include bamboo, brick, concrete, stone, slate, and a wide variety of wood products.

Definition of non-resilient flooring:

"Non-resilient" flooring is defined as hard surfaced flooring material such as stone, brick, slate, or ceramic tile.

Definition of resilient flooring

"Resilient flooring" is defined as materials softer than the non-resilient materials we just listed (stone, slate, brick, ceramic tile), and includes organic types of flooring: asphalt based floor tiles, cork floor tiles, cork floor planks, linoleum sheet flooring (antique & modern), plastic floor tiles, rubber floor tiles, vinyl-asbestos floor tiles.

So what's "wood flooring"? After all, it is organic too. Is a wood floor non-resilient, resilient, or just "wood"?

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Different types of damp proof course

Damp proof courses (DPC‟s) are types of barriers designed to span across the length or width of your walls to prevent the onset of rising or penetrating damp; there are various options to choose from, including:

Solid DPC – a solid DPC is made of some kind of waterproof material – such as bituminous felt, copper sheet or polythene – and is fitted either horizontally or vertically on the exterior or interior of the wall, at least six inches above ground level.

Chemical DPC – this involves drilling holes 10-12mm in diameter into the wall (also at least 6in above ground level), and injecting liquid silicone-based chemicals into the holes using a high pressure pump to create a water repelling layer in the wall. This often proves a more practical and less obtrusive DPC for home owners, but it can take a few months for results to emerge and the effectiveness will vary as the chemicals won't pass through the walls evenly. This method won't work on breeze block walls, as they are non-porous and thus won't allow the chemicals to permeate properly.

Porous tube DPC – this DPC involves fitting small clay tubes into closely spaced rows along the wall, also into the mortar at least 6in above ground level; these tubes then allow moisture to locate an outlet that allows it to evaporate more freely and therefore limits the amount of water that can rise above them. This is a relatively simple and cheap method but it doesn't always produce effective results.

Electro osmotic DPC – if you want a more scientific based DPC, electricity can even be utilized to help prevent the onset of damp. Titanium cathodes and anodes are fitted into the interior of the wall and power is drawn from the mains supply, usually by using a standard 13amp socket. The entire system is professionally earthed and the subsequent injected electricity creates an electric field, whereby the water molecules are naturally drawn downwards toward the negative electrodes and away from the bulk of the wall. The system is specifically designed to counteract the rising water that causes damp.

JOINTS IN CONCRETE CONSTRUCTION

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Suitability: Used for construction of public buildings, hospitals, schools, markets, modern residential buildings etc and in hilly areas where good quality of stone is easily available.

Why Precast?

Faster Construction

What do we mean by faster construction? We're not necessarily talking about how fast the pavement can be constructed, but rather how fast it can be opened to traffic. Conventional castin-place pavement requires several days of additional curing time after the concrete is placed before it is strong enough to withstand traffic loading. While "fast-setting" concrete mixtures have been developed for this purpose, these can be cost-prohibitive for large-scale pavement construction.

Reduced User Delay Costs

What are user delay costs? These are costs to the drivers of the roadway that are directly attributable to congestion caused by construction activities. Increased fuel consumption, lost work time, increased vehicle wear and tear, and increased air pollution are just a few of these costs. The savings in user delay costs realized through limiting construction to only off-peak travel times (at night or over a weekend) can be substantial. This is where the primary economic benefit of precast pavement will be realized.

Improved Durability and Performance

Precast concrete has a proven track record as a durable high-performance product for bridge and commercial building construction. This is the result of a high degree of quality control that can be achieved at a precast fabrication plant. High strength, low permeability concrete mixtures with a low water-cement ratio and uniform aggregate gradation are used routinely by precast fabrication plants. At most plants concrete batching and quality control is done on-site and the concrete is transported only a short distance from the batch plant to the forms, minimizing changes in concrete properties between the mixing and placing operations. What's more, precast fabrication plants offer tremendous flexibility over the curing operation. Precast concrete elements can be fabricated indoors, they can be wet-mat cured, steam cured, and curing can be maintained as long as necessary after casting. Problems that can plague cast-in-place pavement construction such as surface strength loss, "built-in" curling, and inadequate air entrainment, can all be eliminated with precast concrete.

Why Prestressed Precast Pavement?

Prestressing has a proven track record for enhancing the performance and durability of concrete structures. And though it has seen very limited use in pavements,

there are clearly benefits of prestressed concrete pavement, such as reduced cracking, reduced slab thickness, and bridging capability.

Reduced Cracking

While conventional pavements are “designed” to crack at specific locations (at saw cut joints for JCP) or at regular intervals (CRCP), in general cracking is not desirable. Cracks can spall, they can permit water to penetrate the underlying base, they can fault, and they can eventually lead to severe pavement failures such as punch outs. Prestressing helps to minimize or even eliminate cracking. By putting a pavement in compression there is less likelihood of cracking due to tensile stresses. What’s more, the so-called “elasto-plastic” behavior of prestressed concrete will help keep any cracks that do form tightly closed.

Reduced Slab Thickness

While the underlying pavement structure is also a factor, the primary controlling factor in pavement thickness design is the magnitude and number of wheel load repetitions on the pavement over its expected design life. For a given pavement support structure and a given wheel load, tensile stresses in a thinner pavement will be higher than those in a thicker pavement. These higher stresses wear out or fatigue a concrete pavement faster. Prestressing can be used to reduce the tensile stresses in a thinner pavement slab to those of a much thicker pavement slab, increasing the design life of the pavement.

Why is this important? First is the savings in concrete material. Constructing an 8-inch thick pavement slab instead of a 12-inch-thick pavement slab will save more than 780 cubic yards of concrete per lane-mile. Secondly, for removal and replacement it is generally necessary to match the existing slab thickness. Most existing pavements that are in need of replacement are on the order of 8-10 inches thick. Prestressing permits in-kind replacement of the existing pavement with a pavement slab that will have a design life of a much thicker slab. Finally, slab thickness can often times be governed by overhead clearance constraints. When replacing a pavement under a bridge overpass, for example, it is often not possible to construct a thicker pavement than what was in place already without having to excavate base material.

Bridging Capability

Prestressing gives the pavement a certain “bridging” capability that permits the pavement slab to span small voids and “soft” base materials beneath the pavement. This is critical for pavement removal and replacement operations that are limited to short (overnight) construction windows when it is often not possible to recondition or replace the underlying base material.

FOUNDATIONS

The foundations of the building transfer the weight of the building to the ground. While 'foundation' is a general word, normally, every building has a number of individual foundations, commonly called footings. Usually each column of the building will have its own footing.

Since the weight of the building rests on the soil (or rock), engineers have to study the properties of the soil very carefully to ensure that it can carry the loads imposed by the building. It is common for engineers to determine the ***safe bearing capacity*** of the soil after such study. As the name suggests, this is the amount of weight per unit area the soil can bear. For example, the safe bearing capacity (SBC) at a location could be 20 T/m2, or tonnes per square metre.

This capacity also changes at different depths of soil. In general, the deeper one digs, the greater the SBC, unless there are pockets of weak soil in the earth. To properly support a building, the soil must be very firm and strong. It is common for the soil near the surface of the earth to be loose and weak. If a building is rested on this soil, it will sink into the earth like a ship in water. Building contractors will usually dig until they reach very firm, strong, soil that cannot be dug up easily before constructing a foundation.

To study the properties of the soil before designing foundations, engineers will ask for a ***soil investigation*** to be done. A soil investigation engineer will drill a 4" or 6" hollow pipe into the ground, and will remove samples of the earth while doing so. He will then send these samples to a lab to find out the detailed properties of the soil at every depth. Soil is usually composed of *strata*, or different layers, each with its own set of properties. Drilling technology today makes it easy and economical to drill to great depths, easily several hundred metres or more, even in hard rock.

The soil investigation team will then prepare a *soil investigation report* that lists the engineering properties of the soil at regular intervals, say every 2 meters. Based on this deport, engineers designing the structure can decide at what depth of soil to provide the foundations, the type of foundations they should provide, and the size of the foundations.

Every once in a while, engineers will find ***fill*** at a site. This occurs when humans have previously dug up the earth there, and then filled it back in. This happens if a quarry was dug or a building built there previously. Since fill is loose and soft and cannot support weight, engineers will dig to a depth below that of the fill, where strong soil is found, and construct foundations there.

TYPES OF FOUNDATIONS

Broadly all foundations are divided into two categories: shallow foundations and deep foundations. The words shallow and deep refer to the depth of soil in which the foundation is made. Shallow foundations can be made in depths of as little as 3ft (1m), while deep foundations can be made at depths of 60 - 200ft (20 - 65m). Shallow foundations are used for small, light buildings, while deep ones are for large, heavy buildings.

SHALLOW FOUNDATIONS

Shallow foundations are also called spread footings or open footings. The 'open' refers to the fact that the foundations are made by first excavating all the earth till the bottom of the footing, and then constructing the footing. During the early stages of work, the entire footing is visible to the eye, and is therefore called an open foundation. The idea is that each footing takes the concentrated load of the column and spreads it out over

a large area, so that the actual weight on the soil does not exceed the safe bearing capacity of the soil. There are several kinds of shallow footings: individual footings, strip footings and raft foundations. In cold climates, shallow foundations must be protected from freezing. This is because water in the soil around the foundation can freeze and expand, thereby damaging the foundation. These foundations should be built below the *frost line*, which is the level in the ground above which freezing occurs. If they cannot be built below the frost line, they should be protected by insulation: normally a little heat from the building will permeate into the soil and prevent freezing.

Individual footings

Individual footings are one of the most simple and common types of foundations. These are used when the load of the building is carried by columns. Usually, each column will have its own footing. The footing is just a square or rectangular pad of concrete on which the column sits. To get a very rough idea of the size of the footing, the engineer will take the total load on the column and divide it by the safe bearing capacity (SBC) of the soil. For example, if a column has a vertical load of 10T, and the SBC of the soil is 10T/m2, then the area of the footing will be 1m2. In practice, the designer will look at many other factors before preparing a construction design for the footing.

Individual footings connected by a plinth beam. Note that the footings have been cast on top of beds of plain cement concrete (PCC), which has been done to create a level, firm base for the footing.

Individual footings are usually connected by a *plinth beam*, a horizontal beam that is built at ground or below ground level.

Strip footings

Strip footings are commonly found in load-bearing masonry construction, and act as a long strip that supports the weight of an entire wall. These are used where the building loads are carried by entire walls rather than isolated columns, such as in older buildings made of masonry.

Raft or mat foundations

Raft Foundations, also called Mat Foundations, are most often used when basements are to be constructed. In a raft, the entire basement floor slab acts as the foundation; the weight of the building is spread evenly over the entire footprint of the building. It is called a raft because the building is like a vessel that 'floats' in a sea of soil.

Mat Foundations are used where the soil is week, and therefore building loads have to be spread over a large area, or where columns are closely spaced, which means that if individual footings were used, they would touch each other.

DEEP FOUNDATIONS

Pile foundations

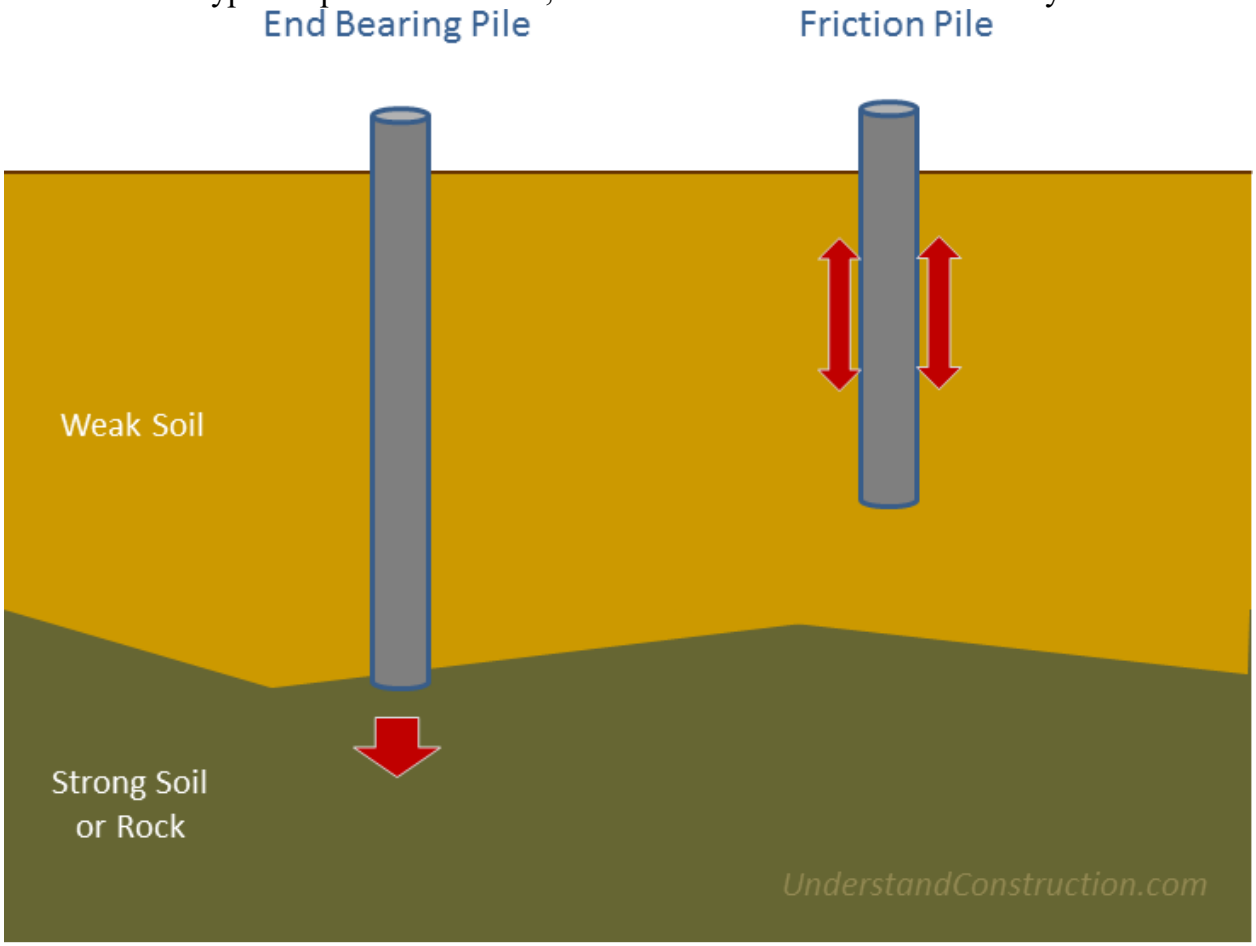
A pile is basically a long cylinder of a strong material such as concrete that is pushed into the ground so that structures can be supported on top of it.

Pile foundations are used in the following situations:

1. When there is a layer of weak soil at the surface. This layer cannot support the weight of the building, so the loads of the building have to bypass this layer and be transferred to the layer of stronger soil or rock that is below the weak layer.

2. When a building has very heavy, concentrated loads, such as in a high rise structure. Pile foundations are capable of taking higher loads than spread footings.

There are two types of pile foundations, each of which works in its own way.



End Bearing Piles

In end bearing piles, the **bottom end of the pile rests on a layer of especially strong soil or rock**. The load of the building is transferred through the pile onto the strong layer. In a sense, this pile acts like a column. The key principle is that the bottom

end rests on the surface which is the intersection of a weak and strong layer. The load therefore bypasses the weak layer and is safely transferred to the strong layer.

Friction Piles

Friction piles work on a different principle. The pile transfers the load of the building to the soil across the full height of the pile, by friction. In other words, the entire surface of the pile, which is cylindrical in shape, works to transfer the forces to the soil.

To visualize how this works, imagine you are pushing a solid metal rod of say 4mm diameter into a tub of frozen ice cream. Once you have pushed it in, it is strong enough to support some load. The greater the *embedment depth* in the ice cream, the more load it can support. This is very similar to how a friction pile works. In a friction pile, the amount of load a pile can support is directly proportionate to its length.

A **foundation** (or, more commonly, **foundations**) the element of an architectural structure which connects it to the ground and transfers loads from the structure to the ground. Foundations are generally considered either shallow or deep.

1. Foundation engineering is the application of soil mechanics and rock mechanics (Geotechnical engineering) in the design of foundation elements of structures.

Basement

A **basement** or **cellar** is one or more floors of a building that are either completely or partially below the ground floor . Basements are generally used as a utility space for a building where such items as the boiler , water heater , breaker panel or fuse box, car park, and air-conditioning system are located; so also are amenities such as the electrical distribution system, and cable television distribution point. However in cities with high property prices such as London, basements are often fitted out to a high standard and used as living space.

Construction of basement in Top-Down method

Technology particulars:

Top-down technology (downward) is the advanced method employed to substructure construction, other than the conventional method (upward).In this method, basement concrete slabs act as lateral bracing for the perimeter wall system.

Ground level and first basement slabs are poured, with access holes left to allow excavation beneath. As each subsequent subgrade level is completed, the floors act as lateral bracing for the perimeter wall system.

Advantages:

Working space and construction duration: it is not required a large working space for foundation excavation and saving cost by eliminating to construct the retaining wall. Especially for public transport works as traffic tunnels, this method helps to soon re-established trafffic road. And the top-down method of construction enables a high-rise superstructure and its sub-basement to be built simultaneously (popularly for civil works have basements) > accelerate construction.

It is not required of the temporary strutting system (Bracsing System) to support the basement walls during excavation and construction of basement. That is cost-saving for construction.

Temporary strut system is often very complex problems of space and very expensive construction.

Construction schedules can be compressed by saving time in construction of substructures and high-rise superstructure at the same time (of course, we have increase the cost of strengthening the lower part, and if the "savings" schedule cannot cover the "cost" for safety strengthening, it's not necessary to do quick, top-down first and then the high-rise super structures.

Temporary Shed

Temporary shed construction will be the first step before you bring your material near your site.

You need to construct temporary Shed to keep your construction material and your watch men will stay there to look after your site and material

You need to construct this in your neighbors site with their permission. So have a plan to contact them early.

Since it is temporary, you can consider using soil instead of cement.

Centering and Shuttering / Form Work

Shuttering or form work is the term used for temporary timber, plywood, metal or other material used to provide support to wet concrete mix till it gets strength for self support. It provides supports to horizontal, vertical and inclined surfaces or also provides support to cast concrete according to required shape and size. The form work also produces desired finish concrete surface.

Shuttering or form work should be strong enough to support the weight of wet concrete mix and the pressure for placing and compacting concrete inside or on the top of form work/shuttering. It should be rigid to prevent any deflection in surface after laying cement concrete and be also sufficient tight to prevent loss of water and mortar form cement concrete. Shuttering should be easy in handling, erection at site and easy to remove when cement concrete is sufficient hard.

Generally there are three types of shuttering.

- Steel Shuttering
- Wooden Planks Shuttering
- Temporary Brick Masonry Shuttering

Steel Shuttering

Steel shuttering plate is the best type of shuttering because this is water tight shuttering which can bear the load of cement concrete placed on it. This shuttering can be used for horizontal vertical or any other shape required for the work. It gives leveled surface which has good appearance. This shuttering gives good appearance and pattern work according to architectural drawings. If the plaster is required, the thickness of plaster will be less. Being water tight shuttering, the strength of concrete with steel shuttering is comparatively higher.

Shuttering with the help of Steel Plates.

Wooden Plank Shuttering

Generally wooden planks shuttering is used by contractors because this shuttering is cheap and easily available. But this type of shuttering effects the strength of concrete and have some disadvantages which are given below.

Disadvantages

This is not water tight shuttering as the size and thickness of planks differ and are not of same size. Due to this difference the water and cement flow to the ground from joints and reduce the strength of concrete.

Bottom level of RCC slab is not in straight line and the surface being uneven , the thickness of plaster is more which remains weak.

Due to leakage of cement slurry through joints, earth work below ‟"Ballies‟ may settle and create problems.

In some cases wooden planks cannot bear the weight of concrete. Due to low strength there is bending or deflection in wooden planks. Sometimes the planks may break.

Temporary Brick Masonry Shuttering

In some cases labor contractor uses Temporary Brick Masonry in mud for vertical support of sides of beams, fascia etc. This shuttering should be avoided. This type of shuttering reduces the strength of cement concrete by soaking cement slurry. Also no proper compaction is made as this shuttering does not bear the pressure of vibrator. The surface of cement concrete given by this type of shuttering is uneven and the thickness of plaster is increased.

Precautions for Vertical Supports for RCC Beams, Slabs etc

The “Ballies” used for vertical support should not be less than 6' ' dia and these should be in one length without joints .

Never allow bricks support of more than one or two bricks below a 'balli' to make required height. Cross Ballies or bracing should be done for better support to beam as well as slab.

The wooden batten used below the plate should not be less than 5" in height.

At the time of concreting one carpenter with helper having spare ballies, nails etc . should be deputed for watching any disturbances in ballies under shuttering.

Precautions for Cantilever slabs and Beams

While doing shuttering of a cantilever part, outer edge of shuttering is 1” to 2" higher than inner edge with the wall .

The bracing of vertical supports for cantilever portion should be tied to vertical supports of internal slab.

The concrete should be laid on cantilever portion very gently .

The shuttering should be removed after 28 days.

Recommended Period for Removal of Shuttering

48 hours for sides of foundations, columns, beams and walls .

7 days for underside of slab up to 4.5 meter span

14 days for underside of slab, beams, arches above 4.5 meter up to 6 meter span .

21 days for underside of beams arches above 6 meter span and up to 9 meter span.

28 days for underside of beams arches above 9 meter span.

Defects Found In Shuttering/Form Work

The supports of form work are not in plumb and are not cross braced.

The ground supports of ballies are poor and therefore settle the form work .

There is insufficient thickness of shuttering plates/planks unable to bear lateral pressure imposed by wet concrete especially in columns.

Shuttering plates are not cleaned and oiled or oiled with dirty oil.

There are many insufficient and loose connections in centering and shuttering .

The form work is removed before time. The work is not planned and designed properly.

In case of beam shuttering proper provision for retaining side is not made. Hence the side of beam is not in proper line .

The shuttering is poorly made with cracked and warped timber planks having lots of holes and knots .

Through bolts for RCC walls form work for an underground tank is used. Later these holes made by bolts are not plugged.

Ballies are resting on bricks or brick pillars

Ballies are not in one piece. Small ballies are used and these are not properly jointed.

Also no additional cross bracing is provided at the joint.

The supports under shuttering plates are not properly tight.

The earth work under supports is not properly compacted before starting shuttering work.

The bottom of ballies are in wedge shape, not having proper base.

SLIPFORM CONSTRUCTION METHOD

Slipform construction is a method for building large towers or bridges from concrete. The name refers to the moving form the concrete is poured into, which moves along the project as the previously poured concrete hardens behind it. The technique has also been applied to road construction.

The technique was in use by the early 20th century for building silos and grain elevators. Vertical slipform relies on the quick-setting properties of concrete requiring a balance between early strength gain and workability. Concrete needs to be workable enough to be placed to the formwork and strong enough to develop early strength so that the form can slip upwards without any disturbance to the freshly placed concrete.

From foundation to rooftop of even the very tallest projects, with the systems hydraulic jacks, installing steel reinforcement and pouring concrete become much easier and faster, plus can be more efficiently controlled to assure the highest quality finished cement structure.

SLIPFORM technology virtually eliminates unnecessary waste and hazards, making this construction system even more efficient and economical .

Benefits

Careful planning of construction process can achieve high production rates

Slip form does not require the crane to move upwards, minimising crane use.

Since the formwork operates independently, formation of the core in advance of the rest of the structure takes it off the critical path – enhancing main structure stability.
Availability of the different working platforms in the formwork system allows the exposed concrete at the bottom of the rising formwork to be finished, making it an integral part of the construction process.
Certain formwork systems permit construction of tapered cores and towers.
Slip form systems require a small but highly skilled workforce on site.

Safety

Working platforms, guard rails, ladders and wind shields are normally built into the completed system.
Less congested construction site due to minimal scaffolding and temporary works.
Completed formwork assembly is robust.
Strength of concrete in the wall below must be closely controlled to achieve stability during operation.
Site operatives can quickly become familiar with health and safety aspects of their job
High levels of planning and control mean that health and safety are normally addressed from the beginning of the work.

Other considerations

This formwork is more economical for buildings more than seven storeys high.
Little flexibility for change once continuous concreting has begun therefore extensive planning and special detailing are needed.
Setting rate of the concrete had to be constantly monitored to ensure that it is matched with the speed at which the forms are raised.
The structure being slipformed should have significant dimensions in both major axes to ensure stability of the system.
Standby plant and equipment should be available though cold jointing may occasionally be necessary.

Scaffolding

Scaffolding, also called **scaffold** or **staging**, is a temporary structure used to support a work crew and materials to aid in the construction, maintenance and repair of buildings , bridges and all other manmade structures. Scaffolding is also used in adapted forms for formwork and shoring, grandstand seating, concert stages, access/viewing towers, exhibition stands, ski ramps, half pipes and even art projects .

There are four main types of scaffolding used worldwide today. These are Tube and Coupler (fitting) components, prefabricated modular system scaffold components, H-frame / façade modular system scaffolds, and timber scaffolds. Each type is made from several components which often include:

- A base jack or plate which is a load bearing base for the scaffold.
- The standard which is the upright component with connector joins.
- The ledger (horizontal brace).
- The transom which is a horizontal cross section load bearing component which holds the batten, board or decking unit.

Slip form systems require a small but highly skilled workforce on site.

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Types of Scaffolding and their uses

There is a surprising range of scaffolding types that can be used in construction and for other purposes. The general principle of a scaffolding construction, whether it is a static, rolling, or any other type of construction, remains the same – to provide a platform for workers and materials while work takes place.

Most often seen in construction projects, scaffolding structures and other constructs can be used for a variety of purposes. It is common to see scaffolding being used for repair work, to access high objects, for window cleaning tall buildings, and more. Choosing the most appropriate form of scaffold structure is an important stage in the project that you are undertaking.

Supported Scaffolding

This is the most commonly used form of scaffolding and is the type that you will see being used in construction work and on most other forms of work where elevation is required. Extra support may be required if the scaffolding will be long or required to take a lot of weight.

Supported scaffolding is built from the base upwards, and will normally be used wherever possible. It is considered the easiest, most convenient, safest, and most cost effective form of scaffolding construct. Different forms of supported scaffolding are available, and each will serve a very specific purpose and used in specific circumstances.

Suspended Scaffolding

Suspended scaffolding is typically suspended from a roof or other tall construct. It is most commonly used when it is not possible to construct a base, or where access to

upper levels may be required, and the building of scaffolding from floor to the required level would be impractical.

This type of scaffolding is commonly used by window cleaners on tall buildings, but may also be seen where repairs are needed to the exterior of upper levels of similarly tall buildings.

Supported scaffolding is usually preferred where possible.

Rolling Scaffolding

Rolling scaffolding is a similar type of construct to supported scaffolding, but rather than offering a stable base, it uses castor style wheels that enable the base to be moved. This is a useful form of scaffolding when you need to complete work over a longer distance than a single scaffolding construction would permit. The wheels should be locked when workers or materials are on the scaffolding, in order to ensure the safety of those using it, and those around it.

Mobile Scaffolding

There are a number of factors to consider when deciding whether to use static or mobile scaffolding. Ease of access is one such consideration, along with the amount of movement on the scaffolding itself. Where possible, you should rely on the use of a single scaffolding structure, or a number of structures, because mobile units, while perfectly safe when well-constructed and used properly, do pose more of a hazard than mobile constructs.

Most scaffolding is considered semi-permanent. Once used, it can be taken apart and moved to another location before it is constructed again. Fixed scaffolding can be left in position for longer periods of time, making it especially useful in those situations where permanent access may be needed to elevated positions.

Aerial Lifts

Aerial lifts should be used where workers need to be able to access a number of levels in order to be able to complete a construction. For example, if building work is being completed on the outside of a multi-storey property and both workers and materials will be needed to work outside two or more floors, at different times, then an aerial lift will make it easier and safer to lift even large amounts of material, and multiple workers to the levels required.

DESHUTTERING in simple means, the process of removing the shuttering (Formwork for Concrete).

Assuming standard conditions of workmanship and quality of materials, you can refer to the following time-frames for the removal of forms.

Walls/Columns & Vertical faces of structural members - 24 Hrs

Slab Spanning up to 4.5 m - 7 days

Slab Spanning more than 4.5 m - 14 days

Beams and arches spanning up to 6 m - 14 days

Beams and arches spanning more than 6 m - 21 days

The steel-framed building derives most of its competitive advantage from the virtues of prefabricated components, which can be assembled speedily at site. Unlike concreting, which is usually a wet process conducted at site, steel is produced and subsequently fabricated within a controlled environment. This ensures high quality, manufacture offsite with improved precision and enhanced speed of construction at site. The efficiency of fabrication and erection in structural steelwork dictates the success of any project involving steel-intensive construction. Current practices of fabrication and erection of steel structures in India are generally antiquated and inefficient. Perhaps, this inadequate infrastructure for fabrication is unable to support a large growth of steel construction. In India, the fabrication and erection of structural steelwork has been out of the purview of the structural designer. Nevertheless, in the future emerging situation, the entire steel chain, i.e. the producer, client, designer, fabricator and contractor should be able to interact with each other and improve their efficiency and productivity for the success of the project involving structural steelwork. Hence it becomes imperative that structural designers also must acquaint themselves with all the aspects of the structural steel work including the "fabrication and erection," and that is the subject matter of the present chapter to briefly introduce good fabrication and erection practices.

FABRICATION PROCEDURE

Structural steel fabrication can be carried out in shop or at the construction site. Fabrication of steelwork carried out in shops is precise and of assured quality, whereas field fabrication is comparatively of inferior in quality. In India construction site fabrication is most common even in large projects due to inexpensive field labour, high cost of transportation, difficulty in the transportation of large members, higher excise duty on products from shop. Beneficial taxation for site work is a major financial incentive for site fabrication. The methods followed in site fabrication are similar but the level of sophistication of equipment at site and environmental control would be usually less. The skill of personnel at site also tends to be inferior and hence the quality of finished product tends to be relatively inferior. However, shop fabrication is efficient in terms of cost, time and quality.

Structural steel passes through various operations during the course of its fabrication. Generally, the sequence of activities in fabricating shops is as shown in Table1. These sequence and importance of shop operations will vary depending on the type of fabrication required. All these activities are explained briefly in the subsequent parts of the section.

FABRICATION AND ERECTION OF STRUCTURAL STEELWORK

Sequence of activities in fabricating shops

Sequence of Operation

Surface cleaning

Cutting and machining

Punching and drilling

Straightening, bending and rolling

Fitting and reaming

Fastening (bolting, riveting and welding)

Finishing
Quality control
Surface treatment
Transportation

Frame Structures - Types of Frame Structures

Frame structures are the structures having the combination of beam, column and slab to resist the lateral and gravity loads. These structures are usually used to overcome the large moments developing due to the applied loading.

Types of frame structures

Frames structures can be differentiated into:

1. Rigid frame structure

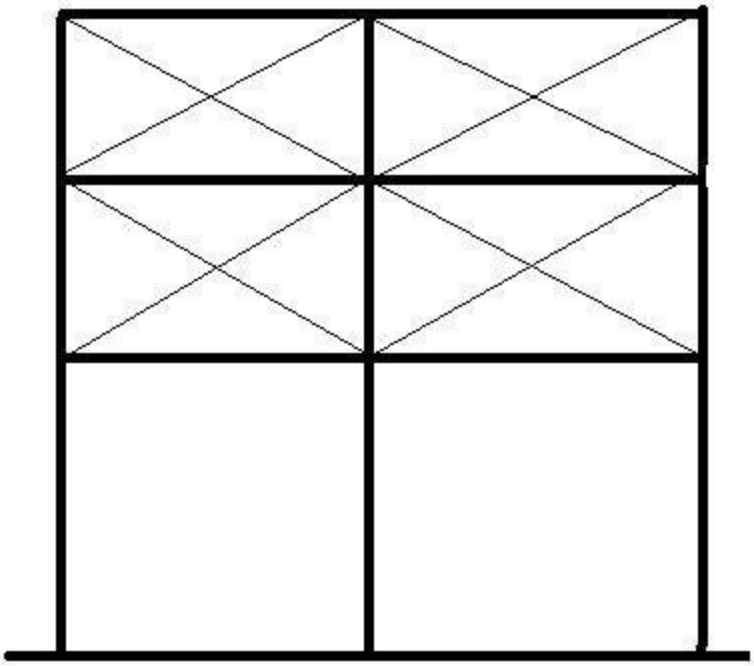
Which are further subdivided into:
Pin ended
Fixed ended

2. Braced frame structure

Which is further subdivided into:
Gabled frames
Portal frames

Rigid Structural Frame

The word rigid means ability to resist the deformation. Rigid frame structures can be defined as the structures in which beams & columns are made monolithically and act collectively to resist the moments which are generating due to applied load.



Rigid frame structures provide more stability. This type of frame structures resists the shear, moment and torsion more effectively than any other type of frame structures. That's why this frame system is used in world's most astonishing building Burj Al-Arab.

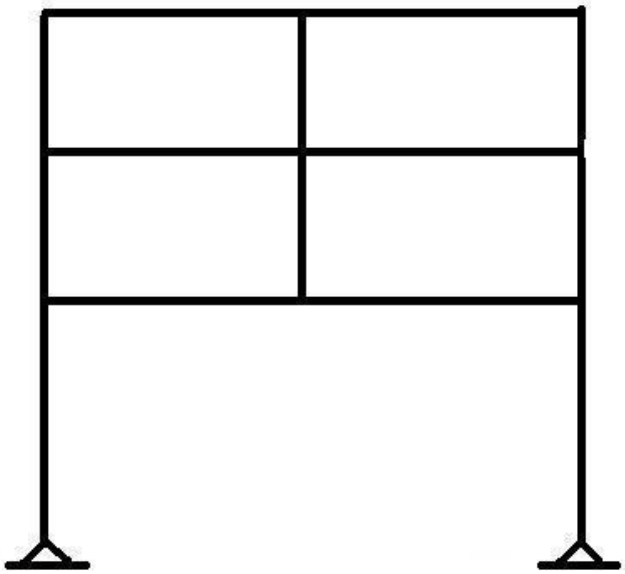
Braced Structural Frames

In this frame system, bracing are usually provided between beams and columns to increase their resistance against the lateral forces and sideways forces due to applied load. Bracing is usually done by placing the diagonal members between the beams and columns.

This frame system provides more efficient resistance against the earthquake and wind forces. This frame system is more effective than rigid frame system

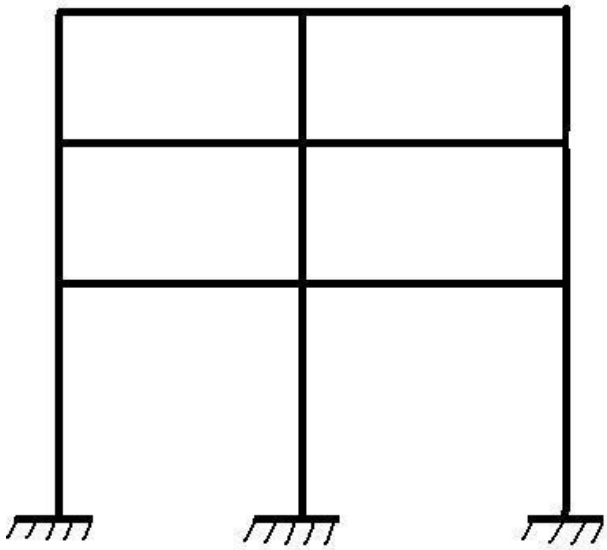
Pin Ended Rigid Structural Frames

A pinned ended rigid frame system usually has pins as their support conditions. This frame system is considered to be non rigid if its support conditions are removed.



Fix Ended Rigid Frame Structure:

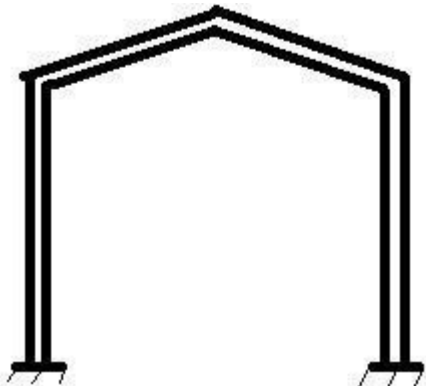
In this type of rigid frame systems end conditions are usually fixed.



Gabled Structural Frame:

Gabled frame structures usually have the peak at their top. These frames systems are in use where there are possibilities of heavy rain and snow.

Portal Structural Frame



Portal structural frames usually look like a door. This frame system is very much in use for construction of industrial and commercial buildings

Load path in Frame Structure:

It is a path through which the load of a frame structure is transmitted to the foundations. In frame structures, usually the load path is:

Load first transfers from slab to beams then to from beam to columns, then from columns it transfers to the foundation.

Advantages of Frame Structures

1. One of the best advantages of frame structures is their ease in construction. it is very east to teach the labor at the construction site.
2. Frame structures can be constructed rapidly.
3. Economy is also very important factor in the design of building systems. Frame structures have economical designs.

Disadvantages of Frames:

In frames structures, span lengths are usually restricted to 40 ft when normal reinforced concrete.

Otherwise spans greater than that, can cause lateral deflections.

Comparison of Frame structures with Normal Load bearing Traditional High Rise Building

Selection of frame structures for the high rise building is due to their versatility and advantages over the normal traditional load bearing structures. These include the following:

Actually the performance of load bearing structures is usually dependent on the mass of structures. To fulfill this requirement of load bearing structures, there is the need of increase in volume of structural elements (walls, slab).this increase in volume of the structural elements leads toward the construction of thick wall. Due to such a type of construction, labor and construction cost increases. in construction of thick wall there will be the need of great attention, which will further reduce the speed of construction.

If we make the contrast of load bearing structures with the framed structures, framed structures appear to be more flexible, economical and can carry the heavy loads. Frame structures can be rehabilitated at any time. Different services can be provided in frame structures. Thus the frame structures are flexible in use.

Braced domes may be fabricated in any of several common grid configurations. With different configurations, the dome performance varies considerably affecting both its competitiveness and suitability for specific applications. The study presented in this paper is an assessment of the most commonly adopted dome configurations and their effect on the dome characteristics such as the stiffness/weight value, member stress distribution, number of joints and members, degree of redundancy and cost. The study is parametric and covers wide variations of dome span/rise ratio and boundary conditions. The results of this study could be of significant value to the design of future braced dome structures.

How to Lay Brick

1. Squared rubble masonry: The rubble masonry in which the face stones are squared on all joints and beds by hammer dressing or chisel dressing before their actual laying, is called squared rubble masonry.
2. There are two types of squared rubble masonry.
3. Coursed Square rubble masonry: The square rubble masonry in which chisel dressed stones laid in courses is called coarse square rubble masonry. This is a superior variety of rubble masonry. It consists of stones, which are squared on all joints and laid in courses. The stones are to be laid in courses of equal layers. and the joints should also be uniform.
4. Suitability: Used for construction of public buildings, hospitals, schools, markets, modern residential buildings etc and in hilly areas where good quality of stone is easily available.

Begin Laying Bricks

A mason's line acts as a guide for setting bricks in perfectly straight rows. It's made of two mason blocks with slots to hold a mason line.

Affix the blocks to either end of the row of bricks, with the line pulled tight. The top of each brick in the row should just touch the top of the line.

Guide the Bricks

A story pole is a strip of wood that acts as a guide for laying bricks. Use a pencil to mark the height of each course of bricks, including the mortar joints, on the pole.

Apply Mortar

Safety Tip: When working with mortar, always wear gloves and a mask or respirator.

Use a spade trowel to apply a generous amount of mortar to each layer of brick. Score a line through the center of the pile of mortar to allow it to spread. "Butter" the brick with mortar, spreading mortar on the sides that will affix to the bricks beside them. Use the handle of the trowel to knock each brick into place and to release any air bubbles that may be in the mortar underneath.

Remove Excess Mortar

Using the sharp end of the trowel, scrape off any excess mortar that spreads beyond the joint.

Finish cleaning off any other debris with a brush. Holding a spade trowel at a 30-degree angle, carve small lines between the bricks and the mortar. The lines will help protect the wall from the effects of precipitation.

Cut Bricks

Most walls require smaller bricks at their ends. Before cutting a brick, place it in a bed of sand or dirt to absorb the shock of the blow. Place the sharp end of a brick chisel at the line where you want to cut. Use a hammer to tap the end of the chisel, scoring lines on all four sides where the brick must be cut.

After scoring the lines, hold the chisel on one of them, slightly angled toward the side of the brick that will be kept and used on the wall. With your other hand, strike the handle of the chisel with a hammer. The blow should break the brick cleanly in two.

Construction chemicals providing strength to construction industry

Waterproofing begins to fight weak monsoon

Chettinad Cement to acquire AP-based Ajani Portland Cement

Cement firms remain pessimistic after bad Q2 run

BASF to build centre for flooring and waterproofing systems in Germany

Waterproofing of building to prevent the ingress of water is an activity, which, perhaps is practiced in one form or the other, ever since the first building was built on earth. The methodology has been changing with the changes in the architectural designs and with the availability different building materials in construction.

In the initial stages when stone was the main building construction material placed in position with mud or lime mortar the emphasis used to be to make the construction in such a way that the rainwater does not collect on the roofs. Hence old architecture relied mainly on dome structures or slanting roofs. The slow speed of such construction and unaffordability of common man to build such structures for their own dwelling, made constant evolution and development in the construction material technology.

With these developments the concepts of waterproofing also changed. Now in present day construction wherein the ordinary Portland cement and its blends with pozzolanic and slag materials has come to stay a lot of compatible alternatives are available for a builder to choose from various waterproofing systems. Some systems are old and conventional but still practiced successfully and some are modern systems designed taking the material and structural behavior into consideration.

There are some compounds, which are used in plastic concrete to make it less permeable to water. These compounds are known as integral waterproofing compounds. They are based on plasticizing and air-entrainment or water repellence principles. These are used as a good waterproofing precautions when other factors such as good mix-design, proper mixing/placing, compacting/curing etc are taken care of. This subject of integral waterproofing compounds requires in depth discussion hence will not be taken up here. Similarly there are some water proofing techniques for vertical surfaces. These techniques are also used for preserving heritage buildings by stopping/minimising the aging process of these buildings.

For solving water seepage problems, customers use both conventional as well as modern waterproofing techniques.

Some of the old and conventional waterproofing systems are as follows:
Brick bat coba system or lime terracing
Bituminous treatment
Metallic sheet wrapping
Polyurethane based waterproofing treatment
Epoxy based waterproofing treatment
Box-type waterproofing system

Brick bat coba system

This system was developed during the initial stages of flat roof construction with lime mortar burnt clay brick pieces. This system involved laying lightweight mortar on the roof and spreading it to give gentle slopes for draining away the rainwater immediately. The mortar consisted of lightweight brick pieces as aggregates and ground brick with lime as binding matrix.

During British rule this system became more popular not because of its water proofing efficiency but because of its efficiency in keeping the interiors cool. Some applicators developed better skills in laying these systems, with neatly finished top with lines engraved on top of plastic mortar now known as IPS.

Some practiced embedding broken tile or ceramic pieces in the plastic mortar and called it china mosaic.

This type of system remained most popular with multi-storeyed construction in all major cities. The system lasts up to 15 years if done by skilful applicators. This system may be considered more from its weather proofing abilities rather than its waterproofing qualities. Once water starts entering into the brickbat coba the brick pieces absorb too much of water and the roof becomes an invisible pond of water continuously causing leakage and increasing burden on the roof slab. It will be highly beneficial if brickbat coba is laid on a flexible waterproofing membrane as water proofing as well as economical weather proofing can be achieved with this system.

Bituminous treatment

Discovery of petroleum and its products and by-products has given the construction industry an indispensable product in the form of bitumen. Bitumen is more commonly used in the form of felt or flexible membrane formed by sandwiching jute fabric or fibreglass/polypropylene mats with chemically modified bitumen. These membranes are laid on the roofing over a bitumen primer. There are two types of membranes one is cold applied and the other hot applied which means one needs to heat the edges of the felt with a torch so that they melt and stick to the second layer in the overlap area.

On the RCC flat roofs the bitumen felts have not been successful because of the unacceptable black appearance and inaccessibility of the terrace for other social uses. Technically it is not preferred because bitumen layer or felt on the terrace not only makes it watertight but also airtight. Concrete has the breathing property. It takes water/moisture and breathes out water vapour. Hindrance of this breathing property of concrete develops pore pressure, which causes blisters in the felt.

After a few seasons the blisters multiply and eventually delaminate the felt from the concrete surface. Hindrance of breathing property of concrete makes the concrete weak. But on the asbestos cement sheets and zinc sheets in factory roofs, this bitumen felt is the only dependable waterproofing system. Hence all factory roofs in India adopt this water proofing system.

Bitumen is very effective in waterproofing of basements from outside. Bitumen primers have very successfully been used as damp-proof course in earlier days. This practice is slowly discontinued for whatever reasons now very few engineers now believe that this was in practice once. As consequence of this absent DPC we have a lot of cases of rising dampness, which we tend to attribute to wrong reasons such as the quality or salinity of sand etc. Bitumen still is the product of first choice where it is commonly recommended, in areas such as industrial roof waterproofing, basement waterproofing, and damp-proof course. More over bitumen is the most economical product available for waterproofing.

Metallic sheet wrapping

Because of the non-existence of suitable expansion joint filling compounds before the discovery of polysulphides, a complex procedure used to be adopted to treat expansion joints, in concrete dams and such huge structures utilising thick copper sheets. An extension of this practice was to try thin foils of copper and aluminium for wrapping the concrete surfaces with nagging leakage problems.

Unavailability of common joining material for these metal foils and the concrete and mortar created weakness in the system at the joints. This discouraged the system in its infancy only. But there after the metal manufacturers have been trying to market this type of waterproofing system with improved adhesives as and when the metal market slumped.

Polyurethane based waterproofing treatment

Polyurethane consists of two liquid components one is called the base component and the other is called reactor or curing agent. Base is a polyol and the reactor is an isocyanide such as TDI or MDI. There are various grades of polyols and so also there are numerous isocyanides. The combination of these two ingredients results in a formation liquid applied rigid membrane or a foam depending upon the selection.

In waterproofing, this rigid liquid membrane was tried with fibre glass reinforcing mats. The systems failed because coefficients of thermal expansion of concrete and rigid PU membrane being different lateral movement or creep occurred with the passage on one working climatic cycle. When exposed to ultra violet rays or direct sunlight most polyurethane rigid membranes became brittle and crumbled.

Apart from this the application of polyurethane coating needed very rigorous surface preparation. The surface needed to be neutralized by removing alkalinity from the concrete surface through acid itching then washing and blowtorching to make the surface bone dry. This kind of surface preparation with acids angered the civil engineering community and the product ceased to be used as waterproofing material apart from its several failures. Never the less continuous research in the polyurethane technology gave the construction industry excellent sealant for glazing industry and foams for thermal

insulations. The new generation polyurethanes, which are alkali stable and water-based, may find better applications in waterproofing industry.

Epoxy based waterproofing system

Like polyurethane is also a two-component system having a base resin and a reactor or curing agent. Base resin is obtained by dissolving bis-phenol a flakes in epichlorohydrin. This base is available in various viscosity ranges to suit different application conditions. The curing agent is an amine/polyamine aliphatic or aromatic, or an amine-adduct for general applications and polyamide or an amino-amide for coating purposes. After mixing base and reactor components the resultant viscous liquid or paste if some fillers are added to it can be brush applied like a paint or trowel applied like a mortar.

Here also epoxies notwithstanding the alkalinity of concrete and the concrete needs to be acid washed and neutralised, which the civil engineers hated. Here again the coefficient of thermal expansion of concrete and epoxy being different the compatibility of epoxy in waterproofing exposed concrete surfaces such as roofs became limited. Later the use of epoxy in waterproofing was discarded. But epoxies have come to stay in civil engineering industry as bonding agents, floor & wall coatings, coatings for food processing units, operation theatres and computer and pharmaceutical industries.

Box type waterproofing

This type of water proofing system is used only for basement waterproofing or waterproofing structures below the ground level from outside to prevent leakages of subsoil water into the basement.

In this method, limestone slabs (Shahabad Stones) are first laid in the excavated pit over blinding concrete in a staggered joint fashion to avoid the continuity of the mortar joints. The joints are effectively filled with rich mortar admixed with integral waterproofing compound and cured. Over this the raft is laid and shear/brick walls constructed. The limestone slabs are erected around the walls in a similar fashion leaving a gap of one to two inches between the external surface of the wall and the inner face of the stone surface. The joints again effectively sealed with rich admixed mortar and the same mortar is filled in the gap between the wall and the stones. This stonework is continued up to ground level. In this system the raft and the sidewalls are protected from direct exposure to sub soil water.

This system works on two principles of common sense. First, the area exposed to subsoil water is only the area of the joint where as the whole stone is impervious to water, hence only a fraction of area, that is, that of the joint is exposed to subsoil water, when the joint itself is filled with rich and quality mortar.

Second, the path of water to reach the raft or the sidewall is elongated. This elongated path is through quality mortar. This system seeks to delay the occurrence of leakages in the basements. A lot of building structures are waterproofed by this system. A few notable successes are to its credit especially in five star hotels and of-course there are a few failures as well.

Types of Roofs finishes

Several **types of roofs** are available for residential construction. Different materials are chosen according to their various qualities, advantages and disadvantages. Roofing a house is quite a cost-intensive affair and you need to be prepared with sound information prior to making your investment. Here s an overview ‟ of some of the most used types of roofing:

1. Wood Shingle Roofing

Wood shingles are also known as shakes and they are especially ideal if you appreciate naturally beautiful looks. They will gracefully age with your house while retaining their aesthetic appeal.

Wood shingle roofing is quite expensive though it makes up for the cost with its durability. Most people have concerns with this type of roofing especially with issues like fire, splitting, rotting and molding. Always invest in shingles that have been treated with special protective glazes and finishes.

2. Slate Roofing

Another beautiful yet very costly roofing material is slate and is especially appropriate if your house is in the French or Colonial design style.

Slate roofing is ideally composed of thin layers of rock and as such the roof is bound to be quite heavy. For this reason it is advisable to first put in place adequate structural support. Laying this type of roof can be quite complicated for a DIY project and the installation is better off when done by a licensed contractor.

3. Tile Roofing

Tile roofing is an option that goes very well with your house if it is in the Spanish or Mediterranean design. There are two types of roofing tiles: clay tiles and concrete tiles.

Tiles are generally laid down on relatively new houses that have adequate structural support since tiles, like slates, are quite a heavy load. The services of a professional contractor will come in handy if you are not confident about taking on the task yourself.

Tile roofing is also quite costly but if properly maintained it can give proper service for up to 50 years.

4. Metal Roofing

Metal roofing options are fast gaining a good reputation in building circles despite their initially high costs. These roof types boast durability as well as low maintenance qualities that extend their life beyond other conventional roof types.

5. Asphalt Roofing

Certainly the most affordable of roofing types has to be asphalt. Asphalt shingles that are made from the conventional highway asphalt are the least expensive. You can also invest in the costlier option that is known as architectural shingles.

Acoustic, Thermal, Fire and Safety

Acoustic

Noise reduction is an increasing priority in both new build and renovation projects.

Thermal

With an impressive array of products, in both roll and batt formats, to suit every conceivable application and a wide range of lambda values the Isover thermal insulation range is second to none.

Fire & Safety

All of our glass mineral wool products are non-combustible, have the highest possible Euroclass A1 fire rating classification, and do not produce any toxic fumes in the event of fire.

Many are also fire rated, offering added protection against fire and providing vital time for building occupants to evacuate.

UNIT III SUB STRUCTURE CONSTRUCTION

BOX JACKING

It is the process in which a pre-cast R.C.C box or a rigid box is pushed into the soil with the help of hydraulic jacks

It is non-intrusive method beneath the existing surface.

It is more often used when a subway or a aqueduct or a underground structure is to be constructed.

It enables the traffic flow without disruption.

R.C.C BOX JACKING

First the box section is designed and cast at the site or can be transported to the site according to the requirement.

The foundation boxes are jacked into the ground designed to carry the dead and the live loads.

Then the high capacity jacks are placed at the back and it pushes the box into the ground.

A purpose designed tunneling shield is provided in the front end.

Then the box is jacked carefully through the earth.

Excavation and jacking are done in small increments in advance.

Measures should be taken to prevent the soil being dragged towards the box.

METHODS OF BOX JACKING

Box Jacking

Non –intrusive method beneath existing surface infrastructure

Frequently used where an existing road or rail tracks is an embankment and space exists for the structure to be cast at the side

Enables traffic flows to be maintained disruption

Procedure

It involves the advancement of a site-cast rectangular or other shaped box using high capacity hydraulic jacks.

An open ended reinforced concrete box is cast on a jacking base.

A purpose designed tunneling shield is provided at its leading end and thrust jacks are provided at its rear end reacting against a jacking slab

The box is then jacked carefully through the ground

Excavation and jacking take place in small increments of advance.

Measure are taken to ensure stability of the tunnel face and to prevent the ground from being dragged forward by the advancing box.

When the box has reached its final position the shield and jacking equipment are removed.

R.C.C box jacking

Is adopted where it is not possible to constructed in situ R.C.C boxes

These boxes are used for canal siphon, road under bridge and culvert for conveying water/service pipes

The R.C.C box is cast over the thrust bed which is provided with –pockets both in longitudinal and traverse jacks

The box is provided with a shield in front in front called “Front shield” Which pierces through the soil by cutting

Thrust boring method

Is a process of simultaneously jacking pipe through the earth while removing the soil inside the encasement by means of a rotating auger.

In unstable soil conditions, the end of the auger is kept retracted back inside the encasement so as not to cause voids.

In stable conditions, the auger can be successfully extended beyond the end of the encasement.

TUNNEL BORING MACHINE

Tunnel boring machine (TBM) as mole recent developments in the tunnel driving technique. The function of TBM is to loosen the earth or break the rock continuously in the entire section of the tunnel, in to cuttings and convey to the rear of the machine, where it can be loaded into muck cars or dumpers or on to conveyor belts for the transportation to the ultimate disposal site.

Working principle and construction features of TBM

These machines perform the boring operation through rotation of the front head against the rock face. The mole has circular cutter head in the front provided with fixed cutters of desired shape. The cutter head while rotating is pressed against the rock to cut or pulverize it. The cuttings while failing down is collected in the buckets provided around the cutter head periphery.

These buckets discharge the muck into a hopper to feed it into the belt conveyor leading to the rear of the machine. This conveyor then discharges the muck either into the mine car or to another belt conveyor leading to the portal of the tunnel. The muck of cuttings can also be disposed off by using the slurry pipelines after mixing the fine muck into water to form slurry.

For driving through full- face on full-face TRMs number of cutter heads is mounted on a drum. The drum when rotates in one direction, the individually driven cutter heads having projected Tungsten carbide tipped tools can be rotated in another direction and the drum advances into the tunnel face, by providing a thrust with the help of hydraulic systems. The tips of the tools when worn out can be easily replaced. The tips

are kept cooled by spraying a mixture of water and compressed air into the cutting area. This also suppress the dust formed during cutting.

Advantages of tunnel boring machines

There is very less danger of fall outs in machine bored tunnels, since adjacent or surrounding rocks are undistributed as no blasting is done.

Mucking is also safe and convenient, since muck is conveyed from the face to the rear of the machine and is loaded automatically by means to the rear of the machine and is loaded automatically by means of belt conveyors.

Higher speed of excavation.

Reduction in the tunnel supports requirement.

Less manpower requirement.

Various types of tunneling technique

Tunneling techniques are

Drill Jumbo

1. Drill jumbo
2. Loading and firing
3. Drilling

Drill jumbos used in tunnels are also known as tunnel jumbos. A drill jumbo is a portable carriage having one more carriage having one or more working platforms equipped with columns, bars or booms to support and guide the drills, enabling the drills to perform drilling operation at any desired pattern. These platforms have arrangement for the supporting the compressed air pipes, water pipes. The booms are operated by hydraulic fluid or air and supports the drifters, and are equipped with control enabling the operator to spot a drill in any desired position conforming to the drilling pattern. The platforms are constructed as per the size of tunnel and can be raised or lowered so as to allow mockers or hauling equipment to pass under the jumbo several drill can be operated from each platform for speedy excavation. The jumbos either on rails on pneumatic tyres depending upon the type of work. The jumbo can be equipped with electricity feeding cables, pneumatic concrete placers etc. Mobile jumbos of modern design with four wheel drive and centrally articulated steering speeds production and reduces tunneling costs

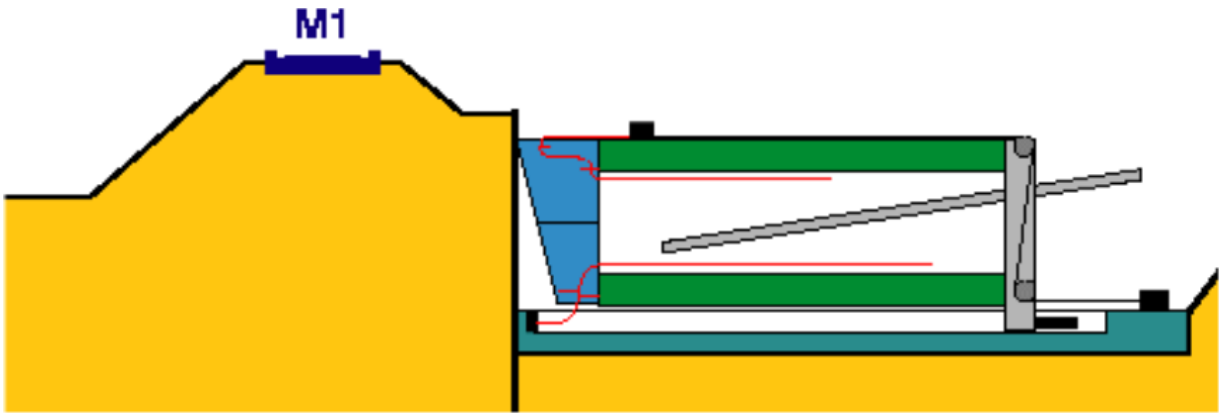
Loading and firing

Drilling pattern when followed produces most economical and efficient breakage of rock for a given tunnel, and is determined by conducting tests using different patterns. Explosive selected for working in tunnels should have low fumes characteristics. Ammonium nitrate explosives are therefore preferred over dynamics due to less toxic fumes.

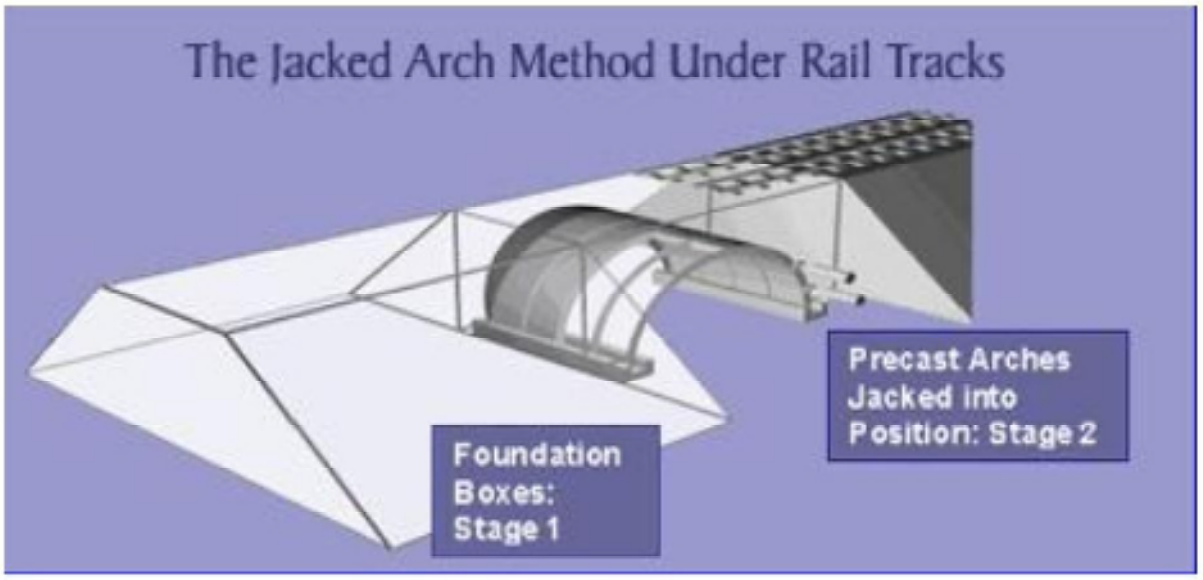
Drilling

For driving a tunnel number of holes are drilled as per drilling pattern in size and depth as decided depending upon the size of the tunnel and its formation Drifters are generally used for drilling in the tunnels where in water is used to remove the cuttings from the holes instead of compressed air to reduced the amount of dust in the air. Holes are drilled slightly deeper than the advance per round to taken care of loss in depth during blasting. Depth advanced due to drilling and blasting operation is called as one round.

R.C.C BOX JACKING



ARCHED JACKING



THRUST BORING METHOD

It is a process of simultaneously jacking the pipe through the earth while removing the earth inside the box by means of a rotating auger.

Unstable conditions- the end of auger is kept retracted inside the encasement so as not to cause voids.

Stable conditions- the auger can be successfully extended beyond the encasement.

This can be successfully used in any kind of soil conditions.

PROBLEMS ENCOUNTERED IN JACKING

Settlement of the above ground.

Seepage of ground water.

Caving in of soil etc.

FREEZING OF GROUND

This method is used when we encounter the problem of ground water seepage and settlement of ground.

In this method a brine solution is continuously passed through the pipes fixed in the soil.

The temperature of the brine would be -30°c.

So when this brine solution is circulated through these pipes it freezes the ground and the ground behaves like an ice block.

The spacing of the freezing pipes will vary according to the type of soil, its permeability and other factors.

Generally it is kept at a spacing of 1.2 m

PROBLEMS IN FREEZING

The main problem in the freezing method is the up heaving of the above ground.

To avoid the upheavement problem we should be careful in the ground freezing process and the temperature of the brine solution.

CASE STUDY - SOUTHERN BOSTON PIERS TRANSIT WAY

The carriageway has to go beneath – a Russian building, 100 years old 2m thick soil was frozen.

Under pinning was also done using mini piles.

ADVANTAGES

Timely completion of project.

No disruption of traffic.

No need to divert the traffic.

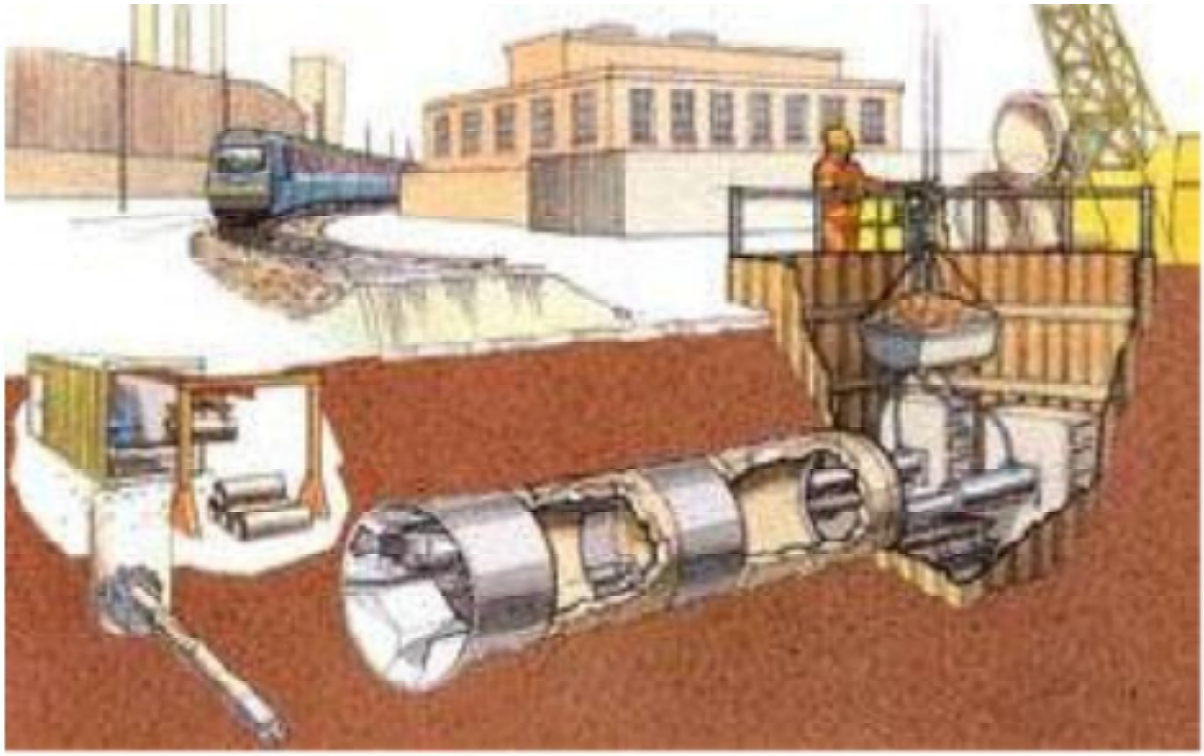
DISADVANTAGES

Cost of project increases.

Skilled personnel required.

Safety precautions to be done properly.

PIPE JACKING



ABOUT THE TECHNIQUE

It is generally referred as “Micro tunneling”

Pipes are pushed through the ground behind the shield using powerful jacks.

Simultaneously excavation takes place within the shield.

This process is continued until the pipeline is completed.

The method provides a flexible, structural, watertight, finished pipeline as the tunnel is excavated.

No theoretical limit to the length of individual pipelines.

Pipes range from 150mm to 3000mm diameter can be installed in straight line or in curvature.

Thrust wall is provided for the reaction of the jacks.

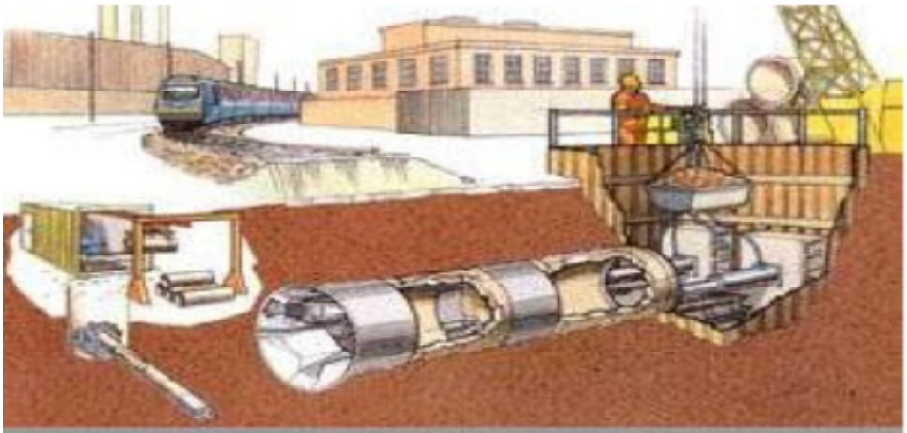
In case of poor soil, the thrust wall may punch inside the soil.

Then piles or ground anchoring methods can be used.

PROCEDURE

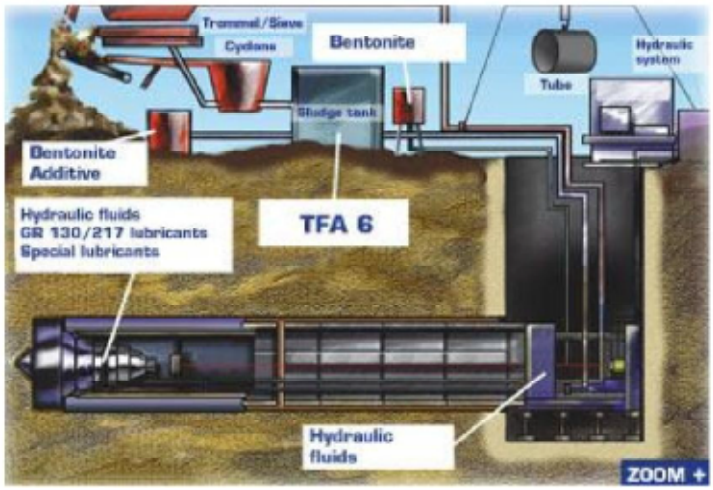
The thrust pit and the reception pit are excavated at the required places.
Then the thrust wall is set up in the thrust pit according to the requirement.
In case of mechanized excavations, a very large pit is required.
But in case of manual excavation, a small pit is enough.
Thrust ring is provided to ensure the even distribution of stress along the circumference of the pipe.
The number of jacks vary upon the frictional resistance of the soil, strength of pipes etc.,
The size of the reception pit is to be big enough to receive the jacking shield.
To maintain the accuracy of alignment a steer able shield is used during the pipe jacking.
In case of small and short distance excavations, ordinary survey method is sufficient.
But in case of long excavations, remote sensing and other techniques can be used.

GENERAL ARRANGEMENTS

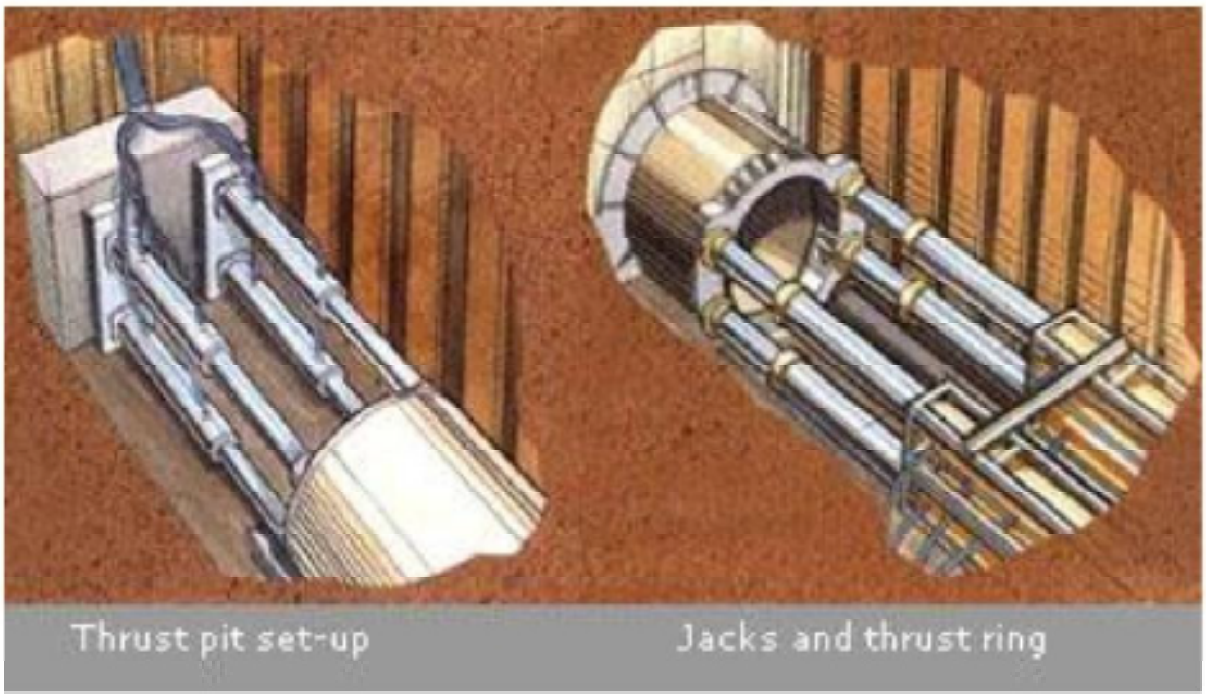


General arrangements of pipe jacking and microtunelling systems

PIPE JACKING SETUP

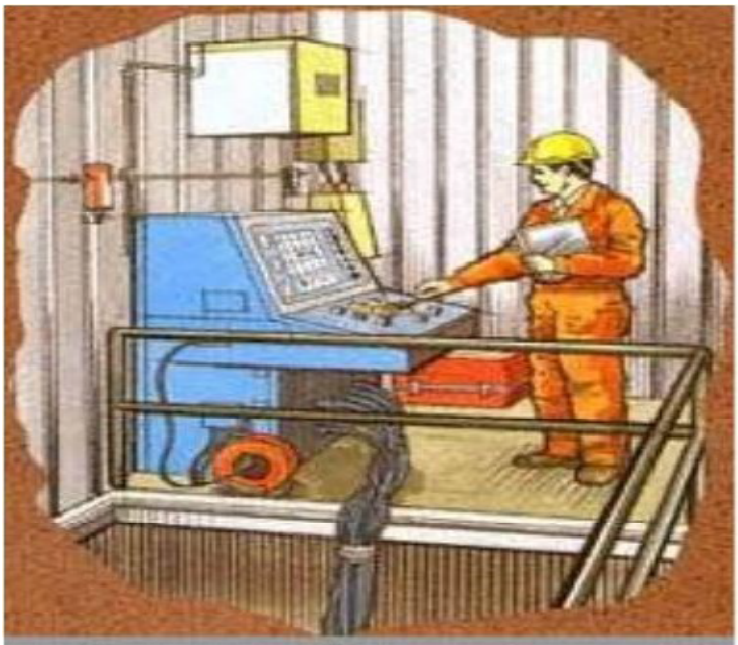


THRUST SETUP



COMPUTER GUIDANCE SYSTEM

The computer system enables us to control the work remotely.



Computer guidance system for microtunnelling

ADVANTAGES

It avoids the excavation of trenches. So it is also called as “Trench less Technique”.

There won’t be any leak problems in the future.

Timely finish of projects.

DISADVANTAGES

Very costly method.

Skilled personnel is required.

DIAPHRAGM WALL

Diaphragm wall are structure elements, which are constructed underground to prevent the seepage into the excavated area

Various methods adopted to construct a diaphragm wall

Slurry trench technique

1. Soil mixing method
2. RC continuous diaphragm wall
3. Precast diaphragm wall
4. Glass diaphragm walls

Slurry trench technique

The technique involves excavating a narrow trench that is kept full of an engineered fluid or slurry. The slurry exerts hydraulic pressure against the trench walls

and acts as shoring to prevent collapse. Slurry trench excavations can be performed in all types of soil even below ground water table.

Soil mixing method

This is the method used to make continuous walls by churning up piled soil using an auger, pouring in cement milk and marking soil mortar columns in the ground using the soil as aggregate. This is an in situ mixing and churning method. In the method after completing excavation of the groove wall using an excavator, soil cement is produced by mixing and churning excavated soil. The excavated soil is classified and graded with cement milk after being put through a tremie. Then the soil cement is poured into the groove wall, after which the steel material is built as the core material.

RC continuous diaphragm wall

This method of building a very long continuous diaphragm wall. Excavate a given groove between the surface and underground using a stabilizing liquid. Insert a given steel bar pour in concrete, thereby building a reinforced concrete wall underground.

Precast diaphragm wall

With this method, a continuous trench or longer panels are excavated under self hardening cement- bentonite(CB) slurry.

The precast concrete wall sections are lifted and positioned by a crane

The CB slurry sets to form the final composite wall

The trench is excavated under bentonite slurry, which is then displaced with CB slurry.

Glass diaphragm walls

For contained enclosure, a diaphragm wall system consisting of special glass panels with a sealing made out of glass are used.

The panels are 50cm wide and upto 15cm long

Common uses of diaphragm wall walls

To provide structural support for the construction

To provide retaining wall

To provide deep diaphragms

Applications of diaphragm wall

As permanent and temporary foundation wall foundation walls for deep foundation for deep basements

In earth retention schemes for highway and tunnel projects

As permanent walls for deep shafts for tunnel access

As permanent cut - off walls through the core of earth dams

In congested areas for retention systems and permanent foundation walls

Deep groundwater barriers through and under dams

CAISSON

Caisson has come to mean a box like structure, round or rectangular, which is suck from the surface of either land or water to some desired depth. Caissons are of three types:

(a) Box caisson

(b) open caisson

(c) Pneumatic caissons

Box caisson

A box caisson is open at top and closed at the bottom and is made of timber, reinforced concrete or steel. This caisson is built on land, then launched and floated to pier site where is suck in position. Such a type of caisson is used where bearing stratum is available at shallow depth, and where loads are not very heavy.

Types of well point systems

1. Pumping from open sumps

2. Pumping from well points

Well point systems are installed in two ways:

Types of piles

a) Line system

b) Ring system

3. Pumping from bored wells

(a) Driven piles – Timber, recast concrete, Prestressed concrete , steel H-section, Box and tube

(b) Driven and cast-in place piles

(c) Bored piles

(d) Composite piles

Use of H-piles

H-Piles are used in construction of bridges where they can be driven through existing construction in small spaces. They are used useful for driving close to existing structures since they cause little displacement of soil. It can be withstand large lateral forces. They require less space for shipping and storing than wood, pipe or precast concrete piles. They do not require special slings or special care in handling.

DEEP EXCAVATIONS

Problems normally developed during deep excavations

To prevent the collapsing of sides of the trenches

To prevent water oozing or coming out from the sides and bottom of the trenches

The remedial measures to avoid the problems deep excavation

Providing shoring for the trenches

Dewatering of the trenches

Line system

This system is employed when excavation area is long. The header is laid out along the sides of the excavation, and the pumping is continuously in progress in one length as further points are jetted ahead of the pumped down section and pulled up from the completed and back filled lengths and repeated till entire length is completed. For narrow excavation, like trenches, header is laid only on one laid, while for wide excavations, the header are required to be placed on both sides of the area.

Ring system

When excavation is done in area of appreciable width, line system is inadequate. The ring system is used in such condition and the header main surrounds the excavations completely. This system is used for rectangular excavations such as for piers or basements.

SHEET PILES

Sheet piles are thin piles, made of plates of concrete, timber or steel, driven into the ground for either separating members or for stopping seepage of water. They are not meant for carrying any vertical load. They are driven into ground with help of suitable pile driving equipment, and their height is increased while driving, by means of addition of successive installments of sheets.

Functions of sheet piles

1. To enclose a site or part thereof to prevent the escape of loose subsoil, such as sand, and to safeguard against settlement.
2. To retain the sides of the trenches and general excavation.
3. To protect river banks.
4. To protect the foundations from scouring actions of nearby river, stream etc. To construct costal defense works

COFFERDAM

Types of cofferdam

1. Cantilever sheet pile cofferdam
2. Braced cofferdam
3. Embankment protected cofferdam
4. Double wall cofferdam
5. Cellular cofferdam

Grout anchors used in constructions

In most cases, however anchorages may be embedded below ground level, with backstays connecting them to adjacent towers, or they may constitute the end abutments of the end spans.

In addition to stability sliding, the anchorage structure must also be checked for stability against tilting and overturning.

Methods o f ground water control

Following methods of ground water control are adopted

1. Pumping from open sumps
2. pumping from well points
3. Pumping from bored wells

(1) Pumping from open sumps

This method is most commonly used where area is large enough for allowing excavation to be cut back to stable slopes and where there are no important structures close to the excavation to effect their stability by settlement resulting from erosion due to water flowing towards the sump. This method is also applicable for rock excavations.

This method costs comparatively low for installation and maintenance. In this method one or more sumps are made below the general level of the excavation. In order to keep the excavator area clear of standing water, a small grip or ditch is cut around the bottom of the excavation failing towards the sump.

For grater depths of excavation the pump is used or submersible deep well pump suspended by chains and progressively lowered down. Pumps suitable for operating from open sumps are:

- Pneumatic sump pumps
- Self priming centrifugal pumps
- Mono pump sinking pumps

Pumping is simple and less expensive, but has serious limitations. When fine sand or cohesion less soil lie below the water, this type of pumping removes the fine material from the surrounding soil and results in settlement of adjacent structures. To product it sumps lined with gravel filter are sometimes used.

(2) Pumping from well points

This system comprises the installation of a number of filter wells generally 1m long, around the excavation. These filter wells are conducted by vertical riser pipes to a large diameter header main at ground level which is under vacuum from a pumping unit. The water flows to the filter well by gravity and then drawn by the vacuum upto the header main and discharged through the pump. This system has the advantage that the water is filleted as it removed from the ground and carries almost no soil with it once steady discharge conditions are attained. This system has the limitation of limited suction lift. Therefore for deeper excavations the well points are installed in two or more stages.

The filter wells or well points are usually 1m long and 60 to 75mm diameter gauge screen surrounding a central riser pipe. The capacity of a single we point with 50mm raiser is

about 10 lit/min. Spacing between two well points depends on the permeability of the soil and on the time available to effect the drawdown. In fine coarse sand or sandy gravels a spacing of 0.75 to 1m is required, while in silty sands of low permeability a 1.5m spacing is sufficient. In permeable course gravels spacing should be as low as only 0.3m.A normal set of well point system comprises 50 to 60 points to a single 150 or 200mm pump with a separate 100mm jetting pump.

(3) Pumping from bored wells

Pumping from wells, for draw-down depth of than the meters can be under taken by surface pumps with their suction pipes installed in bored wells. When dewatering is required to be undertaken from a considerable depth, electricity driven submersible pumps are installed in deep bore holes with rising main to the surface. Since heavy boring equipment is used, installation of wells can be done in all ground conditions including boulders and rocks. Due to higher costs of installation, this method is adopted where construction period is long and other methods of dewatering are not possible. Installation of bore well consists of sinking of a casting having a dia. of about 20-30 cm larger than the inner well casting. The dia of inner well casting depends on the size of submersible pump. This inner well casing is inserted after complete sinking of borehole screen over the length where dewatering of the soil is required and it terminates in a 3-5 m length of unperforated pipe to act as a sump to collect any fine material which may be drawn through the filter mesh. Screen having slots are preferable to holes, since there is less risk of blockage from round stones.

Component parts of pipe jacking

Pipe jacking is specialist tunneling method for installing underground pipelines by assembling the pipes at the foot of an access shaft and pushing them through the ground with the minimum of surface disruption

Component parts of jacking systems

The pump unit has two distinct hydraulic systems

A high pressure systems supplies oil for the main jacking cylinders and till intermediate jacking stations

A low pressure system supplies oil, via hydraulic lines, for the boring head and conveyor. An auxiliary power pack may be easily installed to double the low pressure hydraulic flow. This may be necessary for larger and more powerful boring heads.

Thrust yoke

The yoke is the frame that the main cylinders push against to advance the boring head and pipe. The ring provides a 360 degree surface against the pipe to minimize point pressure and reduce the chance of breakage.

Skid base

The skid base is the foundation of the pump unit and yoke. It also acts as a guide for launching the boring head and pipe into the ground.

Power packs

Power packs with high and low pressure systems typically are matched with the multiple cylinder system. When tunneling, a lower pressure power pack may be selected to supply oil for the tunnel boring machine (TBM)

Power required depend on the size and features of the boring head

A mobile electric power pack may be positioned in the boring head/ TBM

Intermediate jacking stations

Installing intermediate jacking stations is a simple economical way of adding and distributing thrust for pipe jacking. The size and joint of the pipe, cost, length of push and versatility are important considerations that configure intermediate stations. Most popular design is effective with a variety of pipe sizes and design. Each design consists of ram segments. Each segment has 5 rams. All stations are supplied oil by one set of lines from the power pack and operated from one point in the jacking shaft.

Methods of providing shoring for the trenches

Methods for providing shoring for the trenches

(1) Stay bracing

1. Stay bracing
2. Box sheeting
3. Vertical sheeting
4. Runners
5. Sheet piling

Carried out in moderately firm ground

It is adopted when the depth does not exceed 2m

The vertical sheets are placed opposite each other against the sides of the trench

The vertical sheets are held in position by one or two rows of struts

The sheets are placed at an interval of 3 to 4m and they extend to full depth of the excavation

The normal sizes of

Polling bores 200*40&200*50mm

Struts 100*100mm (For trench width upto 2m)

Struts 200*200 (For trench width more 2m)

2. Box sheeting

Carried out in loose soil

It is used when depth of excavation does not exceed 4m

A box like structure is formed by providing sheeting, walls, struts and bracing

In this arrangement, the vertical sheets are placed nearer and touching each other. The sheets are kept in position by longitudinal rows of Wales, usually two and then, struts are provided across the walls.

3. Vertical sheeting

Carried out in soft ground.

Adopted when the depth is about 10m.

This is similar to box sheeting except that the work is carried out in stages and at each stage, an offset is provided.

For each stage, vertical sheets, walls, struts and braces are provided as usual.

The offset is provided at a depth of 3 to 4m and it various from 30 to 60cm per stages

Suitable for laying sewers or water pipes at considerable depths.

4. Runners

Carried out in extremely loose and soft ground which requires immediate support as the excavation progresses

The runners which are long thick wooden sheets or planks are used in this arrangement

One end of runner is made up of iron shoe

These are driven by hammering about 30cm

The walls and struts are provided as usual

5. Sheet piling

Provided when large area is to be excavated for a depth greater than 10m

Used when the soil is soft or loose

Provided when the width of the trench is large

It is also provided when the subsoil water is present

Large reservoir construction with membranes and earth system

The main problem in reservoirs is the loss of water due to seepage

So even if the capacity of the reservoir is large much water by lost due to it

It can be made impermeable by construction of impervious membranes on the embankment

The impervious membrane can be placed on

1. The upstream face of the dam
2. Core inside the embankment

Most of the major earth dams constructed before 1925 were provided with central concrete core walls or concrete slabs on the upstream face

The impervious advantages for the impervious membrane placement in the upstream side or core of the embankment

Concrete slab

Concrete slab can be used successfully up to a height of 150ft
The performance of concrete slab will directly on the quality of concrete
Even through the earth embankment is not required to act as a water barrier, it should be well compacted in order to minimize post-construction settlement of the upstream slope
When single reinforced slab is adopted, some leakage will occur due to the hairline cracks so drains should be provided.

Steel plates

Steel plate can be used where reinforced concrete is used
The life is approximately the same as that of concrete
It can be directly placed on the soil containing appreciable percentage of silt or clay
It is expansive but it has two advantages
It is watertight
It is more flexible and can adapt to differential settlement in a better manner

Asphaltic concrete

They are less costly than concrete or steel
They are more flexible than reinforced concrete and can adapt to differential settlement better
They can be constructed quickly
Under certain circumstances the leaks development are self-sealine
The portion above the reservoir level are easy to repair than either concrete or steel

Advantages of upstream membrane

When the membrane is on the upstream side optimum stability condition are produced ,so the volume of embankment can be reduced
Since the upstream slab is exposed ,damage can be inspected and repaired easily
The upstream membrane can be built after the embankment is completed
Foundation grouting can be carried out while the dam is being built
The membrane can serve a secondary function as wave protection

Internal impervious membrane

Concrete is used mostly for internal membrane steel is used rarely
Since it is not exposed for investigation very little reliable performance is available
It is less influenced by embankment settlement and less likely to crack as a result

Advantages of internal membranes

The area of the membrane is smaller than that of an upstream facing, so less material is required
The surrounding embankment protects the internal membrane
The core can be made almost watertight even if cracking develops, by placing thin layer of clay upstream

A vertical extension of the core membrane below the base of the dam can be used through soil deposits in the foundation

The length of the grout curtain in is shorter.

Well sinking operation procedures

1. **Laying the well curb**

   If the river bed is dry, laying of well curb presents no difficulty. In such a case, excavation upto half a meter above subsoil water level is carried out and the well curb is laid. If, however, there is water in the river, suitable cofferdams are constructed around the site of the well and is lands are made. The sizes of the island should be such to allow free working space necessary to operate tools and plane for movement of labour etc. When the island is made, the center point of the well is accurately marked and the cutting edge is placed in a level plane. It is desirable to insert wooden sleepers below the cutting edge at regular intervals so as to distribute the load and avoid setting of the cutting edge unevenly during concrete.

2. **Masonry in well staining**

   The well staining should be built in initial short height of about 2m only. It is absolutely essential that the well staining is built in one straight line from the bottom to top. To ensure this staining must be built with straight edges preferably of angle iron. The lower portions of the straight edges must be kept butted with the masonry of the lower stage throughout the building of the fresh masonry. In no case should a plumb bob be used to built more than 5m at a time. The well masonry is fully cured for at least 48 hours before starting the loading or sinking operations.

3. **Sinking operations**

   A well is ready to be set in after having cast the curb and having built first short stage of masonry over it. The well is suck by excavating material from inside under the curb. In the initial stage of sinking, the well is unsuitable and progress can be very rapid with only little material being excavated out. Great care should therefore be exercised during this stage, to see the well sinks to true position. To sink the well straight it should never be allowed to go out of plumb.

   Excavation and scooping out of the soil inside the well can be done by sending down workers inside the well till such a stage that the depth of water inside becomes about 1m. As the well sinks deeper, the skin friction on the sides progressively increases. To overcome the increased skin friction and the loss in weight of the well due to buoyancy, additional loading known as kent edge is applied on the well.

Pumping out the water from inside the well is effective in sinking of well under certain conditions. Pumping should be discouraged in the initial stage. Unless the well has gone deep enough or has passed through a ring of clayey strata so that chances of tilts and shifts are minimized during this process. Complete dewatering should not be allowed when the well has been sunk to about 10m depth.

4. Tilts and shifts

The primary aim in well sinking is to sink them straight and at the correct position. Suitable precautions should be taken to avoid tilts and shifts. The precautions to avoid tilts and shifts are as follows

1. The outer surface of the well curb and steinings should be as regular and smooth as possible.
2. The radius of the curb should be kept 2 to 4 cm larger than outside of well Steining.
3. The cutting edge of the curb should be of uniform thickness and sharpness since the sharper edge has a greater tendency of sinking than a blunt edge.
4. As soon as tilt exceeds 1 in 200, the sinking should be supervised with special care and rectifying measures should be immediately taken.

5. Completion of well

When the well bottom has reached the desired strata, further sinking of the well stopped. A concrete seal is provided at the bottom. The bottom plug is made bowl shaped so as to have inverted arch action. As generally under watering concerting as to done, no reinforcement can be provided. Under watering concreting is done the help of tremie. However if it is possible to dewater the well successfully, the concrete can be placed dry also.

After having plugged the well at its bottom, the interior space of the well is filled either with water or sand. It may even we kept empty. The well is capped at its top, with help of reinforced concrete slab.

UNIT IV SUPER STRUCTURE CONSTRUCTION

Launching girders, bridge decks, off shore platforms – special forms for shells - techniques for heavy decks – in-situ pre-stressing in high rise structures, Material handling - erecting light weight components on tall structures - Support structure for heavy Equipment and conveyors - Erection of articulated structures, braced domes and space decks.

LAUNCHING GIRDER

Launching girder is a steel or wooden structural member used to support the super structures such as bridge deck, off shore structures etc. the operation of launching girder is more difficult. Proper study and local site investigations are the only way to make it easier.

Uses:

- It is used for all type of bridge deck construction
- It is used in the field of pier head construction
- It is used for off shore platform construction
- It is used for deep foundation construction
- It is used for lifting heavy equipment
  for various constructions.

The basic steps for a typical construction are

- Delivery of a segment to the launching girder.
- Pick-up and winching of segment into its approximate position.
- Application of epoxy resin to segment faces to be joined.
- Final positioning and temporary stressing for self supporting.
- Internal permanent post tensioning sufficient to allow placing of the next segment.
- Repitation for further segments until completion of the cantilevers.
- Form & stress a concrete stitch at mid-span to complete the span.

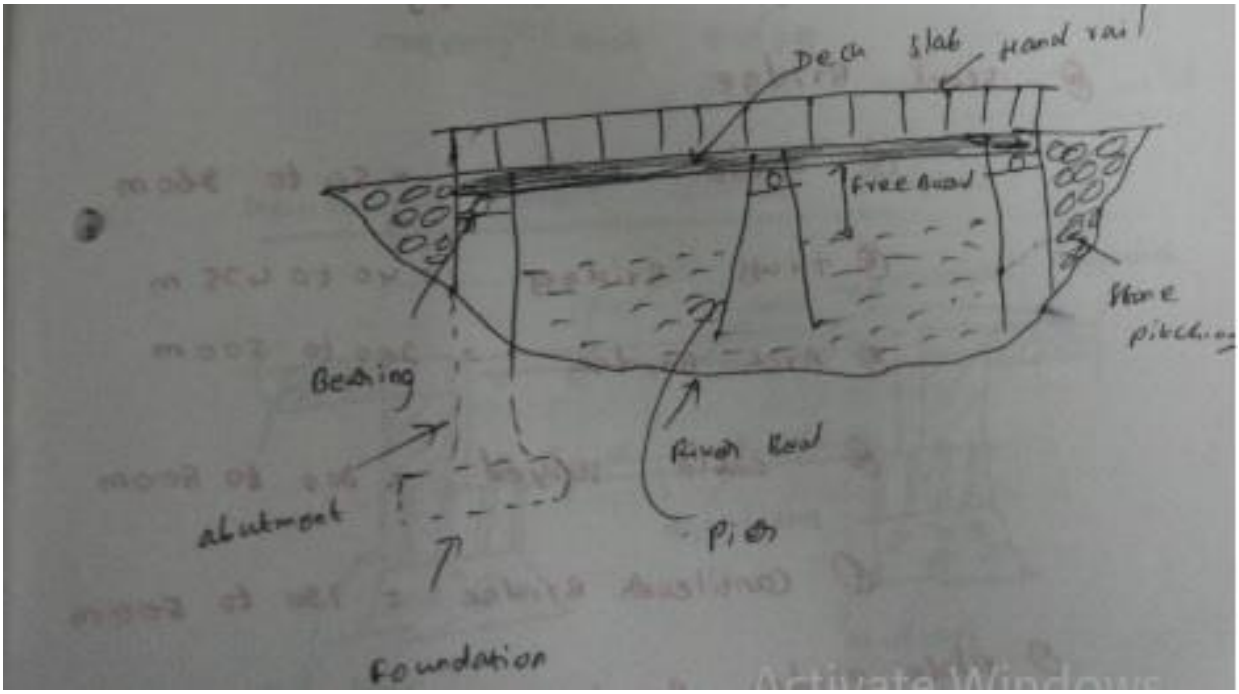
- Launch the launching girder to next span.
- Final post tensioning possibly continous through more than 10m span.

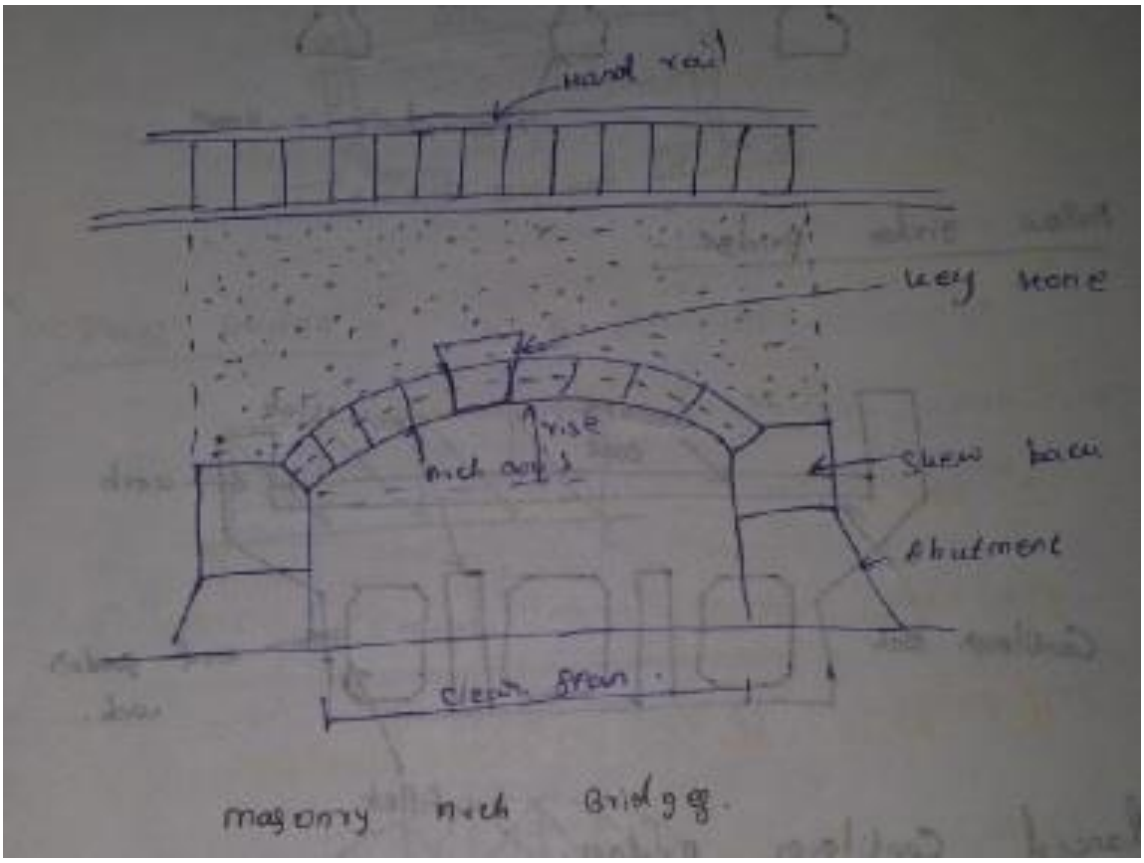
BRIDGE DECKS

Construction of bridge decks

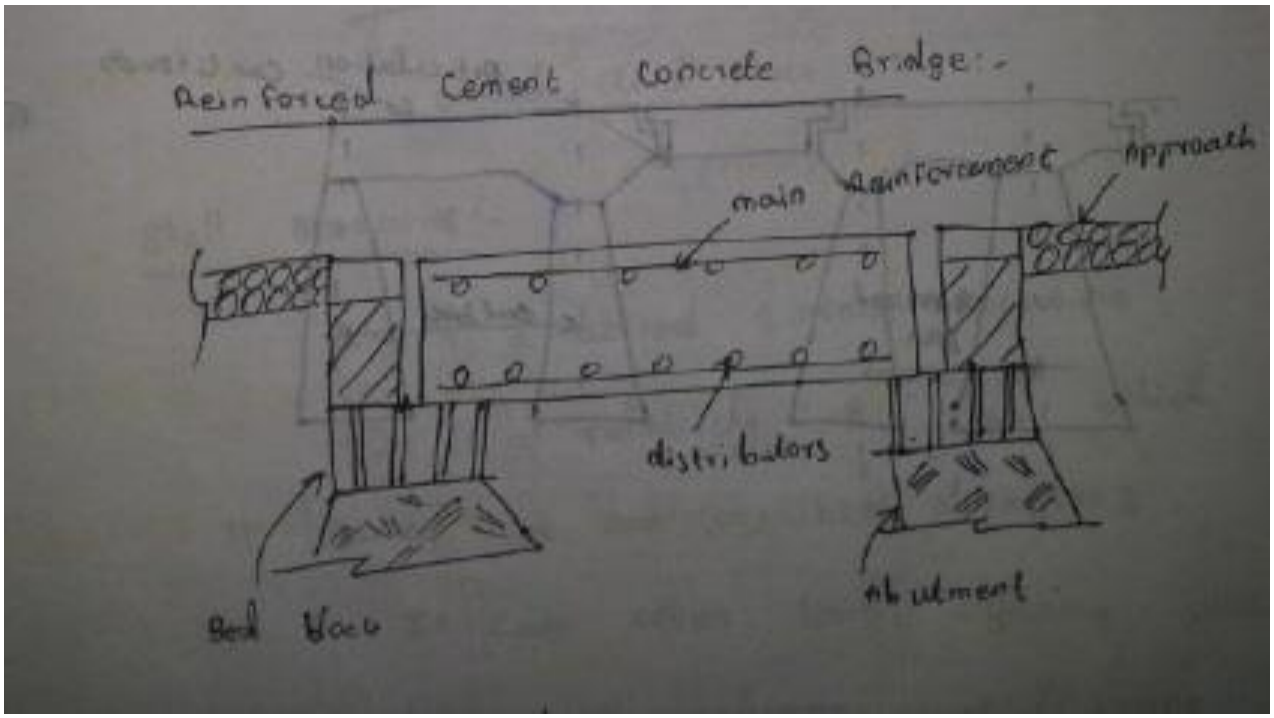
The various bridge decks are constructed by the following construction sequences. They are

- Traditional or technique for heavy decks
- Incremental push launching or launching girder
- Cable stayed bridges
- Bow string bridge

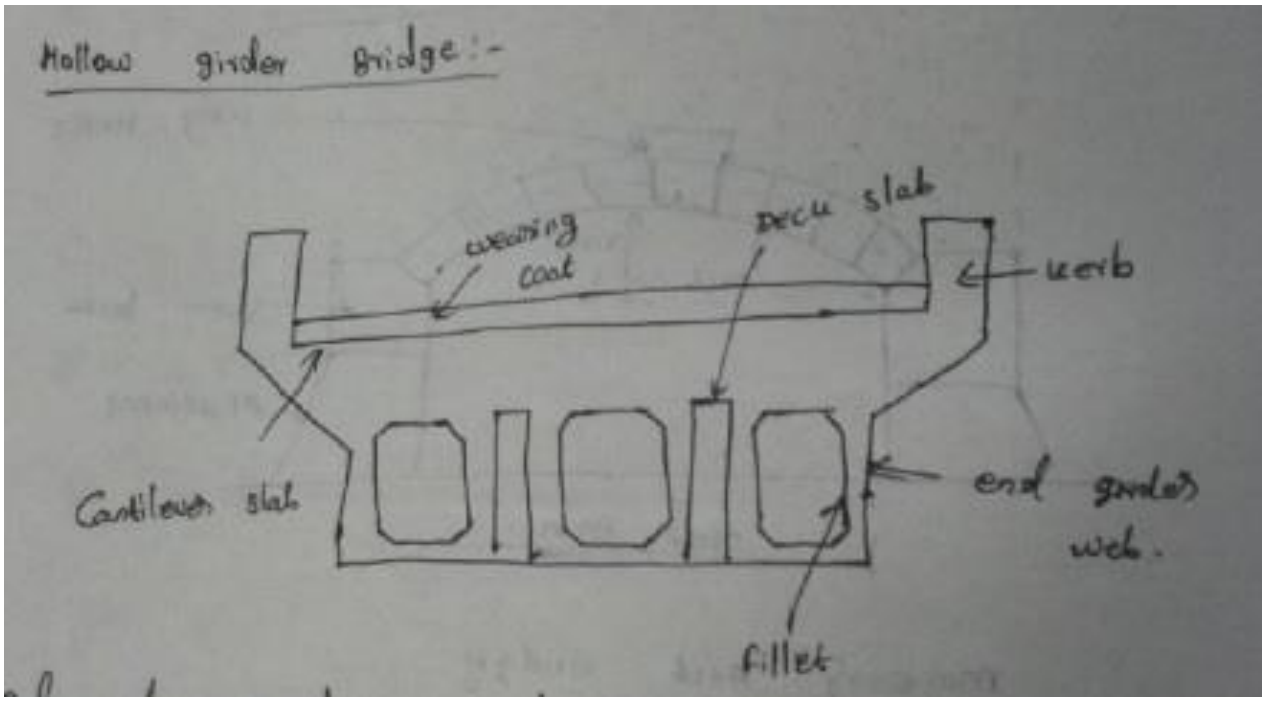




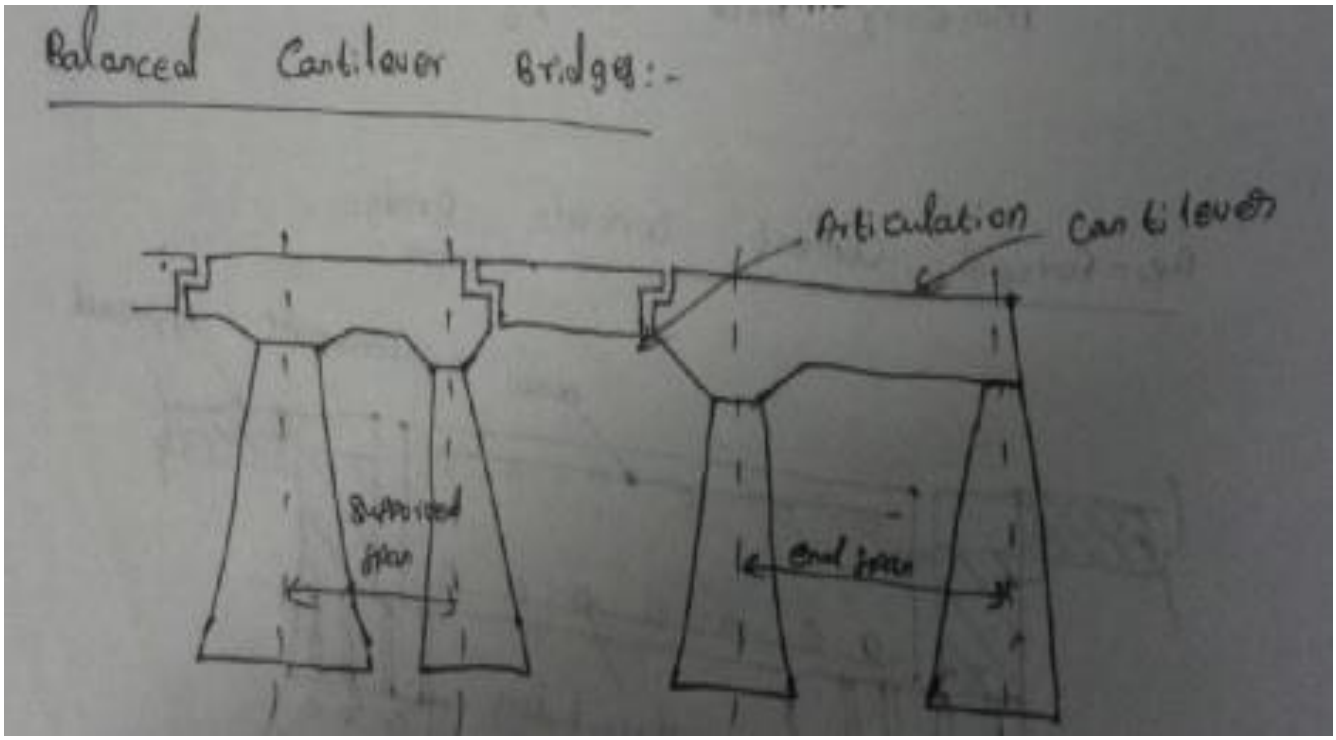
masonry arch Bridge.

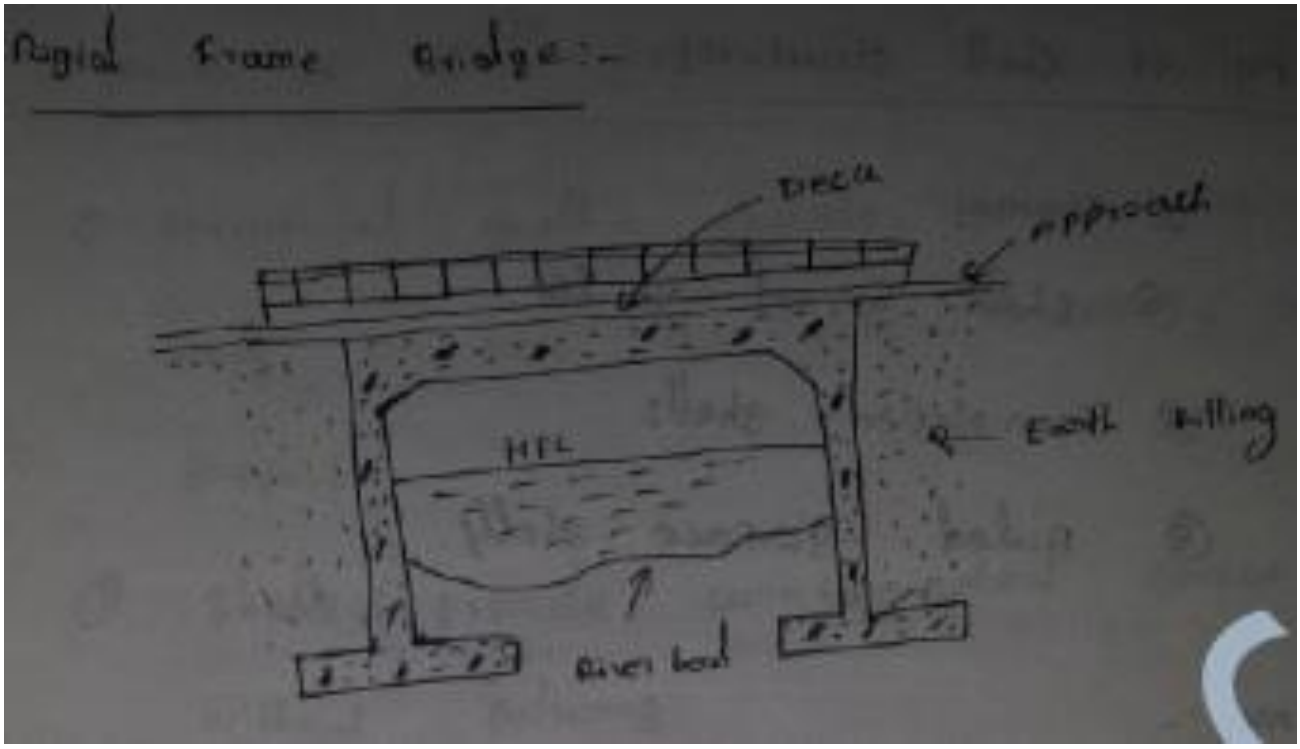


Hollow girder Bridge :-



Balanced Cantilever Bridge :-





Precautions during the construction of bridges:

The local site conditions are studied. It is used to give the proper design and construction of bridges and it includes local weather for whole year. The proposed site soil conditions should be studied, it is used to avoid any settlement of foundations and auxillary support etc. and it is also used for the depth of foundation.

The site of the proposed bridge should be located where the materials and labour are available at cheapest rate.

The proper studies are carried out for velocity if velocity of flow is less than a particular value the silting will occur.

The proper study or precautions carried out to form embankment on both side of bridge it should be solid permanent and straight

The suitable precautions are taken about high flood level. This studying is used to provide the suitable height of the bridge from the water bodies.

The bridge deck should be design for future traffic also. So the proper current traffic as well as future traffic is carried out.

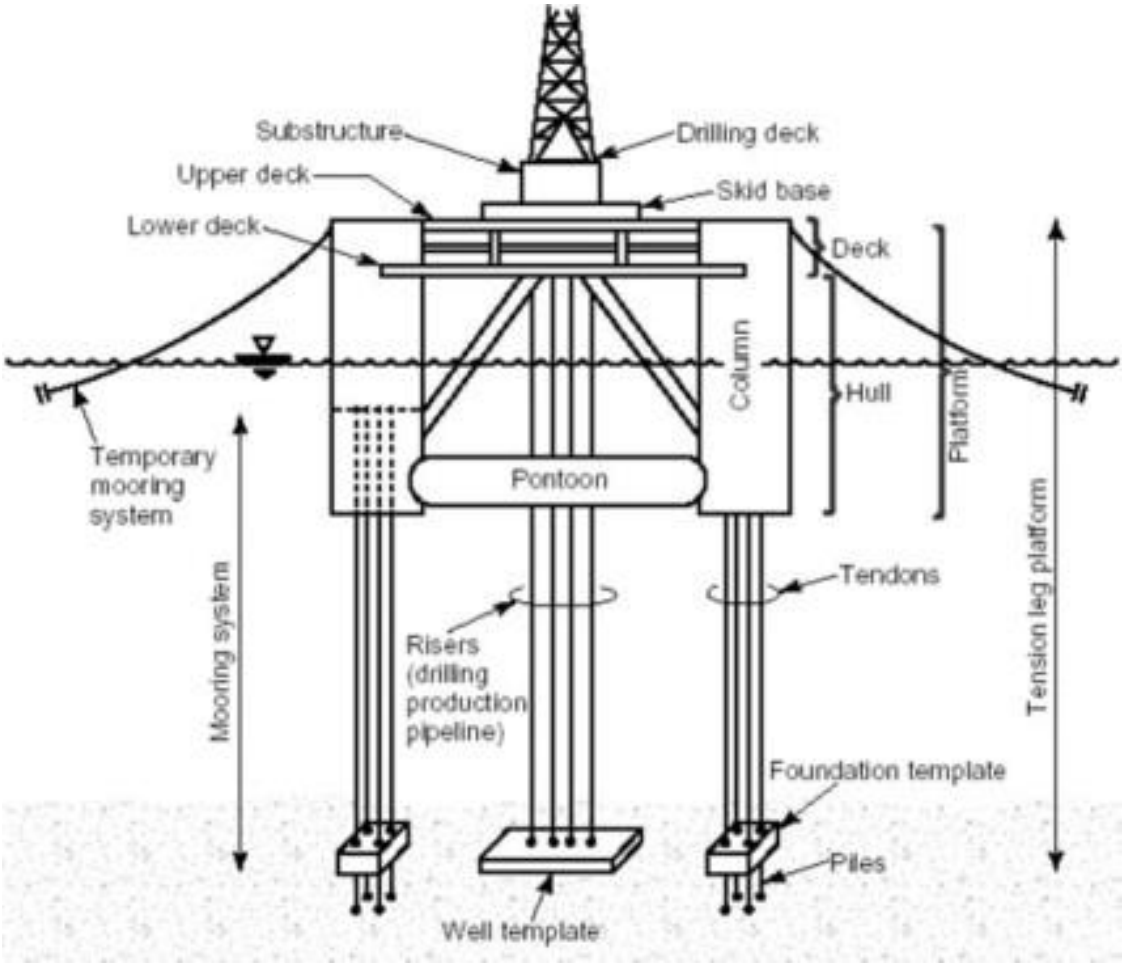
Correct span length is provided for bridge deck. It may used to avoid any structural damage.

The proper finishing works are carried out to avoid any cracks on structure.

OFFSHORE PLATFORMS:

Offshore platforms are a structure that is constructed in the ocean or sea to explore or to produce oil or gas from the sources found below the sea. It is dealt with the foundations in the sea.

Offshore platforms are made up of either in steel or concrete. Since this construction is constructed on sea water utmost care should be taken to resist the structure from the corrosion problems.



Uses:

- Oil and gas exploration
- Navigation aid tower
- Bridges and causeways
- Ship loading and unloading facilities

Types of offshore platform

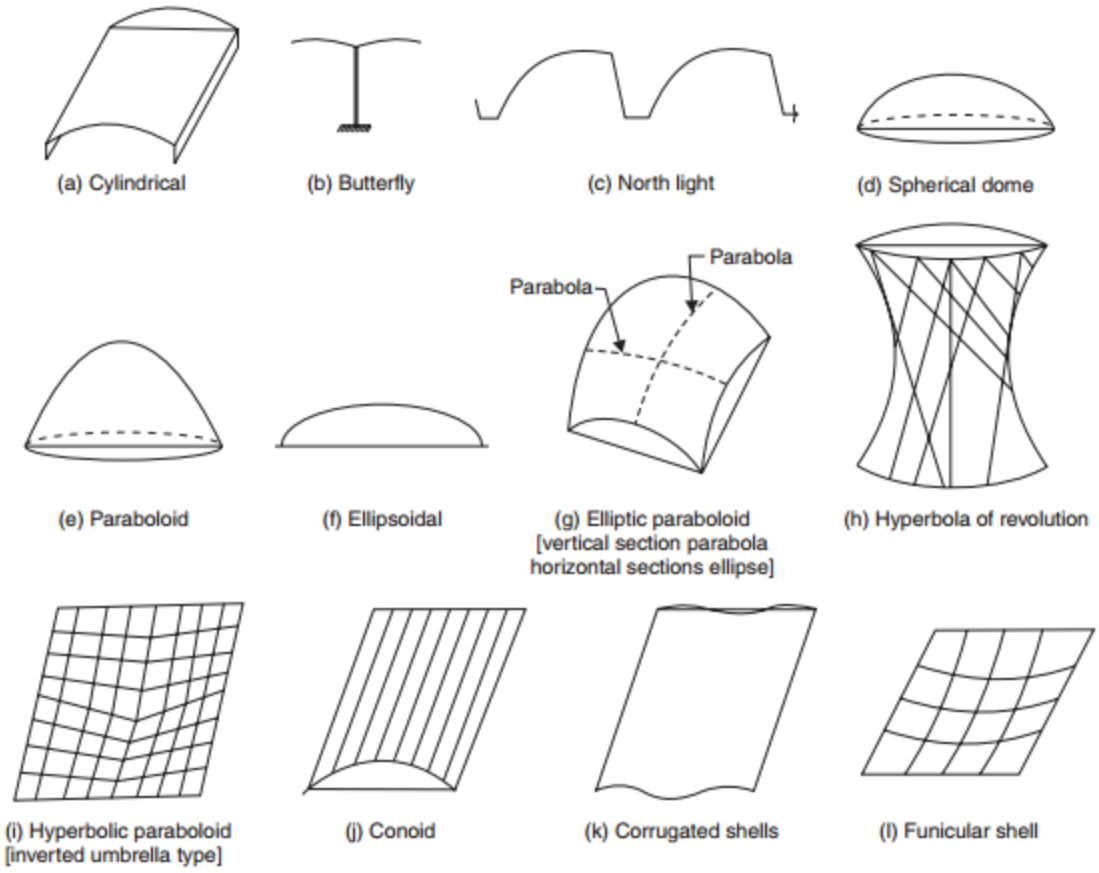
- Fixed platform
- Complaint tower
- Sea shore platform
- Floating production system
- Tension leg platform
- Sub base platform
- Spar platform

Special forms of shell

A shell structure is a three dimensional structure constructed for storage of water, roof of large column free are such as complex theatres etc.

The shell is used as special forms

- Roofs chimney
- Cooling tower



Construction sequence of shell roofs

Due to the minimum thickness, shell structures are used for special roof construction. It is used to cover large area by means of column free structure.

The following are the special forms of shell roofs.

- Single barrel shell
- Butterfly shell
- Multiple barrel shell
- North light cylindrical shell

Advantages

- Very light form of construction to span 30.0m shell thickness required is 60mm.
- Dead load can be reduced economizing foundation and supporting system
- Flat shapes by choosing certain arched shapes.

- Aesthetically it looks good over other forms of construction.

Disadvantages:

- Shuttering problem
- Greater accuracy in formwork is required
- Rise of roof may be disadvantages
- Good labour and supervision necessary.
- Design consideration of shell roof
- Slope shall not exceed 45^o to 65^o

Thickness

Singly curved shell <50mm

Doubly curved shell <40mm

End frames

Traverse or end frame provided to protect the shape of the shell.

Reinforcement:

Diameter of reinforcement <5mm in the unthickened portion of the shell.

Mix proportions for concrete:

Nominal mix 1:2:4 – shells of medium dimensions

Nominal mix (by volume) 1:1.5:3 –very large shell

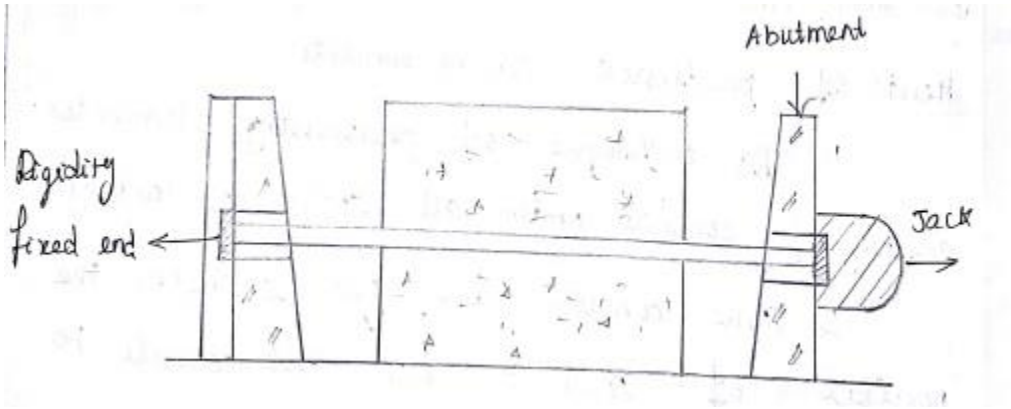
IN SITU PRESTRESSING IN HIGH RISE STRUCTURE

Prestressing is the method of increasing tensile strength of member by introducing internal stresses for prestressing, the tendons are used to introduce stresses and suitable anchorage is used.

Prestressing of concrete member can be obtained by following two methods

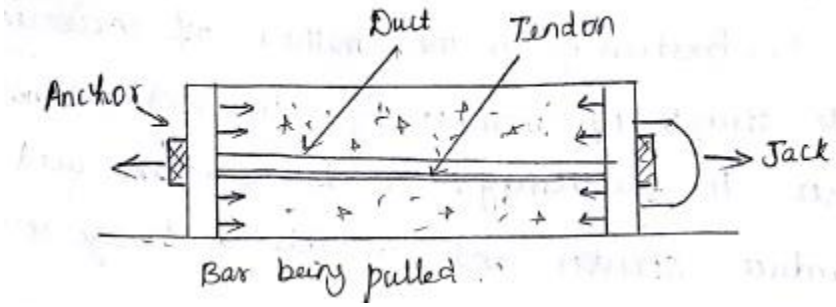
- Pre tensioning method
- Post tensioning method

Pre tensioning method



In the pre tensioning system the tendons are tensioned before concreting.

Post tensioning method



Post tensioning method is one in which the reinforcement is tensioned after the concrete has fully hardened. The concrete is first cast and leaving duct for placing the tendons. The ducts are made in a number of ways by leaving corrugated steel tube or by providing steel special or rubber or any other ducts forming units

Merits of prestressed cement concrete:

This technique of prestressing eliminates cracking of concrete under all stage of loading.

Since concrete does not crack the possibility of steel to rust and concrete to deteriorate is minimized.

Absence of cracks results in higher capacity of the structure to bear reversal of stresses, impact vibration and shock

CONSTRUCTION SEQUENCES IN TALL BUILDING

- Studying of local soil condition
- Form work
- Mixing of concrete
- Pumping system
- Use of admixtures
- Proper curing

MATERIAL HANDLING

Material handling consists of transporting, securing and stacking or protect the manufacturing product for the purpose of construction is known as material handling.

In order to handle materials large amount of equipments such as various types of conveyors, cranes and trucks and labours are involved.

Classification of material handling

- Transport equipment
- Positioning equipment
- Unit load formation equipment
- Storage equipment
- Identification and control equipment

ERECTION OF LIGHT WEIGHT COMPONENT OF TALL STRUCTURE

- The light weight components are transported and stacked.
- The suitable scaffolding and temporary supporting structures are made to establish the light weight component.

- Lifting and placing to the system to ensure stability during erection.
- Aligning and permenantly connecting the member by bolting, riveting or welding concreting
- Connecting all necessary claddings
- Removing all scaffolding or supporting structure

The following precautions are taken

Well trained workers are used for erection process, because minor mistake can cause serious effects.

Proper material handling should be carried out such that it can minimize the storage requirements.

Cleaning process should be carried out on the surface of the elements.

Proper verification should be made to avoid irregular shape of members.

Proper scaffolding should be avoid any structural failure during erection process.

The surface treatments should be made by means of proper finishing work.

SUPPORT STRUCTURE FOR HEAVY EQUIPMENT AND CONVEYORS:

The supporting structure is used to indicate any structure used to support a working platform including plant and equipment. A safe resting surface is required for supporting structures. The supporting structure should be strong enough rigid and stable. The supporting structure and its platform will be affected by the following factors.

Uneven surface of the platforms.

Application of overload to supporting structure.

ERECTION OF ARTICUALTED STRUCTURES

An articulated structure is defined as a structure connected/ constructed by joints.

Articulated structures are very useful for the construction of mega structure. In general by connection only we can make the mega structures.

A traffic management plan is developed and implemented.

Activities of all contractors are being co-ordinated and supervised.

The grand surface or supporting structure is suitable for plant to operate safely.

Weather conditions are continually monitored particularly potentially hazardous situations like high or string winds and electrical storms.

At least one of the erection crew or another person who remains on site throughout erection process.

The builder should ensure that the accuracy of each contractors work is within the tolerance of the level or position nominated by the erection engineer or relevant standard.

Any modification to the building layout also need to checked by the builder for approval by the erection engineer.

Only start the erection of member or sub-assembly when equipment to ensure the structures stability is available and being used.

Ensure temporary bracing securely anchored

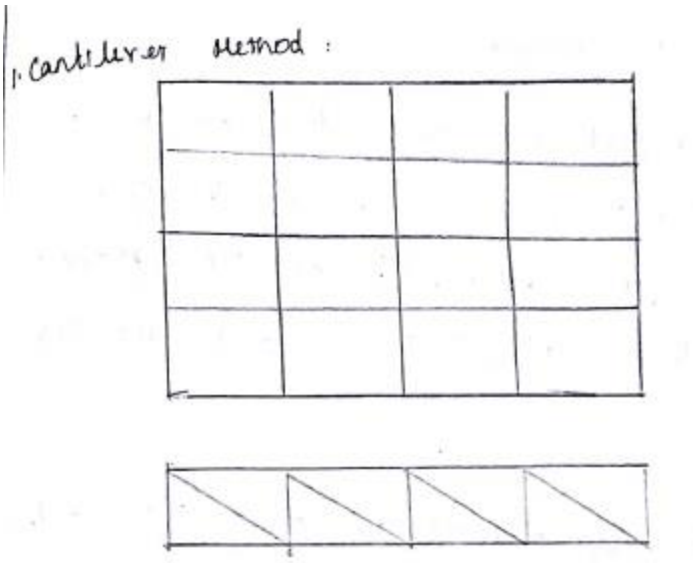
Check the fittings for the support of columns during erection to ensure adequate structural capacity for the erection conditions.

ERECTION PROCESS OF BRACED DOMES AND SPACE DECK:

If the length of the area to be roofed is more than twice the breadth. It is more economical to span one way. If the area is nearer square the more economical solution . theoretically is to span two ways. The rectangular area can be divided into square or near square areas with lattice girder and then two way spanning structure can be installed in the sub-divided roof.

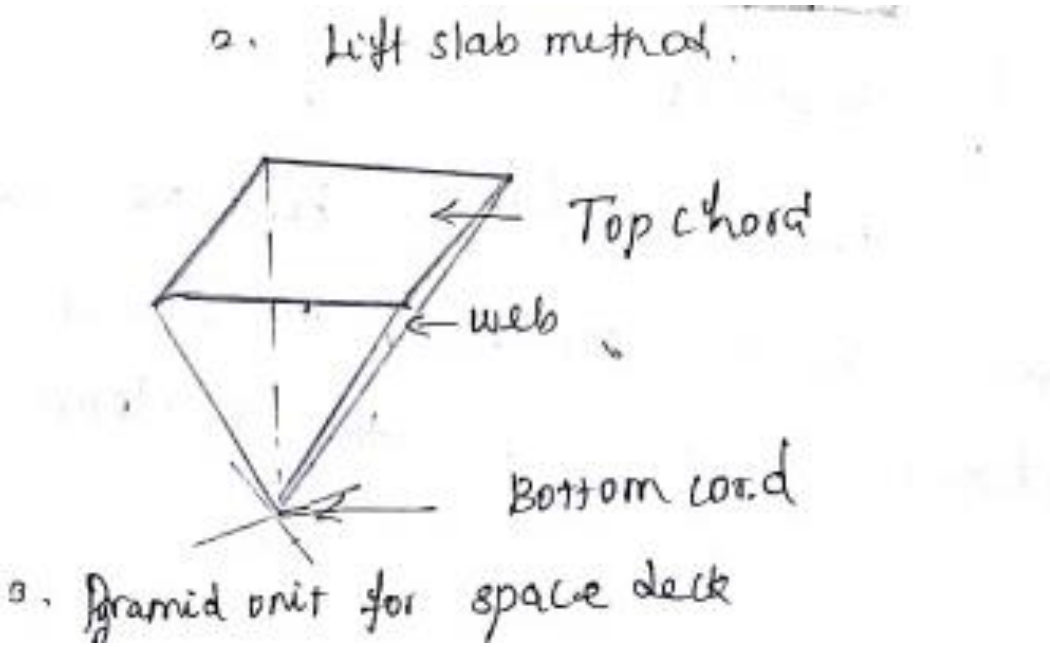
CANTILEVER METHOD

In this method the structure is erected starting from a support point and a section or strip of the structure is erected to span between two adjacent supports with the help of movable scaffolding. Once part of the structure is stabilized, the rest of the structure is assembled by adding separate pieces or units to already erected structure.



LIFT SLAB METHOD

In this method the entire spatial structure is assembled on ground and lifted to the final location using cranes or other heavy lifting equipment. This method is usually upto 200ft weighing upto 200 Kpa have been erected using this method.



UNIT IV SUPER STRUCTURE CONSTRUCTION

1. Explain the construction techniques for bridge decks with flowchart. (Apr 2019)
2. With flow diagram explain the erection of articulated towers. (Nov 2012)
3. Briefly explain General requirements for launching girders.
4. Describe in detail about shell roof structures. (Nov 2016)
5. Explain about the support structures required for heavy equipments and conveyors. (Nov 2016)
6. Explain about various types of domes with neat sketch.
7. What is a sheet pile? List the factors for selection of sheet piles. Explain its types based on materials. (Apr 2019)
8. Discuss in detail about the bridge decks and offshore platform with suitable diagram. (Nov 2013)

UNIT V CONSTRUCTION EQUIPMENTS

The selection of t appropriate type and size of construction equipment often affects the required amount of time and effort and thus the job-site productivity of a project. It is therefore important for site managers and constructions p1anners to be familiar with the characteristics of the major types of equipment most commonly used construction. Construction equipments can be classified based on applications under the following heads:

Excavation an Earthmoving equipments

Concreting equipments

Material handling Erection equipments

Dewatering and Pumping equipments

Typically, construction equipments are used to perform essentially repetitive operations, and can be broadly classified accord to two basic functions:

Operators such as cranes, graders, etc. which stay within the con of the construction site haulers such as dump trucks, ready mixed concrete truck, etc. which transport materials to and from the site. In order to increase job-site productivity, it is beneficial to select equipment with proper characteristics and a size most suitable for the work conditions at the construction site.

Excavation and Earthmoving equipments

Factors that could affect the selection of excavators include:

Size of the job larger volumes of excavation will require larger excavators, or smaller excavator in greater number activity time constraints Shortage of time for excavation may force contractors to increase the size or numbers of equipment for activities related to excavation.

Availability of equipment - Productivity of excavation activities will diminish if the equipment used perform them is available but not the most adequate.

Cost of transportation of equipment - This cost depends on the size of the job, the distance of transportation and the means of transportation.

Type of excavation - Principal types of excavation in building projects are cut and/or fill, excavation massive, and excavation for the elements of foundation

Soil characteristics the type and condition of the soil is important when choosing the most adequate equipment since each piece of equipment has different outputs for different soils.

Geometric characteristics of elements to be excavated - Functional characteristics of different types of equipment make such considerations necessary.

Space constraints - The performance of equipment is influenced by the spatial limitations for the movement of excavators.

Characteristics of haul units - The size of an excavator will depend on the haul units if there is a constraint on the size and/or number of these units.

Location of dumping areas - The distance between the construction site and dumping areas could be relevant not only for selecting the type and number of haulers, but also the type of excavators.

Normally there are three purposes of earth moving equipments,

Excavation of soil from below or above the track/wheel level of the equipment

Clearance of site at the track/wheel level of equipment

Hauling of spoil out of site

A few types of equipments under this head are:

Bull Dozers and Angle Dozers

Graders

Skimmers

Scrapers

Loaders

Face Shovels

Backacters

Draglines

Multipurpose excavators

Bulldozers and Angle Dozers

These machines consist of a track or wheel mounted power unit with a blade at the front, which is usually controlled by hydraulic rams and sometimes by wire cable operation. Many bulldozers have the capacity to adjust the mould blade to from angle dozers and the capacity to tilt the mould blade about a central swivel point. .

Some bulldozers can also be fitted with rear attachments such as rollers and scarifies.

The main uses of a bulldozer are:

Shallow excavations up to 300CM deep either on levee, ground or side hill cutting

Clearance of shrubs and small trees

Clearance of trees by using raised mould blade as a pusher arm

Acting as a towing tractor

Acting as a pusher to scraper machines

Bulldozers push earth in front of the mould blade with some side spillage whereas angle dozers and cast spoil to one side of the mould blade.

Graders

These machines are similar in concept to bulldozers in that they have a long slender adjustable mould blade, which is hung, under the center of the machine. A grader

is used to finish or grade the upper surface of a large area usually as a follow up operation to scraping or bulldozing. They can produce a fine and accurate finish but do not have the power of bulldozer. Therefore they are not suitable for over site excavation work. The mould blade can be adjusted in both the horizontal and vertical planes through an angle of 360 the latter enabling it to be used for grading sloping banks as well.

Two basic types of graders are:

(i) Four Wheeled Graders

In this type of graders all wheels can be driven and steered. This facility gives the machine the ability to offset and crab along its direction of travel.

(ii) Six Wheeled Graders

Six Wheeled Graders have four wheels in tandem drive at the rear and two front tilting idler wheels giving it the ability to counteract side thrust.

Skimmers

These excavators are rigged using a universal power unit for surface stripping and shallow excavation work up to 300 cm deep where a high degree of accuracy is required They usually require attendant haulage vehicles to remove the spoil and need to be transported between sites on a low loader. Because of their limitations and the availability of alternative machines, they are rarely used today.

Scrappers

Scrapers are multiple-units of tractor-truck and blade-bucket assemblies with various combinations to facilitate the loading and hauling of earthwork. Major types of scrapers include single engine two-axle or three aide scrapers, twin-engine all-wheel-drive scrapers, elevating scrapers, and push-pull scrapers. Each type has different characteristics of rolling resistance, maneuverability stability, and speed in operation.

These machines consist of a scraper bowl, which is lowered to cut, and collect soil where site stripping and leveling operations are required involving large volume of earth, When the scraper bowl is full, the apron at the cutting edge is closed to retain the earth and the bowl is raised to the disposal area. On arrival of disposal area, the bowl is lowered, the apron opened and the spoil pushed out by the tailgate as the machine moves forwards.

(i) Towed scrapers

It consists of a four wheeled scraper bowl with a power unit such as a crawler tractor. They tend to be slower than other forms of scrapers but are useful for small capacities with haul distances up to 300 m.

(ii) Two Axle scrapers

These have a two-wheeled scraper bowl with an attached two wheeled power unit. They are view maneuverable with low rolling resistance and very good fraction.

(iii) Three Axle scrapers

It consists of a two-wheeled scraper bowl that may have a rear engine to assist the four-wheeled traction engine. Generally, these machines have a greater capacity than other scrapers, are easier to control and have a faster cycle time.

(e) Loaders

These machines are sometimes called tractor shovels. They are used to scoop up loose materials in the front mounted bucket, elevate the bucket and maneuver into a position to deposit the loose material into an attendant transport vehicle. Tractor shovels are driven towards the heap of loose material with the bucket lowered. The speed and power of the machine will enable the bucket to be filled. To increase their versatility tractor shovels can be fitted with a 4 in 1 bucket enabling them to car out bulldozing as well.

Both crawler mounted and wheel mounted types are available. The tracked loader being more suitable for wet and uneven ground conditions than the wheeled one, which has greater speed, and maneuvering capacities.

Face Shovels

The primary function of face shovels is to excavate above its own track or wheel level. They are available as a universal power unit based machine or as a hydraulic purpose designed unit. These machines can usually excavate any type of soil except that which needs to be loosened, usually by blasting, before excavation. Face shovels generally require attendant haulage vehicles for the removal of spoil and a low ladder transport lorry for travel between sites. Most of these machines have a limited capacity of between 0.3 m and 0.4 m for excavation below their own track wheel level.

Backacters

These machines are suitable for trench, foundation and basement excavations and are available as a Universal power unit base machine or Purpose designed hydraulic unit. They can be used with or without attendant haulage vehicles since the soil can be placed alongside the excavation for the use in back filling. These machines will require a low loader transport vehicle to be transported from one site to another. Backacters used in trenching operations with a bucket width equal to the trench width can be very accurate with a high output rating.

Draglines

Draglines are based on the universal power unit with basic crane rigging to which is attached a drag bucket.

The machine is primarily designed for bulk excavation in loose soils up to 3 m below its own track level by swinging the bucket out to the excavation position and haunting or dragging it back towards the power unit.

Dragline machines can also be fitted with a grab or clamshell bucket for excavating in very soils.

Mu1tIpurpose Excavators

These machines are usually based on the agricultural tractor with 2 or 4 wheel drive and are intended mainly for use in conjunction with small excavation works such as foundation excavations, pipe laying and drainage trenches. Most multi-purpose excavators are fitted with a loading/excavating front bucket and a rear backwater hoe bucket both being hydraulically controlled. When in operation using the backwater bucket, the machine is raised off its axles by rear mounted hydraulic outriggers or jacks and in some models by placing the front bucket on the ground.

The choice of the type and size of haulers is based on the consideration that the number of haulers selected must be capable of disposing of the excavated materials expeditiously. Factors which affect this selection include:

1. Output of excavators - The size and characteristics of the excavators selected will determine the output volume excavated per day.
2. Distance to dump site - Sometimes part of the excavated materials nay be piled in a corner at the job site for use as backfill
3. Probable average speed - The average speed of the haulers to and from the dumping site will determine the cycle time for each hauling trip.
4. Volume of excavated materials - The volume of excavated materials including the part to be piled up should be hauled away as soon as possible.
5. Spatial and weight constraints - The size and weight of the haulers must be feasible at the job site and over the route from the construction site to the dumping area.

Concreting equipments

It is well known that the process of concreting involves batching, mixing, transporting, placing, compacting and curing. Accordingly common concreting equipments are,

- Concrete mixers
- Concrete Hauling Equipments
- Concrete pumps for placement in different conditions
- Concrete vibrators for compaction

Concrete mixers

These are generally related to their designed output performance. Machines are decided based upon what mixing and placing methods are to be employed to mix and place a certain amount of concrete in a given time period. Generally, a batch mixing time of 5 minutes per cycle of 12 batches per hour can be assumed as a reasonable basis for assessing mixer output.

(b) Concrete Hauling Equipments

(i) Wheel barrows he usual means of transporting mixed concrete produced in a small capacity mixer is by wheelbarrow. The run between the mixing and placing positions should be kept to a minimum and as smooth as possible by using planks or similar materials to prevent segregation of the mix within the wheelbarrow

(ii)Dumpers

These can be used for transporting mixed concrete from mixers up to 600-litre capacity and are available in two forms,

(iii) Ready Mix Concrete Mixers

These are used to transport mixed concrete from a mixing plant or depot to the site. Usual capacity range of ready mixed concrete trucks is 4 to 6 rn3. Discharge can be direct into placing position into some form of site transport such as dumpier, crane skip or concrete pump.

(d) Concrete pumps for placement in different conditions

These are used to transport large volumes of concrete in a short time (say up to 100 m3 per hour) in both the vertical and horizontal directions from the pump position to the point of placing. The pump is supplied with pump able special concrete mix or with constant flow of ready mixed concrete lorries throughout the pumping period. Concrete pumps are usually of a twin cylinder hydraulically driven form with a small bore pipeline (100 mm diameter) and can be trailer or lorry mounted.

Pumping ranges may be up to 850.00 m vertically and 200 m horizontally depending on the pump model. It generally requires about 45 minutes to set up a concrete pump on site including coating the bore of the pipeline with a cement grout before pumping. After plumbing, the pipeline should be cleared and cleaned. Usually concrete pump and operator are hired for the period required

(e) Concrete vibrators for compaction

(i) Poker or Internal Vibrators

These consist of a hollow steel tube casting in which is a rotating impeller which generators vibrations as its head comes into contact with casing. Poker vibrators should be inserted vertically and allowed to penetrate 75mm into any previously vibrated concrete.

(ii) External Clamp or Tamping Board Vibrators

These vibrators operate by shaking the formwork. Clamp vibrators powered by either compressed air or electricity whereas tamping board vibrators are usually petrol driven.

Formwork must be stronger than is traditional to withstand vibration.

MATERIAL HANDLING AND ERECTION EQUIPMENTS

Horizontal transportation

Vertical transportation

Upward only

Downward only

Upward and downward

Derricks are commonly used to lift equipment of materials in industrial or building construction

A derrick consists of a vertical mast and an inclined boom sprouting from the foot of the mast.

The mast is held in position by guys or stiff legs connected to a base while a topping lift links the top of the mast and the top of the inclined boom. A hook in the road line hanging from the top of the inclined boom is used to lift loads. Guy derricks may easily be moved from one floor to the next in a building under construction while stiff leg derricks may be mounted on tracks for movement within a work area.

Tower cranes are used to lift loads to great heights and to facilitate the erection of steel building frames. Horizon boom type tower cranes are most common in high rise building construction.

Inclined boom type tower cranes are also used for erecting steel structures

Forklift trucks are useful for horizontal and limited vertical transportation of materials. Hoists are used in two-way vertical transportation of materials and passengers, whereas rubble chutes are used in downward transportation of construction and demolition debris. Cranes are the most versatile material handling equipments that can be chosen or designed for any kind of movement.

(a) Forklift Trucks

Forklift trucks are used for horizontal and limited vertical transportation of packaged materials positioned on paflets or banded together such as brick packs.

They are generally suitable for construction sites where the building height does not exceed three dories. Although designed to negotiate rough terrain sites, forklift trucks have a higher productivity on firm and level soils.

Three types of forklift trucks with various height, reach and lifting capacities are in common use namely,

- Straight mast
- Overhead thicks
- Telescopic boom

(b) Hoists

Hoists are equipments used for transporting materials and passengers vertically. Common types of hoists are as follows:

(i) Material Hoists

These are designed for the vertical transportation of materials and under no circumstances should they be used to transport passengers. Most material hoists are mobile, can be dismantled, folded onto the chassis and moved to another position or site under their own power or towed by a haulage vehicle. When in use material hoists need to be stabilized and / or tied to the structure and enclosed with a protective screen.

(II) Passenger Hoists

These are designed to carry passengers although most are capable of transporting a combined load of materials and passengers within the lifting capacity of the hoist. A wide selection of hoists are available ranging from a single cage with rope suspension to twin cages with rack and opinion operation mounted on two sides of a static tower.

(c) Cranes

Cranes are machines designed to move materials vertically (raise by rope pulley operation) or horizontally. The range of cranes available is very wide, from gear wheel to a complex tower crane. Therefore, choice must be based on:

The loads to be lifted
Height of lifting
Horizontal distance to be covered
Time period of lifting operations
Utilization factors and
Degree of mobility required

However, it may be possible to place most cranes into one following groups

(i) Mobile Cranes

These are low-pivot cranes capable of horizontal motion, either by itself or mounting on crawler or truck. They are classified based on the type of mobility as:

Self propelled cranes with wheeled chassis
Truck mounted hydraulic cranes
Truck mounted lattice jib cranes
Crawler mounted cranes

(ii) Static Cranes

These are either operating from affixed position on ground or is capable of longitudinal motion on rails depending on the height of pivot and operational ability, static cranes are of three types:

Gantry Cranes which are not pivoted, and are cranes with pulley, rope and hook are hung from a portal frame

Most Cranes which are similar to tower cranes are low pivot cranes

Tower Cranes are high pivot cranes

Rubble Chutes

These are used in demolition, repair, maintenance and refurbishment. The concept Involves connecting of several perforated dustbins vertically downwards for expedient and safe conveyance of materials. In customized forms the tapered cylinders are produced from reinforced rubber with chain linkage for continuity. Overall unit lengths are generally 1.1 m, providing an effective length of 1 m. Hoppers and side entry units are made for special applications.

Dumpers

These are used for the horizontal transportation of materials on and off construction sites generally by means of an integral tipping skip.

A wide range of dumpers is available depending on their carrying capacities, discharge control (gravity or hydraulic discharge) and tipping facilities (front tipping, side tipping).

Special dumpers fitted with flat platforms, rigs to carry materials, skips and rigs for concrete, skips for crane hosting are also available. Highway dumpers are of a similar but larger design and can be used to carry materials such as excavated soil along the roads.

PILE DRIVING EQUIPMENTS

Pile driving equipments are of three types

Impact type drivers which drive piles by impact of weight on or into piles Vibration type drivers drive pile be vibrating the pile through the soil Piling hammers combine the desirable effects of both impact and vibration driving.

Piling Hammers

Details of Piling Hammers

These are designed to deliver an impact to the pile to be driven. The hammer weight and drop height is chosen to suit the pile type and nature of subsoil through which it will be driven. There are four types of piling hammers depending on the mechanism of driving

Drop Hammers

Drop hammers are heavy iron blocks, which hammer the pile b free fall onto the pile top. Drop hammers require special arrangement on top of pile to ensure that impact is steady, vertical and correctly located. It also needs a winch to lift the weight and release it.

Single Acting Hammers

These hammers are raised by steam or compressed air and are lowered by free fall. Guide tugs or rollers are required on the piling frame leaders to maintain the hammer position but necessity of winches are eliminated.

Double Acting Hammers

These consist of a cast iron cylinder that remains stationary on top of the pile. Both up and down strokes are powered by steam or compressed air. This eliminates both winch arrangement and leader arrangements. However blow forces are lower in these hammers

Diesel hammers

These are self-contained hammers using free fall for down stroke, which in turn ignites diesel engine for upstroke. Hence, they do not require winches or leaders and deliver moderate impact energy.

Lifting and Erecting

Derricks are commonly used to lift equipment of materials in industrial or building construction.

A derrick consists of a vertical mast and an inclined boom sprouting from the foot of the mast.

The mast is held in position by guys or stiff legs connected to a base while a topping lift links the top of the mast and the top of the inclined boom. A hook in the road line hanging from the top of the inclined boom is used to lift loads. Guy derricks may easily be moved from one floor to the next in a building under construction while stiff legs derricks may be mounted on tracks for movement within a work area.

Tower cranes are used to lift loads to great heights and to facilitate the erection of steel building frames. Horizon boom type tower cranes are most common in high rise building construction.

Inclined boom type tower cranes are also used for erecting steel structures.

Mixing and Paving

Basic types of e for paving" include machines for dispensing concrete and bituminous materials for pavement surfaces. Concrete mixers may also be used to mix Portland cement, sand. Gravel and water in batches for other types of construction other thin paving.

A truck mixer refers to a concrete mixer mounted on a truck which is capable of transporting ready mixed concrete from a central batch plant to construction sites. A paving mixer is a self propelled concrete mixer equipped with a boom and a bucket to place concrete at any desired point within a roadway. It can be used as a stationary mixer

or used to supply slip form payers that are capable of spreading, consolidating and finishing a concrete slab without the use of forms.

A bituminous distributor is a truck-mounted plant for generating liquid bituminous materials and applying them to road surfaces through a spray bar connected to the end of the truck. Bituminous materials include both asphalt and tar which have similar properties except that tar is used when the pavement is likely to be heavily exposed to petroleum spills.

CONSTRUCTION TOOLS AND OTHER EQUIPMENT

Air compressors and pumps are wide! used as the power sources for construction tools and etc

Common pneumatic construction tools include drills, hammers. grinders. saws, wrenches, staple nuns. Sandblasting guns. And concrete vibrators. Pumps are used to supply water or to dewater at construction sites and to provide water jets for some types of construction.

Automation of Equipment

The introduction of new mechanized equipment in construction has had a profound effect on the cost and productivity of construction as well as the methods used for construction itself. An exciting example of innovation in this regard is the introduction of computer microprocessors on tools and equipment. As a result, the performance and activity of equipment can be continually monitored and adjusted for improvement. In many cases, automation of at least part of the construction process is possible and desirable. For example, wrenches that automatically monitor the elongation of bolts and the applied torque can be programmed to achieve the best bolt tightness. On grading projects, laser controlled scrapers can produce desired cuts faster and more precisely than normally manual methods.

Concrete Hauling Equipments

Details of Concrete hauling equipments

Wheelbarrows

The usual means of transporting mixed concrete produced in a small capacity mixer is by wheelbarrow. The run between the mixing and placing positions should be kept to a minimum and as smooth as possible by using planks or similar materials to prevent the mix within the wheelbarrow

Dumpers

These can be used for transporting mixed concrete from mixers up to 600-litre capacity

Drop Hammers

Details of Drop hammers

Drop hammers are heavy iron blocks, which hammer the pile by free fall onto the pile top. Drop hammers require special arrangement on top of pile to ensure that impact is steady, vertical and correctly located. It also needs a winch to lift the weight ht and release it.

The major components of drop hammers are

Block of iron which comprises the body of the hammer

Rear lug that can be placed into the piling rig guides or leaders, so that the impact may be in position

A lifting eve at the top for attachment of the winch rope

The number of blows that can be delivered with a free fall of 1.2 m to 1.5 m ranges from 10 to 20 per minute.

The weight of the hammer should be not less than 50% of the concrete or steel pile weight and 1 to 1.5 times the weight of a timber pile.

Single Acting Hammers

Details of single acting hammers

Single Acting Hammers consist of a heavy falling cylinder raised by steam or compressed air sliding up and down a fixed piston. Guide tugs or rollers are located in the piling frame leaders to maintain the hammer position relative to the pile head. The number of blows delivered ranges from 36 to 75 per minute with a total hammer weight range of 2 to 15 tones

Double Acting Hammers details of Double acting hammers

Double Acting Hammers consist of a cast iron cylinder that remains stationary on the pile head.

A ram powered by steam or compressed air for both up and down strokes delivers a series of rapid blows that tends to keep the pile on the move durin2 driving. The blow delivered is a smaller force than that from a drop or single acting hammer.

The number of blows delivered ranges from 95 to 300 per minute with a total hammer weight range of 0.7 to 6.5 tonnes.

Diesel powered double acting hammers are also available. Diesel Hammers

Details of diesel Hammers

These are self-contained hammers, which are located in the leaders of the pile. The driving action is started by raising the ram within the cylinder that activates the injection of a measured amount of fuel. The free falling ram compresses the fuel above the anvil. This causes the fuel to explode and expand resulting in a downward force on the anvil. It

also generates an upward force that raises the ram to restart the cycle. The process repeats itself until the fuel is cut off

The number of blows delivered ranges from 40 to 60 per minute with a total hammer weight range of 1.0 to 4.5 tones.

Standard Type Dumper Crane Skip Dumper

Ready mixed Concrete Trucks

These are used to transport mixed concrete from a mixing plant or depot to the site. Usual capacity range of ready mixed concrete trucks is 4 to 6 m3. Discharge can he direct into placing position into some form of site transport such as dumpier, crane skip or concrete pump.

Concrete Pumps

Details of Concrete Pumps

These are used to transport large volumes of concrete in a short time (say up to 100 m3 per hour) in both the vertical and horizontal directions from the pump position to the point of placing. The pump is supplied with pump able special concrete mix or with constant flow of ready mixed concrete Lorries throughout the pumping period.

Bore pipeline (100 mm diameter) and can be trailer or lorry mounted.

Pumping ranges made be up to 850.00 in vertically and 200 in horizontally depending on the pump model.

It generally requires about 45 minutes setting up a concrete pump on site including coaling the bore of the pipeline with a cement grout before pumping. After plumbing, the pipeline should be cleared and cleaned. Usually concrete pump and operator are hired for the period required.

Concrete Mixers

Details of Concrete mixers

Types of mixers are generally related to their designed output performance. Machines are decided based upon what mixing and placing methods are to be employed to mix and place a certain amount of concrete in a given time period. Generally, a batch mixing time of 5 minutes per cycle of 12 batches per hour can be assumed as a reasonable basis for assessing mixer output.

Small Batch Mixers have outputs up to 200 liters per batch with wheel barrow transportation on hourly placing rate of 2 to 3 m3 can be achieved. Most small batch mixers are of the tilting drum type. General. These mixers are hand loaded which makes the quality control of successive mixes difficult to regulate.

Medium Batch Mixers have output ranging from 200 to 750 liters. Low output machines are available as tilting drum mixers and high output ones are available as non-tilting drum mixers.

Non-tilting mixers are either reversing drum or chute discharge, the latter usually having a lower discharge height. Such mixers usually have integral weigh batching facility loading hoppers.

scraper shovels and water tanks thus giving better quality control than the small batch mixers.

Generally they are unsuitable for wheel barrow transportation because of their high output.

CONSTRUCTION EQUIPMENT

The selection of the appropriate type and size of construction equipment often affects the requirement amount of time and effort and thus the job-site productivity of a project. It is therefore important for site managers and construction planners to be familiar with the characteristics of the major types of equipment most commonly used in construction.

Excavation and Loading

One family of construction machines used for excavation is broadly classified as a crane-shove. The crane-shovel consists of three major components:

A carrier or mounting which provides mobility and stability for the machine.

A revolving deck or turntable which contains the power and control units.

A front end attachment which serves the special functions in an operation.

The type of mounting for all machines in Figure 4-3 is referred to as crawler mounting which is particularly suitable for crawling over relatively rugged surface at a job site other types of mounting include truck mount1n and wheel mounting which provide creator mobility between job sites, but require better surfaces for their operation. The revolving deck includes a cab to house the person operating the mounting and “or the revolving deck The types of front end attachments in Figure 4-3 mi include a crane with hook, claim shell, dragline. Backhoe. Shovel and pile driver

A tractor consists of a crawler mounting and a non-revolving cab. When an earth moving blade is attached to the front end of a tractor, the assembly is called a bulldozer. When a bucket is attached to its front end, the assembly is known as a loader or bucket loader. There are different types of loaders designed to handle most efficiently materials of different weights and moisture contents.

Scrapers are multiple-units of tractor-truck and blade-bucket assemblies with various combinations to facilitate the loading and hauling of earthwork. Major types of scrapers include single engine two-axle or three axle scrapers, twin-engine all-wheel-drive scrapers, elevating scrapers. and push-pull scrapers. Each type has different characteristics of rolling resistance, maneuverability stability, and speed in operation.

Compaction and Grading

The function of compaction equipment is to produce higher density in soil mechanically.

The basic forces used in compaction are static weight, kneading, impact and vibration.

The compaction that may be achieved depends on the properties of soil, its moisture content, the thickness of the soil layer for compaction and the method of compaction. Some major types of compaction equipment with different operating characteristics.

Concrete Vibrators

Details of Concrete Vibrators

Poker or Internal Vibrators

These consist of a hollow steel tube casting in which is a rotating impeller which generators vibrations as its head comes into contact with casing. Poker vibrators should be inserted vertically and allowed to penetrate 75mm into any previously vibrated concrete.

External Clamp or Tamping Board Vibrators

These vibrators operate by shaking the formwork. Clamp vibrators powered by either compressed air or electricity whereas tamping board vibrators are usually petrol driven.

Formwork must be stronger than is traditional to withstand vibration.

The function of grading equipment is to bring the earthwork to the desired shape and evasion.

Major types of grading equipment include motor graders and grade trimmers.

Drilling and blasting

Rock excavation is an audacious task requiring special equipment and methods. The depth of difficulty depends on physical characteristics of the rock type to be excavated such as grain size planes of weakness, Weathering, Brittleness and hardness.

The task of rock excavation includes loosening, loading, hauling and compacting. The loosening operation is specialized for rock excavation and is performed by drilling, blasting or ripping.

Major types of drilling equipment are percussion drills, rotary drills- and rotary-percussion drills. A percussion drill penetrates and cuts rock by impact while it rotates without cutting on the upstroke. Common types of percussion drills include a jackhammer which is hand-held and others which are mounted on a fixed frame or on a wagon or crawl for mobility. A rotary drill cuts by turning a bit against the rock surface. A rotary- percussion drill combines the two cutting movements to provide a faster penetration in rock.

Blasting requires the use of explosives, the most common of which is dynamite. Generally, electric blasting caps are connected in a circuit with insulated wires. Power sources may be power lines or blasting machines designed for firing electric cap circuits. Also available are nonelectrical blasting systems which combine the precise timing and flexibility of electric blasting and the safely of non-electrical detonation.

Tractor-mounted rippers are capable of penetrating and prying loose most rock types. The blade or ripper is connected to an adjustable shank which controls the angle at the tip of the blade as it is raised or lowered. Automated ripper control may be installed to control ripping depth and tip angle.

In rock tunneling, special tunnel machines equipped with multiple cutter heads and capable of excavating full diameter of the tunnel are now available. Their use has increasing replaced the traditional methods of drilling and blasting.

UNIT V CONSTRUCTION EQUIPMENT

1. List out the different methods of dredging technique and explain with neat sketches. (Nov 2013)
2. What are the different types of cranes? Explain any three in detail. (Apr 2019)
3. Explain the various equipments for pile driving. (Nov 2016)
4. Mention the various types of earthwork equipments and also give their uses. (May 2013)
5. Distinguish between crawler & pneumatic type of wheel excavators.
6. Analyze the equipment used for erection of structures in detail.
7. Explain the various aspects of graders and scrapers in detail. (Apr 2019)
8. Explain in detail about trenching and the equipment used for trenching
9. Classify the Types of earthwork equipments? Mention its uses (Nov 2014)
10. Explain in detail the various equipments used for compaction, batching and mixing of concrete. (Nov 2014)

UNIT –V

CONSTRUCTION EQUIPMENT

Selection of equipment for earth work - earth moving operations - types of earthwork equipment - tractors, motor graders, scrapers, front end waders, earth movers – Equipment for foundation andpile driving. Equipment for compaction, batching, mixing and concreting - Equipment for materialhandling and erection of structures – types of cranes - Equipment for dredging, trenching,tunneling

Introduction: This unit deals with the selection and applications of various construction equipments for different types of works like different types of earth moving equipments, equipments for pile driving (like hammers), compaction, batching and mixing and concreting, material handling and erection of structures (like tower cranes, movable cranes), dredging, trenching, tunneling (Tunnel Boring Machines)

Part A

Selection of equipment for earth work

1. **Write a note on Construction equipment.**

The type of equipment to be used for a specific project depends on the scope of the project involved. Every project is executed not by department but by contracting the work. So it is the choice of contractor to use suitable equipment. If particular equipment is already available, the same if suitable for the new project can be used. If new equipment is required to be purchased, he has to think whether he could get the amount of investment for the equipment during the project itself. It is an acid test to decide the best of equipment. The factors discussed below have to be considered.

2. **Mention the Procurement cost of investment of equipment.**

The procurement cost consists of the following factors: (i) cost price (ii) interest on money invested, (iii) taxes and (iv) insurance.

The owner pays cash for the procurement of the equipment. It is to be noted that if the amount is invested in some other scheme how much he would get. He should get a higher interest annually by investing in the equipment. Each year the equipment earn for the owner, and in the process their value gets depreciated. Thus the investment in the equipment is therefore reduced by the amount of depreciation. A realistic rate of interest would be the one based on the average value of the equipment during their useful life. The average value of the equipment has to be determined.

3. **Write about the Cost Investment on equipment.**

The amount invested for the purchase of equipment is to be compared with an alternate investment made in some industry or deposited in bank. By investment made on the equipment the owner is losing an amount equal to the interest or return he would have received from bank or other sources for

the purpose of calculating the total cost of investment, the interest, the taxes, insurance, etc., may be taken as 10 to 15 % of the cost of equipment.

4. How the Depreciation Cost is calculated for equipment?

Because of wear and tear the cost of equipment reduces which is called as depreciation cost. Depreciation is also a method of assessing the smooth running of the industry. An amount of the earnings has to be set aside so that the plant or industry requires a complete change at that time the accumulated amount can be used. This amount is recovered from the earnings of the equipment and forms a charge on the operating cost.

Earth moving operations

5. How will you select equipment for earthwork?

Commercially a wide range of excavating equipment is available. It demands a much greater care and thought in selecting the most suitable machine for a particular job. No machine will exactly satisfy the 100 % need of the work. As a matter of fact, a large number of factors is contributing to the best running performance of a machine. A lack of knowledge of some or all of these factors may affect the efficiency of operation of particular equipment. As said earlier no machine is designed to suit a particular set of conditions which may be prevalent on a construction project.

While designing earth-moving equipment, a designer has to make a compromise to suit his design to satisfy the major conditions of work. Thus it is not possible to get the same efficiency under different set of conditions.

6. List out the Factors affecting output of an earthwork machine.

Some of the factors which affect the out-put of an earthwork machine are

1. Physical job condition
2. Type of soil
3. Specification of machine
4. Condition of the machine
5. Method of operation

7. List out the Classification of earth moving equipment.

In recent years, a great deal of improvement has been made in earth moving equipment. Earth moving equipment may be broadly classified into:

- Excavating machines
- Tractor and tractor units
- Scrapers or pans
- Grading and compacting machines.

8. What is meant by earthwork equipment and operations?

Earthworks are engineering works created through the moving or processing of parts of the earth's surface involving quantities of soil or unformed rock. The earth may be moved to another location and formed into a desired shape for a purpose. Much of earthworks involves machine

excavation and fill or backfill. Heavy construction equipment is usually used due to the amounts of material to be moved — up to millions of cubic meters. Earthwork construction was revolutionized by the development of the (Fresno) scraper and other earth-moving machines such as the loader, production trucks, the grader, the bulldozer, the backhoe, and the dragline excavator.

9. What is meant by Excavators? And list its components.

Excavators are digging machines. Excavators (Hydraulic Excavators) are heavy construction equipment consisting of a boom, dipper (or stick), bucket and cab on a rotating platform known as the "house". The house sits atop an undercarriage with tracks or wheels. They are a natural progression from the steam shovels and often mistakenly called power shovels. All movement and functions of a hydraulic excavator are accomplished through the use of hydraulic fluid, with hydraulic cylinders and hydraulic motors. These machines consist of the following components:

- An undercarriage - This gives mobility to the excavator. This may be mounted with crawler track or wheel.
- A superstructure with operator's cabin - This could traverse through 360° or fitted on a rigid frame.
- Hydraulically articulated booms and dipper arms with bucket.

<u>Types of earthwork equipment - tractors, motor graders, scrapers, front end waders, earth movers</u>

10. Write a short note on Tractor machine in construction.

A tractor is a multi-purpose machine. This comes in varied types as light model to heavy model. The light model is used for agricultural or small haulage J purposes. Heavy model equipped with several special rigs are used for earth moving work. This is an important piece of equipment which is indispensable on all important projects.

Two principal applications of tractors are:

- Clearing and excavating machinery.
- Hauling and conveying machinery.

11. What are the factors to be considered while selecting a tractor?

- Size of the dozer for a given job
- The type of work expected from the tractor dozer

Example: bulldozing, ripping, land clearing, pulling a scraper

- The type and condition of hauled road
- Gradient of the haul road
- Distance to be moved

12. <u>List the types of blade used in earthwork equipment.</u>(A/M '15)

The various types of blades used in equipment are:

- Backhoe
- Face, Front or loading Shovel

- Forward Loader
- JCB/Poclain
- Dragline
- Grab
- Graders
- Dozer
- Scraper

13. What is meant by Scrapers?

Scrapers are the devices to scrap the ground to load the material, to the transport to the requirement distances, to dump at the intended site, to spread the dumped material over the required area, to attain the desired thickness and to return back to do the next cycle. In simple terms scrapers are designed to dig, load, haul, damp and spread as a scraper does a multiple works it is also called as carry all. The basic parts of scrapers are the bowl, apron and tail gate or ejector.

14. <u>How do you calculate the output of scraper?</u> (A/M '17)

Several types of motorized scrapers with heaped capacity ranging from 15 m3 to 50 m3 are available to suit varying job requirements. These include single engine scraper, double engine scraper and elevating scraper. A Single engine scraper requires a pusher bulldozer to provide the necessary tractive force. Generally one medium sized crawler tractor is sufficient to serve four to five scrapers.

Scrapers per pusher = Cycle time of each scraper / Cycle time of pusher

Example: Cycle time of scraper is 6 minutes and a pusher to fill a scraper is 1.5 minutes. Calculate the number of scrapers which a pusher can serve. Determine the number of pushers to serve 10 scrapers.

Solution: Number of scrapers per pusher = 6.0/1.5 = 4

Number of pushers for 10 scrapers = No. of scrapers / No. served by one pusher

= 10/4=3

15. How the scrapers are unloaded?

When the hopper is lowered, the front edge cuts into the soil or clay like a plane and fills the hopper. When the hopper is full it is raised and closed with a vertical blade(known as apron). The scrapper can transport its load to fill area where the blade is raised, the back panel of the hopper or the ejector is hydraulically pushed forward and the load tumbles out. Then the empty scraper returns to cut site and repeats the cycle.

16. What is meant by Self-propelled Scraper?

This is a popular and conventional type of scraper. These are motorized and available in capacities of 10 to 25 cubic metres. This type of scraper needs push loading by a crawler mounted or a wheel tractor. The crawler-towed scrapers art slow compared to the motorized. Motorized scrapers are with high hauling speed and so very much suitable for long distance hauling.

17. What is meant by Loaders?

Loader is a machine in which a bucket is attached to the arms and capable of being raised, lowered and dumped through mechanical or hydraulic controls. A very common type is one in which the loader is having the bucket in the front which is known as front-end loader.

Loaders are self-propelled and versatile equipment which are mounted either on crawler or wheel-type running gear. These loaders are fitted with front mounted general-purpose bucket.

18. List out theTypes of Loaders

Crawler Loaders

These are low pressure type which are generally preferred for digging and loading jobs of poor ground and rock and sharp stony ground. These are preferred for short moves between loading and dumping points when there is no damage to tyres.

Wheeled Loaders

These are generally four wheel drive. Two-wheel drives are preferred for handling light jobs on good ground conditions. Protective chains are provided which increases the tyre operating life. Four-wheel drives are used for bulk handling of coal, cement, fertilizer, etc., into hoppers and trucks. These are additionally favored rather than more difficult to maneuver crawler.

19. List out the Types of Piles.

Piles are generally classified as bored piles or driven piles depending on the method of installation. Only driven piles are to be installed by driving using an equipment. Bored piles are installed after making a hole in the ground and inserting a cage of reinforcement followed by concreting. In some cases reinforcement is not provided.

Driven piles are made out of some materials like wood, concrete, steel, and sometimes with composite section of wood and steel, wood and concrete or steel and concrete. They are manufactured in specified lengths.Sheet piles, as discussed earlier, may be wood, concrete or steel. These piles are also driven.

Equipment for foundation and pile driving.

20. What is meant by Pile Driving?

The process of pile driving consists of lifting the pile into position, holding it and driving it to refusal or a desired depth. In these exercise long piles need to be cut to the required size and the short piles need to be extended. For safe and economical driving operations, proper judgment, experience and the combined skill of the crew. Driving of sheet piles greatly affect the seepage of ground water and thereby pose special problem. Driving is generally accomplished by hammers but in certain instances to facilitate penetration in hard ground, jetting, predriving or preboring

may have to be used. Driving too hard may damage the top of the pile. On the other hand improper light driving may not penetrate adequately. Thus the selection of the driving plant and an experience crew are needed.

21. Mention the equipments used for pile driving.

Pile driving equipment comprise of the following

- Driving rig
- Guiding leaders
- Pile hammer with accessories
- Additional aids for preboring, jetting etc.
- Boiler for steam raising or air compressor.

22. Give a note on Guiding Leaders.

The leaders guide the pile and the hammer during operation which extends to the entire height of the rig. In case of piles to be driven below the level of the rig into excavations, trenches or water telescopic or extensible leaders can be used. The leader should enable the hammer to deliver blows axially to the pile. During the process of driving, the driving rig should be strong and stable In case a boom is used, adequate space should be available between the pile top and the point for the hammer to work.

23. What is mean by Driving Hammers?

Pile driving hammers impart energy required to drive the pile into the soil. The routinely used pile hammers work by hitting the pile on its head. The vibratory and sonic type of hammers are the two new types.

Hammers are classified as:

- Drop hammers
- Single-acting hammers
- Double-acting hammers
- Differential-acting hammers
- Diesel hammers
- Hydraulic hammers
- Vibratory hammers
- Sonic hammers

24. What are Drop Hammers? Why are they used?

The drop hammer in the pile driving equipment consists of a heavy ram in between the leads. The ram is lifted up to a certain height and released to drop on the pile. This type is slow and therefore not in common use. It is used in the cases where only a small number of piles are driven.This is the simplest form of hammer which does not use any external source of power. The only mechanism needed is to lift the hammer through a cable. Although the process is slower, it is

more efficient as it uses only the gravity. The drop hammer is basically a block of suitably shaped cast-iron with its centre of gravity centered near the base in order to facilitate smoothness of fall.

25. Write a note on Single-acting Hammer.

The functioning of single acting hammer differs from drop hammer only in the manner of lifting of the ram after each blow. A conventional single-acting hammer employs a piston connected to a ram at its bottom end and moving inside a cylinder. The hammer may be of an open type or closed type. Stream power or compressed air is used in the single-acting hammer without any adjustment or alterations and the pressure remains unchanged. This pressure ranges from 5.6 to 10.5 kg/sq.cm and used depending on the size of the hammer and its weight. The operation of single-acting hammer costs less compared to a double-acting hammer but its speed is slower.

26. Give a short note on Double-acting Hammer.

In this type of hammer the motive fluid acts on both sides of the piston. This assists the force of gravity in striking the blow by raising the ram to the top of the driving stroke and then driving it down in its down stroke. An equivalent energy of the single acting hammer can be developed by dropping the ram through a shorter distance and thereby reduces the energy loss. Stream or compressed air is used as the motive fluid. Depending on the hammer weight and the weight of the ram, these hammers are available in light, medium and heavy duty models. Two types of hammers are available, viz., open end and close end. The close-end model is used for under-water driving with-out followers.

27. Write a note on Differential-acting Hammer.

Advantages of single-acting and double-acting hammers are combined in differential-acting hammer. But it suffers with their disadvantages. That is it uses a heavy ram weight, asfollowed in single-acting hammer, and a high speed of operation, as followed in double-acting hammer. Thus it derives the advantage of use under a wide range of pile driving conditions. It uses 25 to 30 % of less steam compared to a single-acting hammer. This hammer is available in open and closed models and could be used, using either steam or compressed air. Lubrication system is similar to that used in single-acting hammer.

28. What is meant by Diesel Hammer?

The working of this hammer is different from other types. It does not depend on the motive fluid but has a self-contained power source. This is more efficient as the hammer is designed to deliver driving energy to the pile in three forms. That is the energy is delivered by compressed air as the piston descends in the cylinder, impact of the piston on the anvil and by explosive force of fuel in the combustion chamber on the top of the anvil. This is not efficient in hard driving or in extremely cold weather.

29. Give a note on Vibrating Hammer.

In the use of conventional driving hammers blows are struck on the pile head with certain frequency and due to this the pile moves down. Friction develops on the surface of the pile before

the next blow. This could be overcome if the pile ' is driven continuously. The vibratory hammer takes care of this and allows the pile to move continuously thereby eliminating surface frictional resistance. In this process the pile sinks fast into the soil due to its own weight and the weight of the driver assembly. The hammer comprises of a vibratory unit which produces vibrations to oscillate the pile along its vertical axis, and a clamping device which transmits these vibrations to the pile. The driving power for the vibrators are given by internal combustion engines or with electric motors. Vibrations are generated by movement of counter rotating shafts to which eccentric weights are fixed.

30. Differentiate between single acting and double acting hammer. (N/D '15)

They arc advantageous when driving heavy piles in compact or hard soils; the heavy ram striking at - tow velocity produces least damage due to impact. The disadvantages arc low driving speed and large headroom requirement. They are generally used to drive piles of light or moderate weight in soils of average resistance against driving. This type of hammer can drive piles at fast speed, requires less headroom and can be used to extract piles by turning them [i.e. the double-acting hammer] upside down.

31. What is meant by Pneumatic-tyred Rollers?

In pneumatic-tyred rollers wheels are placed close together on two axles and Placed such that the rear set of wheels overlap the lines of the front set to ensure complete coverage of the soil surface. In order to avoid the lateral displacement soil, wide tyres with flat treads are provided. The compaction produced by types are better than that of the smooth wheel rollers.

32. Write note on Static Compaction Equipment.

These rollers can be used on any type of compaction, in general. Light weight rollers of 3 tons for foot path construction whereas for road construction heavy rollers are used. Static rollers with weight of 8 to 10 tons are used for works ranging from earth work and sub-bases to bituminous road surfacing materials Tandem roller is preferred as a finishing roller on wearing course.

Equipment for compaction, batching and mixing and concreting

33. Name some equipment used for compaction. (N/D '14)

Following are different types of Compaction Equipments for different soil types:

The soil compaction equipments can be divided into two groups:

1. Light soil compacting equipments
    - Rammers
    - Vibrating Plate Compactors
    - Vibro Tampers
2. Heavy Soil Compaction Equipments:
    - Smooth Wheeled Rollers
    - Sheep foot Roller
    - Pneumatic Tyred Rollers
    - Grid Rollers

- Pad Foot / Tamping Rollers

34. <u>What are the factors influencing compaction?</u> (N/D '16)

Each and every process and materials involved in concrete mixing affects the workability of concrete. Workability of concrete is measured in terms of ease with which it can be mixed, transported to construction site, placed in forms and compacted.

- Cement content of concrete
- Water content of concrete
- Mix proportions of concrete
- Size of aggregates
- Shape of aggregates
- Grading of aggregates
- Surface texture of aggregates
- Use of admixtures in concrete
- Use of supplementary cementitious materials

35. <u>Write a note on material handling equipment.</u> (M/J '13)

Material handling is an important function in a construction work. There is a need of equipment to handle heavy loads with fast speed, reliability, safety and economy. Material handling includes heavy earth moving which is already dealt. Here other type of material handling is held. The main objective of the efficient material handling is to save cost.

Material handling devices, are expected to satisfy one or more of the following functions. (Jagman Singh, 1993)

- Construction material is to be moved and positioned.
- Lifting of a load and placing it at a particular place.
- Loading of materials into transportation equipment.
- Unloading of materials from transportation equipment.

36. List out the type of handling devices

- Vertical motion devices (lifting and lowering devices)
  - Block and tackle
  - Winches
  - Hoists
  - Elevators
  - Pillar crane
  - Overhead crane
- Horizontal motion devices(Transportation devices)
  - Wheel barrows and hand trucks
  - Norrow-grauge mine rail road
  - Tractors and trailors
  - Skids
  - Pipe line
- Combination devices (Lifting and lowering plus Transportation)
  - Spiral chute
  - Lift track

Crane truck
Forklift truck
Conveyors of various types

- Arial transport
  Cable ways
  Rope ways

37. What is meant by Conveyors?

These are the material transportation devices used when the parts of flow of material is fixed. Because of this desired fixity lifting and lowering of materials are done automatically. Conveyors require no stopping or starting but the operation is continuous. The transportation is effected by friction between materials being transported and the belt or roller. A detailed treatment of conveyors is done

Equipment for material handling and erection of structures

38. List out the various hoisting equipment.

Hoisting equipments are used for transporting materials or passengers vertically by means of a moving level platform. Various hoisting equipments generally used are:

- Pulleys and sheaves
- Chain hoists
- Winches
- Cranes

Pulley and sheaves: They are utilized to lift, rough surfaced and heavy objects. Alloy chains and wide ropes are used for this purpose.

Chain hoists: They consist of two sets of chains. One chain is called hand chain and the other is load chain. They can lift loads up to 50 tons.

39. Give the list of equipment needed for the construction of tall structures. (M/J 12)

Some of the equipments used for construction of tall structures are:

- Cranes
  Derrick cranes
  Mobile cranes
  Overhead or gantry cranes
  Tower cranes
- Hauling equipment
- Loading equipment
- Lifting equipment

40. What is meant by Derrick cranes? (A/M '15)

A **derrick** crane is a lifting equipment consists of a mast, a boom and a bull wheel on which the boom rotates about a vertical axis and guys or supporting members.They are electrically operated,

diesel operated or diesel-electrically operated. The boom can revolve through 360 degree. This crane is used for heavy loads up to 200 tons. Forms of derricks are commonly found aboard ships and at docking facilities. Some large derricks are mounted on dedicatedvessels, and known as floating derricksand sheerlegs.

41. List out the types of cranes.

Cranes are classified as given below:

- Derrick cranes
- Mobile cranes
- Tower cranes
- Pillar cranes
- Overhead or gantry cranes
- Self-propelling boom cranes
- Crane trucks

Equipment for dredging, trenching, tunneling,

42. Define dredging. (N/D '15)

Dredgers are used for excavation from riverbed, lake or sea for purpose of deepening them. Dredging is an important operation in navigation canals, harbours, dams etc. Dredging is an excavation activity usually carried out underwater, in shallow seas or freshwater areas with the purpose of gathering up bottom sediments and disposing of them at a different location. This technique is often used to keep waterways navigable. It is also used as a way to replenish sand on some public beaches, where sand has been lost because of coastal erosion. Dredging is also used as a technique for fishing for certain species of edible clams and crabs (see fishing dredge).

43. What are the types of dredgers? (N/D '16)

The excavation carried out in either shallow or fresh waters with the aim to gather up the sediments located in the bottom to dispose them off at another place is called Dredging. They are generally classified under two types (a) Mechanical dredgers and (b) Hydraulic dredgers.

1.dipper dredger
2.back hoe dredger
3.bucket or ladder dredger
4.suction dredger
5.grab dredger

44. What is meant by Trenching?

A **trench** is a type of excavation or depression in the ground that is generally deeper than it is wide (as opposed to a wider gully, orditch), and narrow compared to its length (as opposed to a simple hole).

In geology, trenches are created as a result of erosion by rivers or by geological movement of tectonic plates. In the engineering field, trenches are often created to install underground infrastructure or utilities (such as gas mains, water mains or telephone lines), or later to access these installations. Trenches have also often been dug for military defensive purposes. In archaeology, the "trench method" is used for searching and excavating ancient ruins or to dig into strata of sedimented material

45. Name the equipments used for dredging and trenching.(M / J '12 '13)

The equipments used for dredging and trenching are the following.

- Bucket or ladder dredger.
- Hydraulic or cutter dredger.
- Grab dredger.
- Dipper dredger.
- Rock dredger.
- Clamshell
- Grab

46. List the types of tunneling equipments. (N/D '14)

- Tunnel Boring Machine also known as Mole
- Tunneling jumbos,
- Road headers
- Load and haul equipment for high efficiency in road tunneling
- bolters,
- drilling and cutting tools,
- hydraulic breakers,
- mobile crushers

47. List any two reasons for dredging. (A/M '17)

The following are the uses:

In order to maintain the design depth of a harbor, the waste and other rubbish material collected periodically have to be dredged frequently.Before starting of construction of a harbor site if the design depth is not available, dredgers are used to remove the sand or other materials till the required depth is got. Materials deposited in inland and swampy areas due to waves, and tides have to be dredged periodically.

48. List out the different types of earth work equipment. (N / D '13)

Following are the earth work equipment:

- Excavators
- Excavator - loaders Bucket - Wheel Excavator Cable excavator
- Power Shovels
- Dipper Shovel Drag Shovel or Hoe Dragline Clamshell

- Bull dozers
- Dragline
- clamshell
- Scraper
- Tractors Motor Graders Scrapers Loaders

49. <u>When are the scrapers used?</u> (N/ D '12 '13)

The scraper is a large piece of equipment which isused in mining, construction, agriculture and other earthmoving applications. The rear part has a vertically movable hopper also known as bowl, with a sharp horizontal front edge. The hopper can be hydraulically lowered and raised. When the hopper is lowered, the front edge cuts into the soil or clay like a plane and fills the hopper. When the hopper is full, it is raised and closed with a vertical blade.

Part B

1. **<u>Explain in details about the types of earth work equipment with neat sketches.</u>**

Earthwork equipment and operations

There is a wide range of excavating equipments available. In selection a much greater care and thought needed to find a suitable machine for a particular job. The best performance of a machine depends on a large number of factors. It should be noted that no machine is designed to suit a particular set of conditions which may be demanded at a construction project. Thus a best designer would design the machine such that the machine fits to more construction projects.

Excavators

These are digging machines. These machines consist of the following components:

An undercarriage - This gives mobility to the excavator. This may be mounted with crawler track or wheel.

A superstructure with operator's cabin - This could traverse through 360° or fitted on a rigid frame.

Hydraulically articulated booms and dipper arms with bucket. (6)

Shovels

Drag shovels have applications in

- Digging trenches, footing or basements
- Digging for hard materials
- Providing close trimming whenever needed, and
- Where excavation materials needed to be dumped at a short distance

Tractors

A tractor is a multi-purpose machine. This comes in varied types as light model to heavy model. The light model is used for agricultural or small haulage J purposes. Heavy model equipped with several special rigs are used for earth moving work. This is an important piece of equipment which is indispensable on all important projects.

Two principal applications of tractors are:

- Clearing and excavating machinery.
- Hauling and conveying machinery.

Scrapers

Scrapers are the devices to scrap the ground to load the material, to the transport to the requirement distances, ton dump at the intended site, to spread the dumped material over the required area, to attain the desired thickness and to return back to do the next cycle. In simple terms scrapers are designed to dig, load, haul, damp and spread as a scraper does a multiple works it is also called as carry all. (7)

2. **Mention various types of equipment's for dredging, trenching and tunneling?**

(N/D '13 '14) (13)

In order to maintain the required level of water in a harbour the external materials deposited in the bed has to be removed from time to time. This operation of removal of materials from the sea or river bed is called dredging. The mechanically operated equipment used for this purpose is called as dredger During the construction of structure in a harbour complex, the wastes and other construction rubbish gets deposited in the bed. This results in the reduction in the available depth of water for berthing of vehicles. Thus to maintain the design depth the excess material has to be removed.

Trenching

The common type of trencher excavator is the wheel trenchers. It consists of a pair of circular rims whose outside diameters are connected by V-shaped buckets or cutters. The wheel is turned by a chain drive which connects to the power source. The wheel moves to the top position when discharging the material and at the bottom position while digging. The buckets or cutters on the wheel perform the work of excavator while travelling upward. When the wheel reaches the top position the excavated material drops. The dropped material is carried on conveyors and discharged alongside of the trench to form windrow.

Motor grader

A grader is primarily a device for levelling or finishing earthwork. Sometimes it is also used for

- mixing gravel,
- making windrows and
- trimming slope.

There are two types of graders, viz., towed and motorized.

Tunneling

Tunneling with liner plates

Needle beam method

Tunnel Boring Machine (TBM) method: TMB is used as an alternative to drilling and blasting (D&B) methods. TBMs are used to excavate tunnels with a circular cross section through a variety of subterranean matter; hard rock, sand or almost anything in between.

As the TBM moves forward, the round cutter heads cut into the tunnel face and splits off large chunks of rock. The cutter head carves a smooth round hole through the rock -- the exact shape of a tunnel. Conveyor belts carry the rock shavings through the TBM and out the back of the machine to a dumpster. Tunnel lining is the wall of the tunnel. It consists of precast concrete segments that form rings, cast in-situ concrete lining using formwork or shotcrete lining.

Shallow-buried Tunnel or Soft Soil Tunnel

Shallow tunnels are of a cut-and-cover type (if under water of the immersed-tube type). Deep tunnels are excavated, often using a tunneling shield. For intermediate levels, both methods are possible.

-- Cut-and-cover method

Cut-and-cover is a method of tunnel construction where a trench is excavated and roofed over. Strong supporting beams are necessary to avoid the danger of thetunnel collapsing.

-- Shield method

The Shield method uses one or two shields (large metal cylinder) to cut out a tunnel through the soft ground. A rotating cutting wheel is located at the front end of the shield. Behind the cutting wheel is a chamber where, depending on the type of the TBM, the excavated soil is either mixed with slurry (called slurry TBM) or left as is (earth pressure balance or EPB shield). Systems for removal of the soil (or the soil mixed with slurry) are also present. Behind the chamber is a set of hydraulic jacks supported by the finished part of the tunnel which are used to push the TBM forward. Once a certain distance has been excavated (roughly 1.5-2 meters), a new tunnel ring is built using the erector. The erector is a rotating system that picks up pre-cast concrete segments and places them in the desired position. Behind the shield, inside the finished part of the tunnel, several support mechanisms can be found that are part of the TBM: dirt removal, slurry pipelines if applicable, control rooms, and rails for transport of the precast segments, etc. (6)

3. **Describe in detail various equipments used for compaction, batching and mixing of concrete. (M/J '12)(N/D '14, '16) (13)**

Batching of Concrete

It is the process of measuring concrete mix ingredients either by volume or by mass and introducing them into the mixture. Traditionally batching is done by volume but most specifications require that batching be done by mass rather than volume. Percentage of accuracy for measurement of concrete materials is as follows:

Cement: When the quantity of cement to be batched exceeds 30% of scale capacity, the measuring accuracy should be within 1% of required mass. If measuring quantity is less than 30% i.e. for smaller batches then the measuring accuracy should be within 4% of the required quantity.

Aggregates: If the measurement is more than 30% of the scale capacity then the measuring accuracy should be within 1%. If measurement is less than 30% then the measuring accuracy should be within less than 3%.

Water: Water is measured in volumetric quantity as 1 litre = 1kg. In case of water, the measuring accuracy should be within 1%.

Admixtures: For mineral admixtures same accuracy as that required for cement. For chemical admixtures same accuracy as that required for water. Mineral admixtures accuracy is same as that of cement because it is used as partial replacement of cement. As chemical admixtures are liquid or added to water therefore its accuracy is same as that of water.

Mixing of Concrete: The mixing operation consists of rotation or stirring, the objective being to coat the surface the all aggregate particles with cement paste, and to blind all the ingredients of the concrete into a uniform mass; this uniformity must not be disturbed by the process of discharging from the mixer.

Batch mixer: The usual type of mixer is a batch mixer, which means that one batch of concrete is mixed and discharged before any more materials are put into the mixer. There are four types of batch mixer.

Tilting drum mixer: A tilting drum mixer is one whose drum in which mixing take place is tilted for discharging. The drum is conical or bowl shaped with internal vanes, and the discharge is rapid and unsegregated so that these mixers are suitable for mixes of low workability and for those containing large size aggregate.

Non tilting drum mixer: A non tilting drum is one in which the axis of the mixer is always horizontal, and discharge take place by inserting a chute into the drum or by reversing the direction or rotation of drum. Because of slow rate of discharge, some segregation may occur.

Pan type mixer:

A pan type mixer is a forced–action mixer, as distinct from drum mixer which relies on the free fall of the concrete inside the drum. The pan mixer consist of a circular pan rotating about its axis with one or two stars paddles rotating about vertical axis of pan.

Dual drum mixer:

A dual drum is sometimes used in highway construction. Here there are two drums in series, concrete being mixed part of the time in one and then transferred to the other for the remainder of the mixing time before discharging.

Charging the mixer:

There are no general rules on the order of feeding the ingredients into the mixer as this depend on the properties of the mixer and mix. Usually a small quantity of water is fed first, followed by all the solids materials. If possible greater part of the water should also be fed during the same time, the remainder being added after the solids. However, when using very dry mixes in drum mixers it is necessary to feed the coarse aggregate just after the small initial water feed in order to ensure that the aggregate surface is sufficiently wetted.

4. **What are the factors that influence the selection of equipment for earthwork? Explain the types of earthwork equipments.** **(13)**

Some of the factors which affect the out-put of an earthwork machine are

Material Type

Material type of a jobsite forms the topmost criteria in selection of an earthmoving system. Let's take the example of tractor scraper and articulated truck. Experienced engineers recommend use of scrapers if the conditions are right and loading material is smooth and spreads easily. Wheel tractor scrapers are said to be great for areas that have sandy loam soil because scrapers can pull through this soil easily and it also loads quickly.

But if the jobsite has rocky soils or wet clay, then scrapers won't work smoothly. For this, an articulated truck would be more suitable because scrapers cannot pull through rocky soils easily. The bottom line is before choosing any earthmoving system, get to know the material well.

Flexibility and Versatility

Sudden weather changes can drastically alter soil conditions. Exceptional heat will toughen the soil whereas too much rain will make it exceptionally smooth. Therefore, before picking up a system, you should check on its versatility and flexibility. You should select an earthmoving system which is flexible enough to adapt to changing weather conditions.

Articulated haulers are considered to be exemplary systems when it comes to flexibility and versatility. These equipment can perform well under limited traction. Therefore, if your jobsite falls under region that experiences frequent weather changes, then articulated haulers can be a good choice.

Hauling Distance

Hauling distance plays a vital role in selection of vehicles and equipment. Small vehicles will do fine when hauling distance is small. But if earth has to be excavated over longer distances, then a bigger, stronger vehicle would be required. Smaller vehicles won't be able to sustain the pressure for so long, and there are possibilities of break down. You'll end up paying additional repairing costs.

Cut

Length and depth of cuts in jobsite greatly influences selection of earthmoving system. For example, it becomes difficult to load a scraper if length of the cut is below 100 feet. But this is not so with articulated haulers. These systems have top-loading methodology, which enables them to be placed comfortably under excavators even in the most confined spaces.

Scrapers on the other hand operate pretty well in those areas where there is enough room for outlining circuits. Similarly, if the task involves digging a borrow pit on a construction site, then articulated truck becomes the most suitable choice for it.

Condition of Towing Roads

Besides considering towing distance, one should also consider conditions of towing roads before finalizing an earthmoving system. While both scrapers and trucks can perform well on smooth roads, rough roads can be a trouble for the former. In addition, rough roads will exert more pressure on vehicles as they'll have to exert more power. (8)

Classification of earth moving equipment

In recent years, a great deal of improvement has been made in earth moving equipment. Earth moving equipment may be broadly classified into:

- Excavating machines

- Tractor and tractor units
- Scrapers or pans
- Grading and compacting machines.

Earthwork equipment and operations

There is a wide range of excavating equipments available. In selection a much greater care and thought needed to find a suitable machine for a particular job. The best performance of a machine depends on a large number of factors. It should be noted that no machine is designed to suit a particular set of conditions which may be demanded at a construction project. Thus a best designer would design the machine such that the machine fits to more construction projects.

5. **Mention about the various types of pile driving equipment. (M/J '12)(N/D '16) (13)**

Pile driving equipment comprise of the following

- Driving rig
- Guiding leaders
- Pile hammer with accessories
- Additional aids for preboring, jetting etc.
- Boiler for steam raising or air compressor.

Driving Rigs.

Driving rig provides basic operations of lifting the pile, holding the pile in position, hammering it into the ground or of pulling it out of the ground and guiding the pile in the desired direction of movement. The rig supports the boom and winch mechanism, driving hammer, the guiding leaders, and a platform for mounting of auxiliary equipment such as a jet pump, drilling auger, steam boiler or air compressor.

Guiding Leaders.

The leaders guide the pile and the hammer during operation which extends to the entire height of the rig. In case of piles to be driven below the level of the rig into excavations, trenches or water telescopic or extensible leaders can be used. The leader should enable the hammer to deliver blows axially to the pile. During the process of driving, the driving rig should be strong and stable In case a boom is used, adequate space should be available between the pile top and the point for the hammer to work.

Concreting equipment.

Concreting generally involves: batching and mixing, handling and transportation, placing, finishing and curing

A concrete plant is provided with arrangements for

1. Receiving all ingredients for making concrete, viz., aggregates, sand and cement and water.
2. Weighing each ingredient of concrete for each batch of the mix.
3. Mixing these ingredient thoroughly to form a concrete of required consistency (7)

Concrete Batching and Mixing Plant.

Batching comprises of proportioning of ingredients of concrete, aggregate, sand, cement and water, separately for each batch. In the construction field, batching and mixing plants consists of the following (Peurify and Schexnayder 2009).

Aggregate Feeders

Aggregate feed bins are made available for each size of aggregate and sand and mix based on volume. In important jobs weighing system is adopted. Aggregate feed bins are loaded by the following methods:

- By shovels directly into the bins.
- By lorries tipping directly into the bins.
- By means of boomscrapers from the aggregates stored in bulk heads on the ground.

6. **Explain about the various types equipments for materials handling and erection of structures.** **(N/D '13)** **(13)**

a. Bulk or units
b. Large or small
c. Heavy or light
d. Shape

- Rough or fragile
- Volume of the material
- Distance over which to be transported
- Height to which to be lifted or to be lowered.
- Availability of spaces for the equipment
- Frequency of material to be handled (6)

Handling devices

- Vertical motion devices (lifting and lowering devices)
  Block and tackle
  Winches Hoists
  Elevators
- Horizontal motion devices
  Wheel barrows and hand trucks
  Narrow-gauge mine rail road
  Tractors and trailors
  Skids
  Pipe line

The types of cranes

Cranes are classified as given below:

- Derrick cranes
- Tower cranes
- Pillar cranes
- Overhead or gantry cranes

- Self-propelling boom cranes
- Crane trucks

7. **<u>What is meant by tunneling? Explain the features of the equipment used for tunneling operation.</u> (N/D '15) (13)**

A **tunnel** is an underground or underwater passageway, dug through the surrounding soil/earth/rock and enclosed except for entrance and exit, commonly at each end. A pipeline is not a tunnel, though some recent tunnels have used immersed tube construction techniques rather than traditional tunnel boring methods.

A tunnel may be for foot or vehicular road traffic, for rail traffic, or for a canal. The central portions of a rapid transit network are usually in tunnel. Some tunnels are aqueducts to supply water for consumption or for hydroelectric stations or are sewers. Utility tunnels are used for routing steam, chilled water, electrical power or telecommunication cables, as well as connecting buildings for convenient passage of people and equipment.

Secret tunnels are built for military purposes, or by civilians for smuggling of weapons, contraband, or people. Special tunnels, such aswildlife crossings, are built to allow wildlife to cross human-made barriers safely.

Tunnels are dug in types of materials varying from soft clay to hard rock. The method of tunnel construction depends on such factors as the ground conditions, the ground water conditions, the length and diameter of the tunnel drive, the depth of the tunnel, the logistics of supporting the tunnel excavation, the final use and shape of the tunnel and appropriate risk management.

There are three basic types of tunnel construction in common use:

- Cut-and-cover tunnel, constructed in a shallow trench and then covered over.
- Bored tunnel, constructed in situ, without removing the ground above. They are usually of circular or horseshoe cross-section.
- Immersed tube tunnel, sunk into a body of water and laid on or buried just under its bed.
- Tunnel boring machines (TBMs) and associated back-up systems are used to highly automate the entire tunneling process, reducing tunneling costs. In certain predominantly urban applications, tunnel boring is viewed as quick and cost effective alternative to laying surface rails and roads. Expensive compulsory purchase of buildings and land, with potentially lengthy planning inquiries, is eliminated. Disadvantages of TBMs arise from their usually large size - the difficulty of transporting the large TBM to the site of tunnel construction, or (alternatively) the high cost of assembling the TBM on-site, often within the confines of the tunnel being constructed.
- There are a variety of TBM designs that can operate in a variety of conditions, from hard rock to soft water-bearing ground. Some types of TBMs, the bentonite slurry and earth-pressure balance machines, have pressurized compartments at the front end, allowing them to be used in difficult conditions below the water table. This pressurizes the ground ahead of the TBM cutter head to

balance the water pressure. The operators work in normal air pressure behind the pressurized compartment, but may occasionally have to enter that compartment to renew or repair the cutters. This requires special precautions, such as local ground treatment or halting the TBM at a position free from water. Despite these difficulties, TBMs are now preferred over the older method of tunneling in compressed air, with an air lock/decompression chamber some way back from the TBM, which required operators to work in high pressure and go through decompression procedures at the end of their shifts, much like deep-sea divers.

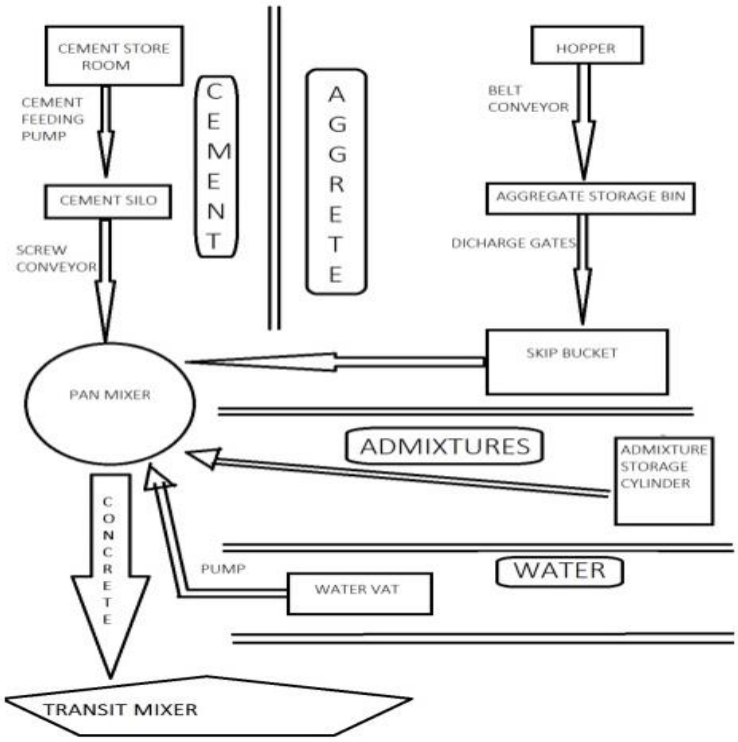
8. **With sketch explain a typical batching plant. (A/M '17)** **(13)**

Batching

The measurement of materials for making concrete is known as batching. There are two methods of batching:

(i) **Volume batching:** Volume batching is not a good method for proportioning the material because of the difficulty it offers to measure granular material in terms of volume. Volume of moist sand in a loose condition weighs much less than the same volume of dry compacted sand. The amount of solid granular material in a cubic metre is an indefinite quantity. Because of this, for quality concrete material have to be measured by weight only. However, for unimportant concrete or for any small job, concrete may be batched by volume. Cement is always measured by weight. It is never measured in volume. Generally, for each batch mix, one bag of cement is used. The volume of one bag of cement is taken asthirty five (35) litres. Gauge boxes are used for measuring the fine and coarse aggregates. Gauge boxes are generally called farmas. They can be made of timber or steel plates. Often in India volume batching is adopted even for large concreting operations. In a major site it is recommended to have the following gauge boxes at site to cater for change in Mix Design or bulking of sand. The volume of each gauge box is clearly marked with paint on the external surface.

(ii) Weigh Batching: Strictly speaking, weigh batching is the correct method of measuring the materials. For important concrete, invariably, weigh batching system should be adopted. Use of weight system in batching, facilitates accuracy, flexibility and simplicity. Different types of weigh batchers are available, the particular type to be used, depends upon the nature of the job. Large weigh batching plants have automatic weighing equipment. The use of this automatic equipment for batching is one of sophistication and requires qualified and experienced engineers. In this, further complication will come to adjust water content to cater for the moisture content in the aggregate. In smaller works, the weighing arrangement consists of two weighing buckets, each connected through a system of levers to spring-loaded dials which indicate the load. The weighing buckets are mounted on a central spindle about which they rotate. Thus one can be loaded while the other is being discharged into the mixer skip. A simple spring balance or the common platform weighing machines also can be used for small jobs.



FLOW CHART: BATCING PLANT OPERATION

9. **Explain briefly about the Loaders,in construction,and its types. (13)**

Loader is a machine in which a bucket is attached to the arms and capable of being raised, lowered and dumped through mechanical or hydraulic controls. A very common type is one in which the loader is having the bucket in the front which is known as front-end loader.

Loaders are self-propelled and versatile equipment which are mounted either on crawler or wheel-type running gear. These loaders are fitted with front mounted general-purpose bucket.

Types of Loaders

- Crawler Loaders
- Wheeled Loaders

Crawler Loaders

These are low pressure type which are generally preferred for digging and loading jobs of poor ground and rock and sharp stony ground. These are preferred for short moves between loading and dumping points when there is no damage to tyres.

Wheeled Loaders

These are generally four wheel drive. Two-wheel drives are preferred for handling light jobs on good ground conditions. Protective chains are provided which increases the tyre operating life. Four-wheel drives are used for bulk handling of coal, cement, fertilizer, etc, into hoppers and trucks. These are additionally favored rather than more difficult to maneuver crawler.

10. **Explain various types of vibratory compaction equipment.** **(13)**

Vibratory Compaction Equipment

Vibratory compactors can be categorized into the following groups (Sharma, 1988):

- Tandem vibratory compactors
- Towed vibratory compactors
- Towed sheepsfoot and tamping-footvibratory compactors
- Self-propelled vibratory compactors
- Hand-guided vibratory compactors

Tandem Vibratory Compactors.

Two types are available, viz., single-drum vibrating or double-drum vibrating. In the compactors with double-drum vibrating system two tandem wheels are provided with separate controlled vibrators in the front and rear rolls. Comparing single and double drum vibratory compactors, the output of double drum vibratory compactor is to be 80 % more than the single-drum vibratory compactor. The double-drum vibratory type has an option to operate the single- drum or the double-drum. (6)

Towed Virbatory Compactors

This type of compactor is especially used for compacting cohesive soils, fine and coarse grained mixed soil and rocky materials. The heavy type towed vibratory compactor is used in earth dam and embankment constructions. Because of the large amplitude, it shows more impact motion and therefore preferred for compacting cohesive soils, fine grained soils, and mixed fine or coarse grained

Towed Sheepsfoot or Tamping-foot Vibratory Compactors.

This type of compactor is useful in highly cohesive soils and soft rocks. The kneading and crushing effect of the feet improves the compaction performance. The compactors are provided with sheepsfoot or tamping-foot vibratory equipment. Tamping-foot are larger than the sheepsfoot and hence has a more contact area.

Self-propelled Vibratory Compactors.

These compactors are available with a weight of 8 to 10 tons dead weight. In one type large vibratory steel roll in the front and two rubber tyres at the rear. The rubber tyres may be smooth or with treads. The smooth one can be used for bituminous work and the treds one for earth compaction work.

In the other type vibratory steel roll is in the front and two static steel rolls at the rear for multi purpose work. (7)

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Part C

1. **What are the equipments available for material handling? (13)**

(https://en.wikipedia.org/wiki/Material-handling_equipment)

Material handling equipment is mechanical equipment used for the movement, storage, control and protection of materials, goods and products throughout the process of manufacturing, distribution, consumption and disposal. The different types of handling equipment can be classified into four major categories: transport equipment, positioning equipment, unit load formation equipment, and storage equipment.

Conveyors: Conveyors are used when material is to be moved frequently between specific points over a fixed path and when there is a sufficient flow volume to justify the fixed conveyor investment. Different types of conveyors can be characterized by the type of product being handled: unit load or bulk load; the conveyor's location: in-floor, on-floor, or overhead, and whether or not loads can accumulate on the conveyor. Accumulation allows intermittent movement of each unit of material transported along the conveyor, while all units move simultaneously on conveyors without accumulation capability.

Jib crane

Cranes are used to transport loads over variable (horizontal and vertical) paths within a restricted area and when there is insufficient (or intermittent) flow volume such that the use of a conveyor cannot be justified. Cranes provide more flexibility in movement than conveyors because the loads handled can be more varied with respect to their shape and weight. Cranes provide less flexibility in movement than industrial trucks because they only can operate within a restricted area, though some can operate on a portable base. Most cranes utilize trolley-and-tracks for horizontal movement and hoists for vertical movement, although manipulators can be used if precise positioning of the load is required. The most common cranes include the jib, bridge, gantry, and stacker cranes.

Pallet jack

Industrial trucks are trucks that are not licensed to travel on public roads (commercial trucks are licensed to travel on public roads[7]). Industrial trucks are used to move materials over variable paths and when there is insufficient (or intermittent) flow volume such that the use of a conveyor cannot be justified. They provide more flexibility in movement than conveyors and cranes because there are no restrictions on the area covered, and they provide vertical movement if the truck has lifting capabilities.

Hand trucks (including carts and dollies), the simplest type of industrial truck, cannot transport or stack pallets, is non-powered, and requires the operator to walk. A pallet jack, which cannot stack a pallet, uses front wheels mounted inside the end of forks that extend to the floor as the pallet is only lifted enough to clear the floor for subsequent travel.

2. **List out the types of excavators. What are the advancements made in them? (13)**

(http://www.engineeringintro.com/all-about-construction-equipments/excavator-types-function-of-excavator/)

Excavator is the machine that can excavate the soil of various types forcefully and then using hydraulic system a hydraulic force is generated and utilizing this force bucket is pull back towards the machine. Bucket of excavator is replaceable. If front bucket is exchange with some other attachments then excavator can be used for multi-purpose. For example: pile diver, hydraulic jack hammer etc…

Excavator comes in numerous sizes depending on bucket size, length of boom, length of arm, and operation speed. Performance of excavator can be measured from the production cycle. Production cycle is the time that an excavator took to load the bucket from source, swing, dump, return back and then dig again. Therefore, faster the operation speed, the faster will be the one complete cycle and hence production cycle will increase. Excavators are mostly used for digging of soils and for loading dump trucks. It is either of;

Crawler excavator

Crawler excavator runs on two endless tracks (chain wheel system). These types of excavators are used in hilly areas where risks of sliding of machinery are on the verge. Crawler type excavator has low ground pressure because of spreading of load on large area. Therefore, it is also used where soil support is weak.

Wheel excavator

Wheel excavator runs on wheels and are used for excavation and loading of dump trucks and most of the time it is only used for plain ground operations. Because of wheel, it is not suitable for hilly areas due to low grip value to the ground.

Excavators are used for;

- Digging of earth Crawler Excavator used for digging of earth
- Earth Digging
- Loading and dumping
- Excavator used for loading trucks
- Trenching
- making Trenching using excavators
- Excavator during trenching
- Excavating Under Water
- Breaking previous layers of highways and loading.

3. What are the modern equipments available for compaction, mixing and concreting? (13)

Concrete Batching and Mixing Plant: A concrete batching and mixing plant is a huge set up of machines meant to combine cement, aggregates such as sand or gravel, and water to form concrete (ready-mixed). These plants are either mobile or stationary and their sizes range from portable mixer to heavy industrial mixing plant. Stationary plant mixer mixes the concrete before it is discharged into a truck mixer. Revolving drums, conveyor and diesel or electric powered engines are used in this plant. The truck mixer is used primarily as an agitating haul unit at a central mix operation. Dump trucks or other non-agitating units are sometimes used for low slump and mass concrete pours supplied by central mix plants.

Apart from stationary concrete plant mixer, mobile concrete mixing plant is also very popular and widely used. Mobile concrete mixer plant is a unit mounted on a trailer which carries sufficient unmixed materials, such as cement, sand, coarse aggregates, water, and any chemicals required, for special mix specifications to the job site. In this type of plant cement, sand and aggregates are carried in separate bins. The materials mixed proportionately are mixed with water and then discharged through the conveyor system.

Truck Concrete Pumps: Truck mounted concrete pumps are used to supply concrete to places which are difficult to reach by other heavy machines. Concrete Pumping Equipments are concrete pump, heavy-duty pipe, hose and other accessories. When pressure is applied to a column of fresh concrete by the concrete pump, it forces the concrete through a lubricated pipe. Concrete pumping is useful in the areas where space available for construction equipment is limited. It is faster and saves enough man power and energy. It is all weather operation and does not require heavy equipments like cranes and hoists for other construction operations

Trailer Concrete Pumps: Like truck concrete pump, trailer concrete pump is designed to spread concrete in an area which is difficult to reach out. The trailer pump is ideally suited for the construction of foundations and pools, pressure grouting, and rock scaping. Trailer concrete pump can pump concrete both horizontally and vertically. It can pump concrete to the difficult areas. Pumping is faster than other methods. It is all weather operations. It saves enough time and energy and helps in the completion of work with the faster rate. Concrete can be easily handled as it is pumped to desired spot.

Mobile Concrete Placer: This Machine can be used for Bridges, Culverts, mass Concreting Purpose and Canal Works. It is available in 56 feet length, pouring at the height of 27 feet and ability to fold for Towing without removing discharge hopper. Mechanical power for the conveyor is provided by 25 HP (19 Kw) Engine, which drives a Hydraulic Double Pump. Hydraulic steering which pivots the two under carriage wheels 900 to the Right and 45 0 to the Left and the steering wheel at the charging end rotates the towing hitch wheel 360 degree about its yoke. So the conveyor can be moved in a straight line and vertical too.

Concrete Mixer Truck: The hydrostatic truck mixer transports concrete/mortar directly from plant to the place where it is to be poured. Concrete mixer with various capacities like 3, 4 and 6 cum is mounted on truck. It has a wide range of applications specially for mass concreting works like Multi-storied buildings, Bridge works etc. The basic function of transit mixer is to maintain the concrete's liquid state, through the turning of the drum till the point of delivering at construction site.

4. Explain briefly about the operations involved in Tunnel Boring Machine (TBM) (13)
(http://www.railsystem.net/tunnel-boring-machine-tbm/)

A tunnel boring machine (TBM) also known as a “mole“, is a machine used to excavate tunnels with a circular cross section through a variety of soil and rock strata. They can bore through hard rock, sand, and almost anything in between. Tunnel diameters can range from a meter (done with micro-TBMs) to almost 16 meters to date. Tunnels of less than a meter or so in diameter are typically done using trenchless construction methods or horizontal directional drilling rather than TBMs.

Hard rock TBMs

In hard rock, either shielded or open-type TBMs can be used. All types of hard rock TBMs excavate rock using disc cutters mounted in the cutter head. The disc cutters create compressive stress fractures in the rock, causing it to chip away from the rock in front of the machine, called the tunnel face. The excavated rock, known as muck, is transferred through openings in the cutter head to a belt conveyor, where it runs through the machine to a system of conveyors or muck cars for removal from the tunnel.

Open-type TBMs have no shield, leaving the area behind the cutter head open for rock support. To advance, the machine uses a gripper system that pushes against the side walls of the tunnel. The machine can be continuously steered while gripper shoes push on the side-walls to react the machine's forward thrust. At the end of a stroke, the rear legs of the machine are lowered, the grippers and propel cylinders are retracted. The retraction of the propel cylinders repositions the gripper assembly for the next boring cycle. The grippers are extended, the rear legs lifted, and boring begins again. The open-type, or Main Beam, TBM does not install concrete segments behind it as other machines do. Instead, the rock is held up using ground support methods such as ring beams, rock bolts, shotcrete, steel straps, and wire mesh (Stack, 1995).

Soft ground TBMs

In soft ground, there are two main types of TBMs: Earth Pressure Balance Machines (EPB) and Slurry Shield (SS). Both types of machines operate like Single Shield TBMs, using thrust cylinders to advance forward by pushing off against concrete segments. Earth Pressure Balance Machines are used in soft ground with less than 7 bar of pressure. The cutter head does not use disc cutters only, but instead a combination of tungsten carbide cutting bits, carbide disc cutters, and/or hard rock disc cutters. The EPB gets its name because it is capable of holding up soft ground by maintaining a balance between earth and pressure. The TBM operator and automated systems keep the rate of soil removal equal to the rate of machine advance. Thus, a stable environment is maintained. In addition, additives such as bentonite, polymers and foam are injected into the ground to further stabilize it.

Urban tunneling and near surface tunneling

Urban tunneling has the special challenge of requiring that the ground surface be undisturbed. This means that ground subsidence must be avoided. The normal method of doing this in soft ground is to maintain the soil pressures during and after the tunnel construction. There is some difficulty in doing this, particularly in varied strata (e.g., boring through a region where the upper portion of the tunnel face is wet sand and the lower portion is hard rock).

TBMs with positive face control, such as EPB and SS, are used in such situations. Both types (EPB and SS) are capable of reducing the risk of surface subsidence and voids if operated properly and if the ground conditions are well documented.

When tunneling in urban environments, other tunnels, existing utility lines and deep foundations need to be addressed in the early planning stages. The project must accommodate measures to mitigate any detrimental effects to other infrastructure.