Unit 4- SUPER STRUCTURE CONSTRUCTION

2 MARKS

1. **What are the advantages of articulated towers (April/May 2017)**

   Articulated tower platform is one of the compliant structures which is economically attractive especially as loading and mooring terminal to deep waters. These platforms are comparatively light compared to the conventional fixed platforms.

2. **Define forms for shells (April/May 2017)**

- Folded Plates
- Barrel Vaults
- Short Shells
- Domes (surfaces of revolution)
- Folded Plate Domes
- Translational Shells
- Warped Surfaces
- Combinations

3. **What are the methods of pre stressing (April/May 2018)**
   - Pre-tensioning
   - Post-tensioning

4. **What is conveyor belt (April/May 2018)**

   A conveyor belt is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials.. Many kinds of conveying systems are available and are used according to the various needs of different industries. There are chain conveyors (floor and overhead) as well. Chain conveyors consist of enclosed tracks, I-Beam, towline, power & free, and hand pushed trolleys

5. **What are the precautions to be taken while erecting light weight components on tallstructures? (April/May 2019,Nov/Dec 2015,May/June2012)**

   The precautions to be taken while erecting light weight components on tall structures are,

- a) Excellent coordination and site organization have to be maintained
- b) All heavy equipments like generators, lightning system, twists, etc., are to be in working
- Condition
- c) Adequate communication facility should be coordinated between ground level, crane drivers, ship format and twist operators

6. **Mention the reasons for using special forms for shells. (April/May 2019, Nov/Dec 2015, May/June2012)**

   A **thin shell concrete structure**, is a structure composed of a relatively thin shell of concrete, usually with no interior columns or exterior buttresses. The shells are most commonly flat plates and domes, but may also take the form of ellipsoids or cylindrical sections, or some combination thereof.

7. **What are launching girder. (Nov/Dec 2018, Nov/Dec2016,Apr/may-2019)**

   For erection of large beams in buildings or bridges, temporary girders are used. Such girders are called launching girders. Launching girders are usually of steel as it would be light compared to concrete girders.

8. **What are the factors influencing compaction(Nov/Dec2016)**

- Moisture content.
- Types of soil.
- Amount of compaction.
- Contact Pressure.
- Speed of Rolling.

9. What are shells (Nov/Dec2016)

A shell is a dome set on four arches. The shape is different from a spherical dome and is generated by a vertical circle moving on another circle. All vertical slices have the same radius. It is easier to form than a spherical dome.

9. **What is false work for construction of heavy structure (Nov/Dec 2018)**

False-work consists of temporary structures used in construction to support a permanent structure until its construction is sufficiently advanced to support itself.

10. What do you mean by bridge and write their types (Nov/Dec 2017)

A *bridge* is a structure built to span a physical obstacle, such as a body of water, valley, or road, without closing the way underneath

- Beam Bridge: Beam bridges are the simplest bridge type normally consists of one or more spans, supported by abutment or pier at each end. ...
- Arch Bridge:
- Cantilever Bridge:
- Suspension bridge:
- Cable-stayed Bridge:
- Truss Bridge:

11. What are the various operations involved in offshore platform (Nov/Dec 2017)

- Fixed **platforms**.
- Compliant towers.
- Semi-submersible **platform**.
- Jack-up drilling **rigs**.
- Drillships.
- Floating production systems.
- Tension-leg **platform**.
- Gravity-based structure.

SIXTEEN MARKS

1. Explain the construction techniques for bridge decks (April/May 2019,April/May 2017)

1. Cast-in-situ Method of Bridge Construction

This method is a flexible method of bridge construction where complex and unusual geometrical shapes of dams can be constructed easily. Situations when it is hard to transport pre-fabricated elements either due to size or unreachability, this method is a good choice.

2. Balanced Cantilever Method of Bridge Construction

This method is used for constructing bridges with span 50 to 250m. The bridge constructed can either be cast-in-place or precast. Here, the segments are attached in an alternative manner at opposite ends of the cantilevers supported by piers. This is the best choice for the construction of long span length bridges, irregular length, and cable-stayed bridges.

Fig.1: Balanced Cantilever Bridge Construction

3. Precast Method of Bridge Construction

In this method, the bridge is constructed with the help of precast concrete elements. The prefabrication is performed in different methods. The precast elements include:

- Precast Beams
- Precast Decks
- Precast Segmental Decks

Fig.2: Precast method of bridge construction

4. Span by Span Casting method of Bridge Construction

This method is associated with cantilever construction method but with many advancements in the technique, it is considered as most economic and rapid in construction. For long bridges and viaducts with an individual span up to 60m, the method is feasible.

Decks are begun at one abutment and constructed continuously by placing segments to the other end of the bridge. Segments can be positioned by either a temporary staying mast system through more commonly using an assembly truss.

5. Incremental Launching Method of Bridge Construction

The Incremental Launching Method (ILM) method of bridge construction is employed mainly for the construction of continuous concrete bridges or steel girder bridges. The method performs the procedure in increments. With this method of construction, the bridge deck is

built in sections by pushing the structure outwards from an abutment towards the pier. The ILM method can be used for bridge decks with a length greater than 250m.

Fig.3: Incremental Launching Method of Bridge Construction

6. Cable-Stayed Method of Bridge Construction

In the cable-stayed method of construction, cables are used to carry the bridge deck from one or both sides of the supporting tower. The cables carry and transfer all the loads to the foundations. Cable-stayed method of construction is used for constructing bridges that span more than 300m.

7. Arch Method for Bridge Construction

Arch shaped bridge construction is one of the most economical choices when the bridge under consideration is required to cross over landscapes that are inaccessible. Many modern arch construction methods have made the arch construction more economical. The arch construction can be built with concrete or pre-cast concrete. The cast-in-situ free cantilever

method and slip formed sections are two main construction techniques coming under arch methods.

Factors Affecting Selection of Bridge Construction Methods

Before a bridge can be built an appropriate method of construction must be chosen. The decision is made by the design team. The principle factors considered by the design team when choosing a suitable method of construction are given below:

1. The scale of the bridge
2. The obstacles to be crossed
3. The regularity of the span lengths
4. The horizontal and vertical profiles of the bridge decks
5. The nature of the soil strata
6. The local weather
7. The local cost of materials
8. The local labor markets
9. The accessibility of the site
10. The time allowed for construction.

2. Briefly explain the erecting procedure of light weight components on tall structures (Nov/Dec2014, April/May 2017)

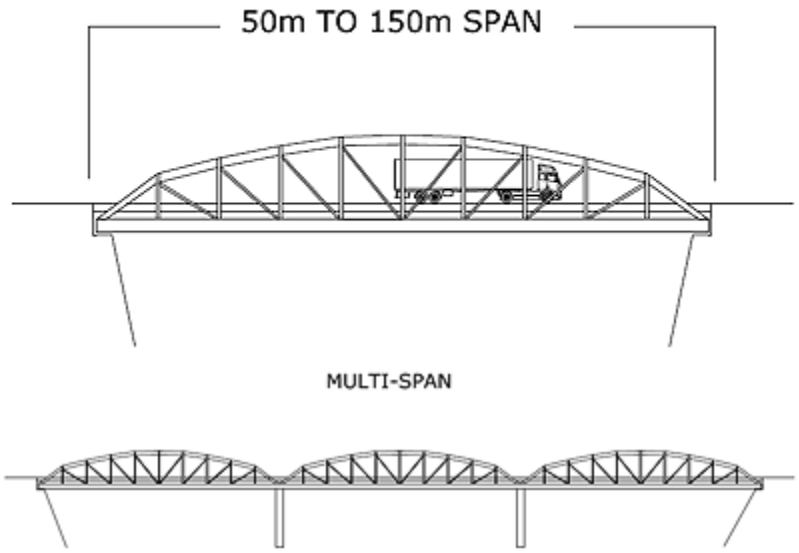
A structure in which relative motion is allowed to occur between parts, usually by means of a hinged or sliding joint or joints

- Besides high raise buildings the usage of steel element is also popular with construction of hospital and commercial complexes
- Instead of concrete beams and columns more than 6100 tonnes of steel have been used to build the main frames
- Light weight blocks are used for patricians to reduce the dead load building

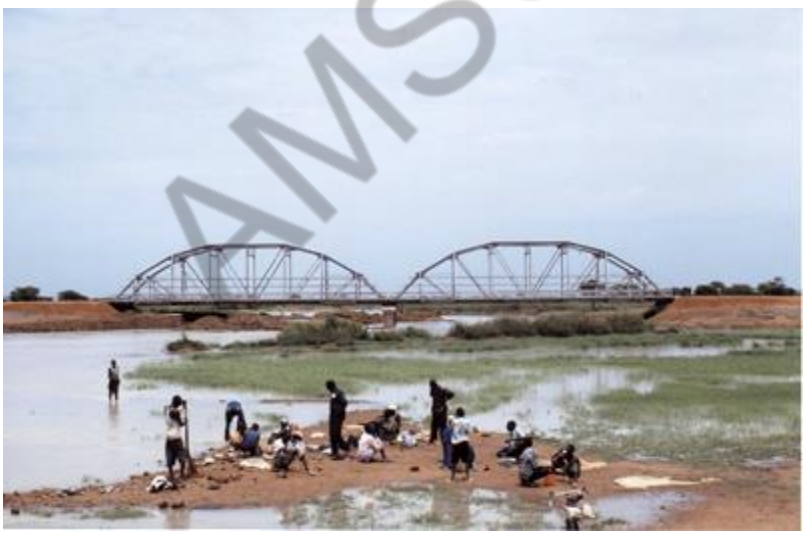
- The usage of permanent concrete form works and structural steel elements will be the main constituter for erecting light weight components on tall structures results rapid speed of constructions.
- Hence the erection of steel beams and columns as well as the installation of concrete form work consumes only less time
- Self-drilling tapping screws are the most prevalent fasteners. Steel to steel connections can be carried out to connect struts or joist and track together
- Entire can be erected manually without the use of heavy equipment
- All these structures require few battery powered screw gunes and some ropes and pulleys
- No scaffoldings is require for assembly and disc assembly of the structures because the structure itself provides the scaffoldings as it goes up or comes down

- Almost any number of column sections can be added to make it any height we desire
- During the construction of tall structures the following equipment are used for the aerial transporting and handling

3A. **Bow string girder bridge (April/May 2018)**



- Much like a through-truss bridge, except that the truss can be a higher, deeper segmental curve
- Suitable for 50m - 150m spans
- Attractive
- Can be constructed on less robust foundations e.g. atop elevated piers/areas of uneven soil
- Can be pre-fabricated offsite and hauled or lifted into place



Cable-stayed bridge

Cable-stayed bridge is a bridge similar to suspended bridge in that it has towers and a deck that is held by cables, but its cables hold the deck by connecting it directly to the towers instead via suspender cables. It usually carries pedestrians, bicycles, automobiles, trucks, and light rail. It is used in places where spans need to be longer than **cantilever bridge** can achieve (because of its weight), but the span is short enough so a suspension bridge is not practical there economically.

II. Uses of offshore platform (April/May 2018)

Offshore platforms are structures constructed in the ocean to explore or to produce oil and gas from the sources found below the sea. Offshore platforms are in steel or in concrete.

An oil platform, offshore platform, or offshore drilling rig is a large structure with facilities for well drilling to explore, extract, store, and process petroleum and natural gas which lies in rock formations beneath the seabed. Many oil platforms will also contain facilities to accommodate their workforce.

iii. **Domes(April/May 2018)**

A **dome** is a hollow half of a sphere. **Domes** are one of the most familiar features in architecture, frequently **used for** government and religious buildings

b. launching girder and bridge decks

A launching gantry is a special-purpose mobile gantry crane used in bridge construction. It is used to install precast box girders in highway and high-speed rail bridge construction projects.

A **deck** is the surface of a **bridge**. A structural element of its superstructure, it may be constructed of concrete, steel, open grating, or wood. Sometimes the **deck** is covered a railroad bed and track, asphalt concrete, or other form of pavement for ease of vehicle crossing.

Prestressing Method (April/May 2018)

There are two methods of pre-stressing concrete: -

1) Pre-cast Pre-tensioned

2) Pre-cast Post-tensioned

Both methods involve tensioning cables inside a concrete beam and then anchoring the stressed cables to the concrete.

Pre-cast Pre-tensioned: -

Pre-tensioning is a method of pre-stressing in which the steel tendons are tensioned before the casting of the member. In this method the tendons are tensioned using hydraulic jacks, which bear on strong abutments between which the moulds are placed. After the concrete attains full strength the tendons are released and the stress is transferred to the concrete by bond action.

Procedure of precast pre-tensioned concreting

Stage 1

Tendons and reinforcement are positioned in the beam mould.

Stage 1

Stage2

Tendons are stressed to about 70% of their ultimate strength.

Stage 2

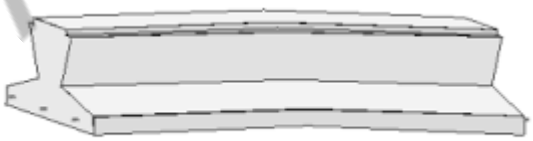
Stage3

Concrete is cast into the beam mould and allowed to cure to the required initial strength.

Stage 3

Stage4

when the concrete has cured the stressing force is released and the tendons anchor themselves in the concrete.



Stage 4

Pre-cast Post-tensioned: -

Post-tensioning is a method of pre-stressing in which the steel tendons are tensioned after the casting of the member. In this method ducts or sheaths are placed in the required profile in the mould and the tendons are passed through the ducts. After the concrete had attained sufficient strength the tendons are tensioned using hydraulic jacks which bear on the member itself. The stress is transferred to the concrete by bearing action of tendons which are anchored using suitable anchorages. Finally the ducts are grouted and the anchor plates concealed by cement mortar.

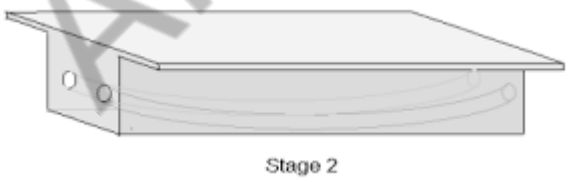
Procedure of precast post-tensioned concreting

Stage1

Cable ducts and reinforcement are positioned in the beam mould. The ducts are usually raised towards the neutral axis at the ends to reduce the eccentricity of the stressing force.

Stage2

Concrete is cast into the beam mould and allowed to cure to the required initial strength.



Stage3

Tendons are threaded through the cable ducts and tensioned to about 70% of their ultimate strength.

Stage 3

Stage 4

Wedges are inserted into the end anchorages and the tensioning force on the tendons is released. Grout is then pumped into the ducts to protect the tendons.

Stage 4

4. Erection of articulated towers (April/May 2019) (April/May 2017)

There are four main methods of erection of steel transmission towers which are described below:

1. Build-up method or Piecemeal method.
2. Section method.
3. Ground assembly method.
4. Helicopter method.

Build Up Method

This method is most commonly used in India for the erection of 6.6 kV, 132 kV, 220 kV and 400 kV transmission line towers due to the following advantages :

- Tower materials can be supplied to site in knocked down condition which facilitates easier and cheaper transportation.

- It does not require any heavy machinery such as cranes etc.
- Tower erection activity can be done in any kind of terrain and mostly throughout the year.
- Availability of workmen at cheap rates.
- This method consists of erecting the towers, member by member. The tower members are kept on ground serially according to erection sequence to avoid search or time loss. The erection progresses from the bottom upwards. The four main corner leg members of the first section of the tower are first erected and gaurd off. Sometimes more than one contiguous leg sections of each corner leg are bolted together at the ground and erected.

Section Method Tower Erection

In the section method, major sections of the tower are assembled on the ground and the same are erected as units. Either a mobile crane or a gin pole is used. The gin pole used is approximately 10 m long and is held in place by means of guys by the side of the tower to be erected. The two opposite sides of the tower section of the tower are assembled on the ground. Each assembled side is then lifted clear of the ground with the gin or derrick and is lowered into position on bolts to stubs or anchor bolts. The first face of the second section is raised. To raise the second face of this section it is necessary to slide the foot of the gin on the strut of the opposite face of the tower. After the two opposite faces are raised, the lacing on the other two sides is bolted up.

Ground Assembly Method of Tower Erection

This method consists of assembling the tower on ground, and erecting it as a complete unit. The complete tower is assembled in a horizontal position on even ground. The tower is assembled along the direction of the line to allow the cross arms to be fitted. One slopping ground, however, elaborate packing of the low side is essential before assembly commences. After the assembly is complete the tower is picked up from the ground with the help of a crane and carried to its location, and set on its foundation.

For this method of erection, a level piece of ground close to footing is chosen from the tower assembly..

Helicopter Method of Transmission Tower Erection

In the helicopter method, the transmission tower is erected in section. For example bottom section is first lifted on to the stubs and then the upper section is lifted and bolted to the first section and the process is repeated till the complete tower is erected. Sometimes a completely assembled tower is raised with the help of helicopter. Helicopters are also used for lifting completely assembled towers with guys from the marshaling yards where these are fabricated and then transported one by one to line locations. Helicopter hovers over the line location while the tower is securely guyed. Tightening of Nuts and Punching of Threads and Tack Welding of Nuts of Transmission Towers

Checking the Verticality of Erected Towers

The finally erected tower shall be truly vertical after erection and no straining is permitted to bring it in alignment. Tolerance limit for vertical shall be one in 360 of the tower height.

5**. Explain the process involved in construction of space decks and braced domes (Nov/Dec 2015)**

Erection of space decks

The principal function of a bridge deck is to provide support to local vertical loads (from highway traffic, railway or pedestrians) and transmit these loads to the primary superstructure of the bridge, Figure 1(1). As a result of its function, the deck will be continuous along the bridge span and (apart from some railway bridges) continuous

across the span. As a result of this continuity, it will act as a plate (isotropic or hotropic depending on construction) to support local patch loads.

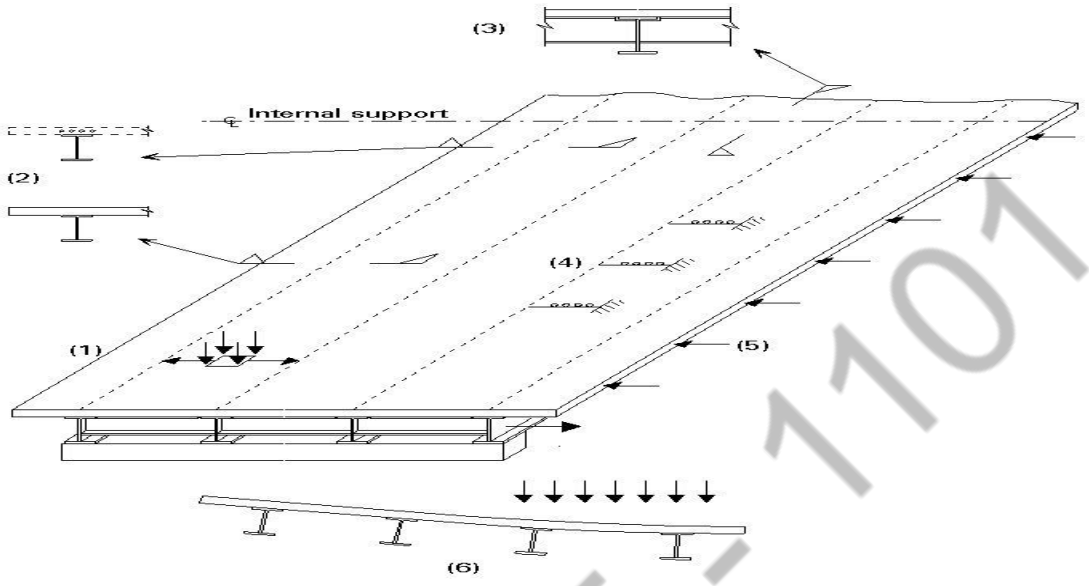


Figure 1 Structural actions of a highway bridge deck.

Continuity ensures that whether or not it has been designed to do so, it will participate in the overall structural action of the superstructure. The overall structural actions may include:

- Contributing to the top flange of the longitudinal girders, Contributing to the top flange of cross girders at supports and, where present in twin girder and cross girder structures, throughout the span,
- Stabilizing longitudinal and cross girders, Acting as a diaphragm to transmit horizontal loads to supports,
- Providing a means of distribution of vertical load between longitudinal girders,

It may be necessary to take account of these combined actions when verifying the design of the deck. This is most likely to be the case when there are significant stresses

from the overall structural actions in the same direction as the maximum bending moments from local deck actions, e.g. in structures with cross girders where the direction of maximum moment is along the bridge.

The passage of each wheel load causes a complete cycle of local bending stresses. The number of significant stress cycles is, therefore, very much higher for the deck than for the remainder of the superstructure. In addition, some of the actions of the deck arising from its participation in the overall behavior are subject to full reversal;

An example is the transverse distribution of vertical load between girders. For both these reasons, fatigue is more likely to govern the design of the bridge deck than the remainder of the superstructure

Erection of braced domes

One method for constructing domes is the flattened conduit method. This involves the molding and flattening of metal tubes. After slightly bending the tubes, a hole is drilled on both the ends of the structure using frames and various other tools. This method is simple and less time-consuming, but the structure that is formed must be with other materials as the joints don't have fine finishing

Another method for is the tube and hub style. This is a very simple, cheap, and professional method which requires the joining of the struts with a larger diameter pipe at the hub holes. However, the method involves no option for rectifying a damaged hard cover material.

Though a dome structure lasts for a long time, it doesn't need any specialist tools. It does have its drawbacks however. Poor ventilation in a dome can lead to problems such as damp and dry rot. To avoid this wooden beams are used while joining the metal hubs at the edges with outside plywood.

This method of building is called the panelized timber frame. This is a simple strategy which only requires panels to be nailed together in the correct order. However, as the panels used in the process are not custom-made, the options available for the design are few. It should be

noted that wooden beams cannot be used for constructing domes for regions with extreme climate conditions.

Modern Techniques for Constructing Domes

The stressed skin technique is one more modern building method. This uses metal or fiberglass panels riveted together. The method saves costs and doesn't require any beams or support structure. However, to prevent any kind of condensation, it becomes necessary to install insulators in the structure.

The monolithic, yet modern type of dome construction is made of three phases. This involves using a special type of membrane that is inflated and placed on the dome, giving it a finish that serves like a weather-proof skin, but that can also be damaged very easily. Unlike the previous method, this style involves the spraying of polyurethane foam to insulate the structure. However, the materials used in the process are not environmentally friendly as they have oil-based chemicals.

The space frame type of dome construction, generally observed at airports and exhibition halls, heavily relies on connecting struts to spherical structures that have slots machined into them.

One of the oldest techniques of earth architecture is the brick strategy, which was often used to construct bridges and arches. In this technique, concrete, brick or stone are put on top of a wooden frame, which is molded according to the desired shape. The mold helps in holding the stone or brick in place until it settles and supports the whole structure.

One more recent technique is the foam and renders method using polystyrene foam. The dome shape is made by cutting and sticking the foam together. Chicken wire serves the purpose of reinforcing mesh. Lastly, in order to ensure that the structure is weatherproof, a thin layer of cement is spread over the entire building. These conditions only favor construction of small domes.

Of all the methods, the geodesic type of dome has been the most famous and extensively used in the last century. The main advantage of this dome structure is that it provides a massive enclosed space without any type of hindrance or support system. Moreover, geodesic dome construction can be erected easily and quickly using lightweight materials and a very small crew. There have also been several advancements made in geodesic dome construction methods in the past few years.

Nowadays, several companies sell plans and dome materials along with instruction so that the owners can make the dome themselves.

Dome structures, though advantageous, don't match urban planning styles and do not mix well with walls and angled rooftops. However, unlike other construction designs, domes are strong and resistant enough to bear bad weather conditions such as electrical storms, lightning, and earthquakes.

5. **What are the advantages of belt conveyor. Describe construction of typical belt conveyor(Nov/Dec 2015)**

ADVANTAGES OF BELT CONVEYORS

(a) Noiseless operation.

(b) Large length of conveying path

(c) Lower power consumption.

(d) Long life.

(e) Adaptability to different types of goods.

(j) Ability to carry almost any bulk material

(g) High reliability of operation.

(h) Can transport material in any direction.

CONVEYOR SET-UP

1) Locate center line of the conveyor by marking a chalk line on floor.
2) Determine flow of conveyor related to drive.
3) Position the conveyor sections in the proper order (See Figure 8.1).
4) Fasten floor or ceiling supports to Drive, Intermediate and Tail sections.
5) Use splice and pivot plates to fasten conveyor sections together.
6) Check to ensure that the conveyor is square and level across the length. Adjust leg supports and/or ceiling hangers
as necessary to achieve desired height.
7) Wire motor and install controls.

BELT INSTALLATION

The belt has been cut and laced to the proper length at the manufacturing facility and is ready for installation. To install follow these steps:

1) Loop belt over snub rollers, return rollers and end pulleys Bring laced ends together and thread lacing pin through loops

2) Adjust the take-up or tail pulley to remove excess slack from the belt. Keep the pulley square by moving both tension bolts an equal amount. Maintain just enough tension so that the drive pulley will not slip when carrying the rated load.

Note: Over tightening the belt will make it difficult to track and may damage the belt.

3) Check for squareness of all frame sections, end units, drive units, etc. All snubber rollers and pulleys must be squared with the frame before making any belt adjustments.

4) Use belt tracking instructions to properly track the belt.

START-UP OVERVIEW

1) Ensure that conveyor sections, leg supports, etc. were installed properly.

2) Ensure that drive chains and sprockets are installed, aligned and tensioned properly.

3) Ensure set screws are tight in sprockets, bearings and pulleys.

4) Ensure that all drive, mounted bearings and fasteners are securely tighten.

5) Ensure that all motor and control wiring is connected properly.

6) Ensure that the conveyor is not loaded with product.

7) Ensure that gearboxes are properly filled with the correct amount of lubricant or that they were factory filled with lubricant.

8) Ensure that the gearbox has necessary vent plugs installed (if applicable).

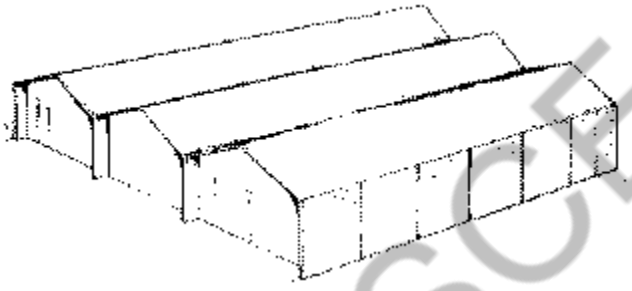
6. **Describe in detail about shell roof structures (Nov/Dec2016)**

A **thin shell concrete structure**, is a structure composed of a relatively thin shell of concrete, usually with no interior columns or exterior buttresses. The shells are most commonly flat plates and domes, but may also take the form of ellipsoids or cylindrical sections, or some combination thereof.

Types and Forms of Shell Structure

- Folded Plates
- Barrel Vaults
- Short Shells
- Domes of Revolution
- Folded Plate Domes
- Intersection Shells
- Warped Surfaces
- Combinations
- Shell Arches

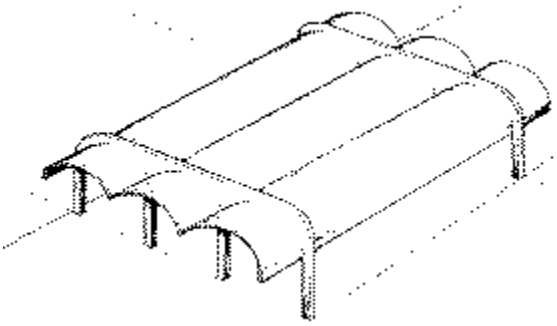
Folded Plates



The elements of a folded plate structure are similar to those of a barrel shell except that all elements are planar, and the moments in the slab elements are affected by the differential movement of the joints.

For the structure shown, the end supports and the side supports are both complete walls

Barrel Shells



The elements of a barrel shell are:

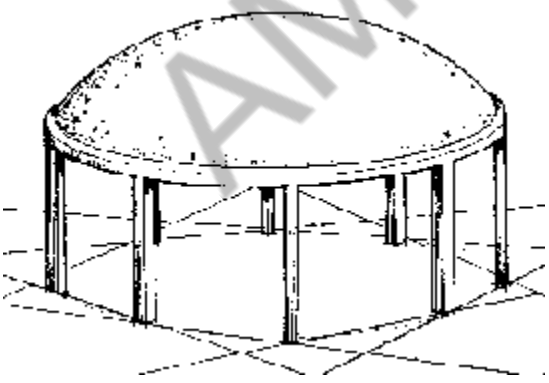
(1) The cylinder,

(2) The frame or ties at the ends, including the columns, and

(3) The side elements, which may be a cylindrical element, a folded plate element, columns, or all combined.

For the shell shown in the sketch, the end frame is solid and the side element is a vertical beam.

Domes



Domes are membrane structures, the internal stresses are tension and compression and are statically determinate if the proper edge conditions are fulfilled. In a dome of uniform

thickness, under its own weight, the ring stresses are compression until the angle to the vertical is about 57 degrees. If the dome is less than a full hemisphere, a ring is required at the base of the dome to contain the forces.

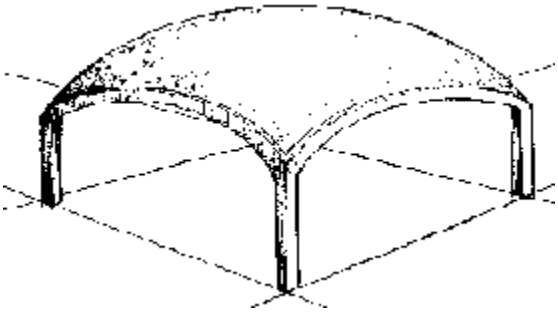
Advantages of Concrete Shells

Like the arch, the curved shapes often used for concrete shells are naturally strong structures, allowing wide areas to be spanned without the use of internal supports, giving an open, unobstructed interior. The use of concrete as a building material reduces both materials cost and a construction cost, as concrete is relatively inexpensive and easily cast into compound curves. The resulting structure may be immensely strong and safe; modern monolithic dome houses, for example, have resisted hurricanes and fires, and are widely considered to be strong enough to withstand even F5 tornadoes.

Disadvantages of Concrete Shells

Since concrete is porous material, concrete domes often have issues with sealing. If not treated, rainwater can seep through the roof and leak into the interior of the building. On the other hand, the seamless construction of concrete domes prevents air from escaping, and can lead to buildup of condensation on the inside of the shell. Shingling or sealants are common solutions to the problem of exterior moisture, and dehumidifiers or ventilation can address condensation.

Translation Shells



A translation shell is a dome set on four arches. The shape is different from a spherical dome and is generated by a vertical circle moving on another circle. All vertical slices have the same radius. It is easier to form than a spherical dome.

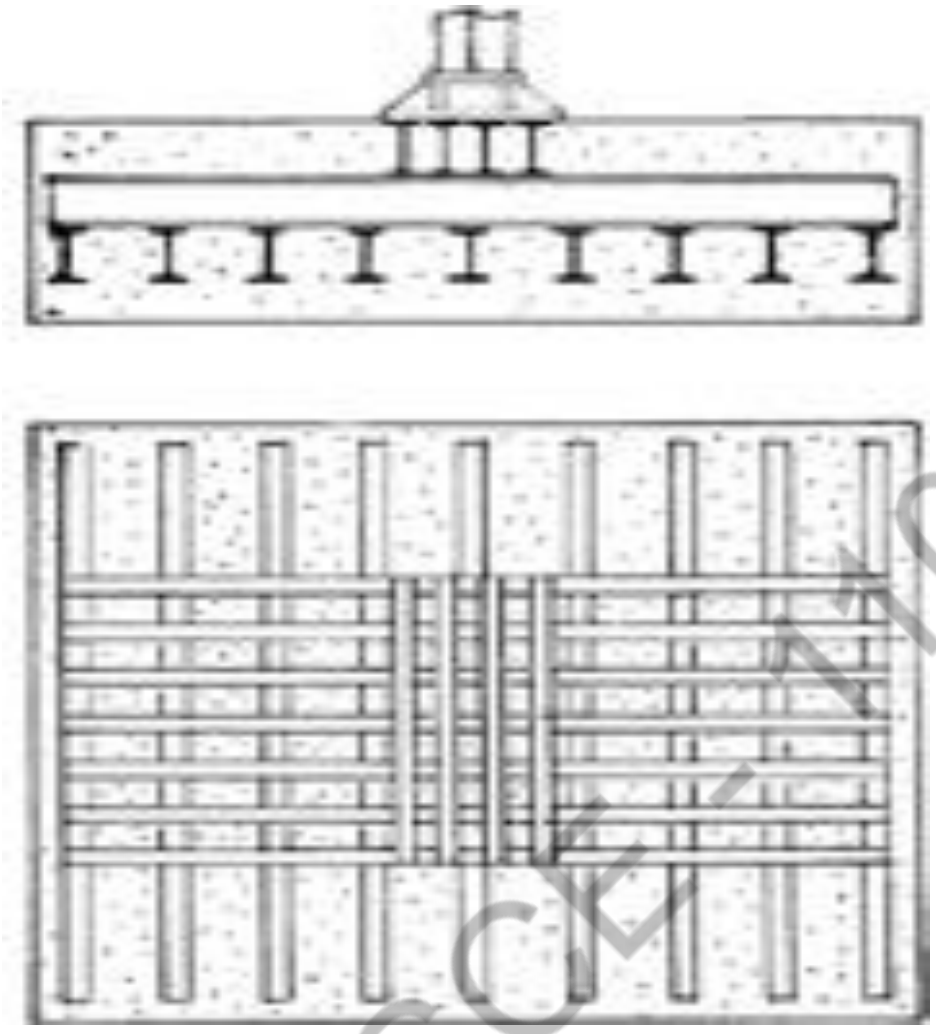
The stresses in a translation shell are much like a dome at the top, but at the level of the arches, tension forces are offset by compression in the arch. However there are high tension forces in the corner.

7. **Explain about support structure for heavy equipment and conveyors (Nov/Dec2016)**

Column Base

- Foundation is necessary for a column to distribute the column load on sufficient area of the soil so that the bearing capacity of the soil is not exceeded, it is also equally important that the column load be applied on sufficient area of the concrete foundation so that bearing strength of the concrete is not exceeded
- A steel base plate is therefore used to spread the column loaf on sufficient area of the concrete foundation
- Base plate used may be of following types
- Slab bases
- Gusseted bases

- Slab bases : In this case the column stands directly on the base plate the bearing end of the column is machined so that the column load is transferred to the slab base by bearing
- Gusseted base: Gusseted base plates are used in columns carrying heavy loads.
- In this case fastenings are used to connect the base plate and the column in the form of gusset plate, angles etc.,
- In case the end of the column is sufficiently machined so as to provide full bearing on the base plate, it is usual to assume that half the column load is liable to be transferred to the base plate through the fastenings and the balance load is transferred to the base plate by direct bearing.
- Suppose the ends of the column and gusset plates are not exactly faced for full or complete bearing. Then it is usual to design the fastenings to transmit all the forces to which the base is subjected.
- Grillage foundation: It is provided for a column carrying heavy load when it has to transfer its load to a soil of low bearing strength
- This foundation consists of two or more layers or tiers of steel beams, the layers being provide one above the other at right angles at each other .
- The beams are completely encased in well compared concrete.
- Generally only two tiers of beams are used
- The column rests on a base plate through which the load is transmitted to the upper tiers beams
- These beams in turn transfer the loads to the lower tier beams. From the lower tier beams the load will be transmitted to the soil.



8. **Explain about various types of domes (Nov/Dec 2017)**

Types of dome

Corbel dome

Dating back to Paleolithic construction, this is one of the earliest dome forms, also known as a 'beehive dome'. They are not domes in the strict sense, as they are formed by horizontal masonry layers that are slightly cantilevered until meeting in the centre.

Cloister vault

Cloister vaults, also known as dome vaults, maintain a polygonal shape in their horizontal cross-section. They arch towards the centre from a constant spring point along a wall.

Crossed-arch dome

This is one of the earliest type of ribbed vault where the ribs, instead of meeting in the dome's centre, are intertwined to form polygons, leaving an empty space in the centre. The earliest known example is in Spain's Great Mosque of Cordoba, dating back to the 10th century.

Geodesic dome

Geodesic domes are sphere-like structures consisting of a network of triangles which provide a self-balancing structural framework whilst using minimal materials. They were developed by the American engineer and architect Buckminster Fuller in the late 1940s.

Monolithic dome

This is a dome structure that is cast in a one-piece.

Onion dome

These domes are characterised by the way they bulge out beyond their base diameters and taper smoothly in an ogee (S-curve) profile. Their height usually exceeds their width and they are often gilded or brightly painted. These are traditionally associated with Russian architecture, in particular their multi-domed churches. For more information, see St. Basil's Cathedral.

Oval dome

An oval dome may be defined as a dome whose plan or profile (or both) has an oval form. The geometry is defined as using combinations of circular arcs that transition at tangential points.

Rotational dome

Also known as 'hemispherical domes', these are one half of a sphere, constructed on a circular ring beam.

Saucer dome

In terms of area these are often some of the largest domes, and are shallower in profile than other forms of dome.

Umbrella dome

Also known as a 'ribbed', 'parachute' or 'scalloped' dome. These are divided into curved segments that follow the elevation's curve. Radial lines of structure that act as the dome's 'ribs' extend down the springing from the apex.

Cable net dome

Whilst not conventional domes in that they are not compression structures, but tension structures, cable net structures can adopt an overall domed shape, albeit individual sections are generally flat or anticlastic in form (rather than the synclastic form of compression domes). The Millennium Dome in London is a cable net dome structure, and at 320m in diameter, is the largest dome in the world.

Inflated domes

Inflated structures are formed by pressurising a volume of air enclosed by a lightweight fabric membrane. Inflated structures can adopt a domed shape, and are typically used for spaces requiring a large enclosure uninterrupted by columns, such as radomes, warehouses, sporting facilities, stadia and so on.

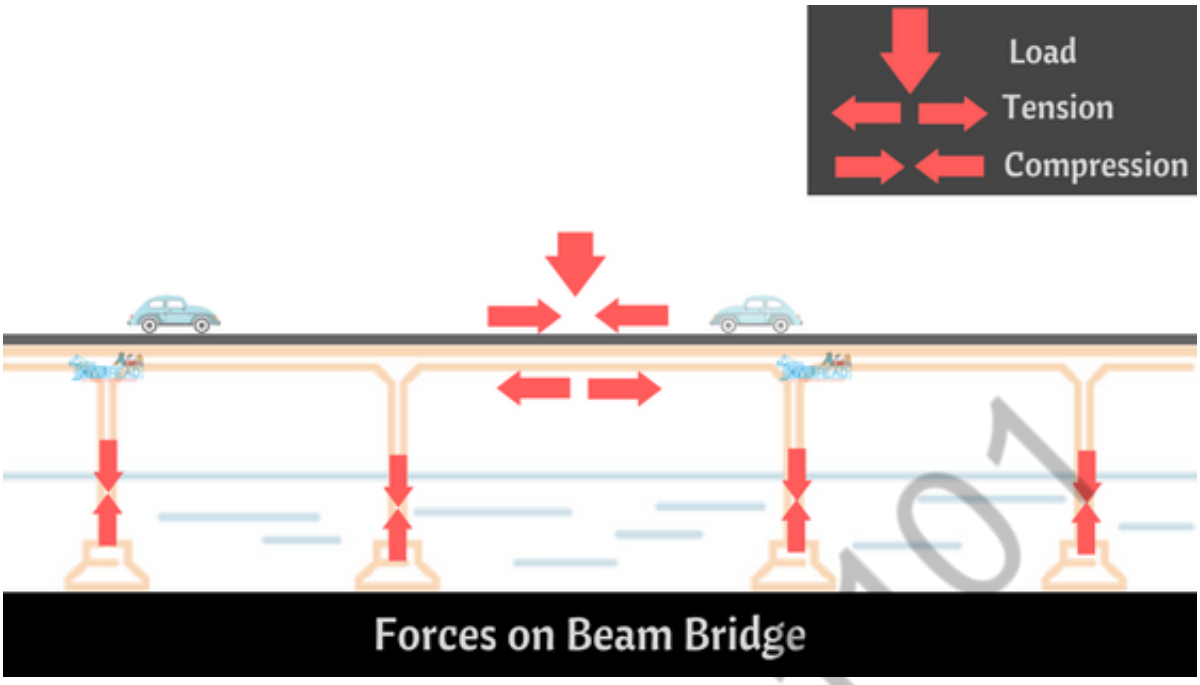
9. **Describe various types of bridge decks (Nov/Dec 2017)**

Beam bridge or Stringer Bridge or Girder bridge:

This type of bridges are simply supported bridges consisting of horizontal beams and vertical piers; Beam bridges are also named as **stringer bridge or girder bridge.** These type of bridges are typically spanned with two or more spans and supported by abutment or pier at each end. This type of bridges is constructed using RCC, Wood, steel etc. **Beam bridges have span less than 80m.**

As mentioned above, beam bridges are simply supported bridges (beam that is supported on piers), where the beam is laid across the supports. In this type of bridges, the beam should be strong enough to bear the loads on it. These loads are further carried to bridge supports and then to earth.

The top edge of the beam possesses compression as the loads are applied on it where the lower part of the beam is being stretched and is under tension.



Advantages of Beam bridge:

1.This type of beams are very easy to construct and erect.

2. This type of beams are good for short spans.

3. Wide distances can be spanned by resting beams on piers.

4. Ease in constructing temporary bridges.

Disadvantages of Beam bridge:

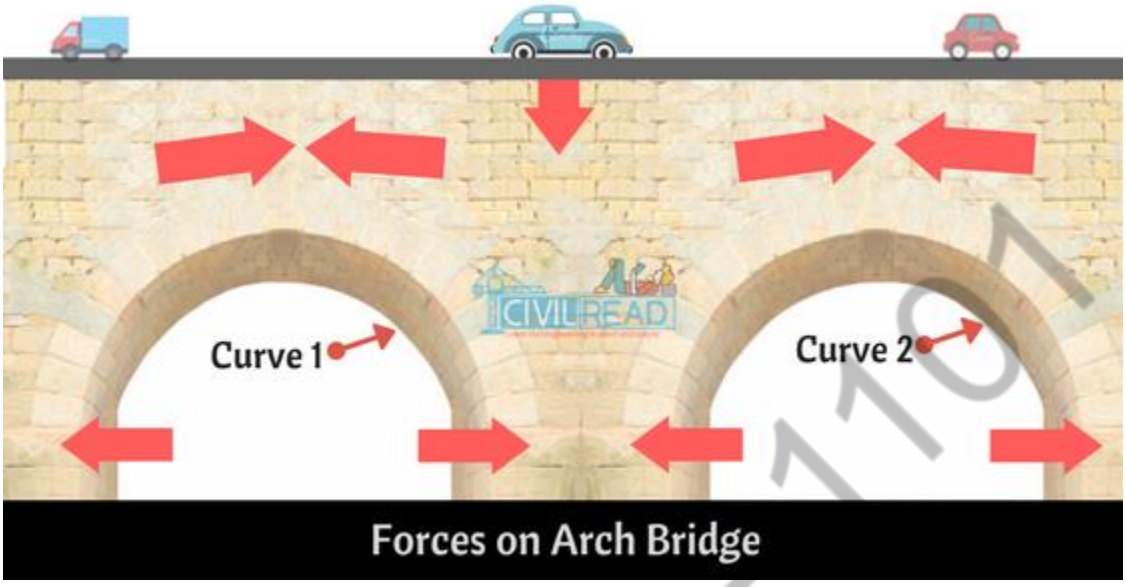
1. Can be expensive, requires RCC to built.

2. They are spanned by limits.

Arch bridge:

An arch bridge is the most popular type of bridge which is extensively used by ancient Romans.The arch bridge is usually made up of stone, concrete or steel. As the name itself mirroring that, the bridge is in the shape of an arch. An arch bridge is a curve shaped bridge where the load on the curve is not directly applied straight down, but instead, loads are carried along the curve of the arch to the end of supports. Meaning that no part of the bridge

takes a high amount of pressure. These supports are also called as abutments. Abutments carry loads of the entire bridge & it is responsible for holding the arch in a precise position.



The no. of curves (arches) in a bridge depends on stress and loads that bridge should support. **The span length of arch bridges is normally up to 250m**, and the roadway of the bridge lies on the arch structure.

Advantages of Arch Bridge:

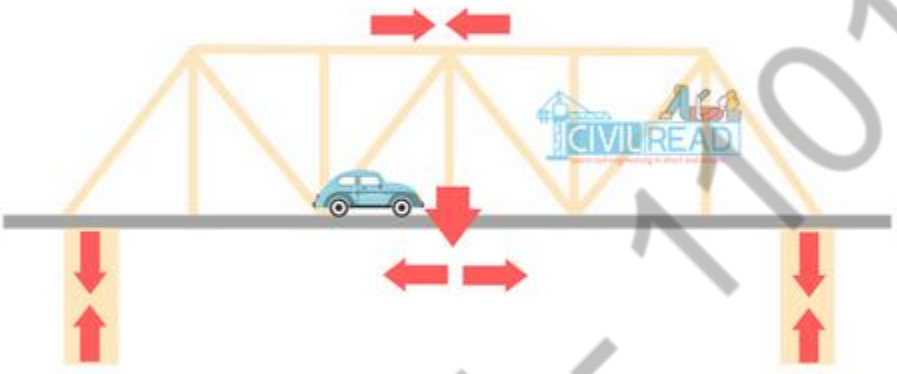
1. Easy to build with the locally available material.
2. These type of bridges are very rigid and extremely strong.
3. Arch bridges are built up with a variety of materials like stone, concrete, steel, etc.

Disadvantages of Arch bridge:

1. They take a long time to build.
2. It requires a massive amount of building materials to build.

Truss Bridge:

Truss is a framework consisting of struts (inclined members). These bridges are constructed by using trusses which are comprised of many small elements forming triangular trusses. **The span length of truss bridge is in between 50m-110m.**



Forces on Truss Bridge

Trusses are very rigid, lightweight and can support heavy loads. Trusses serve in transferring the load from a single point to the wider area. The weight of the bridge is very less when compared with other types.

When the load is applied to the truss bridge, the top edge possess compression and loads are shared among the angled members to supports and then to earth.

Advantages of Truss Bridge:

1. This type of bridge is easily built in the factory and then framed on site.
2. The piers or supports are comparatively less when compared to the beam bridge,
3. They are strong and rigid and very light on weight possess efficient use of materials.

Disadvantages of Truss Bridges:

1. Requires high skilled professionals to design it.
2. They are more complex than beam bridges in terms of designing.

Suspension bridges:

This type of bridges is constructed by suspending the **deck slab** using suspension cables. The roadway is hanged using steel cables which are connected to two towers and secured by anchors on both ends of the bridge.

In addition to the **deck slab,** the truss system is also featured with truss system just beneath the deck which helps to stiffen and to keeps the deck in precise position to reduce the tendency of the roadway to sway.

Forces on Suspension Bridge

When the load is applied to the suspension bridge, the deck slab possess compression and then travels up the ropes, cables or chains to transfer the compression to the towers. The towers then dissipate the compression directly into the earth by anchors.

The supporting cables which run parallel to the bridge possess tension forces, and these are connected to anchorages. Bridge anchorages are massive concrete blocks which serve in dissipating the tension force to the ground

Bridge anchorages are essentially solid rock or massive concrete blocks in which the bridge is grounded. Tensional force passes to the anchorages and into the ground. **The span length of Suspension bridge is in between 150m-2000m**

Advantages of Suspension bridge:

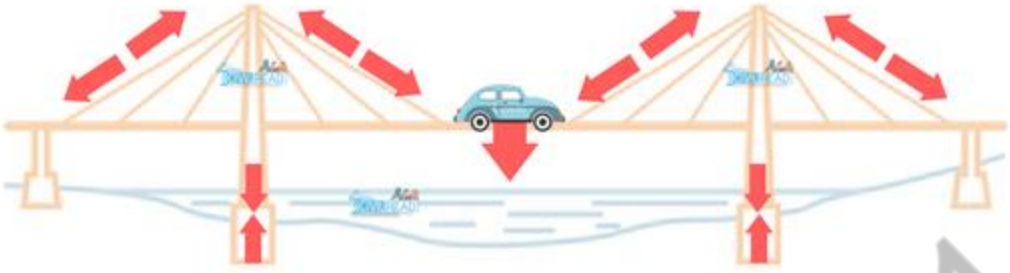
1. Strong and lightweight.
2. These type of bridges provide long span which helps in crossing the river.

Disadvantages of Suspension bridge:

1. Expensive to build.
2. Prone to sway and ripple with the wind, so this type of bridges are not suitable for railways.

Cable-stayed bridge:

This type of the bridge is modern bridges and it is similar to the suspension bridge. In this type, cables are connected directly to the tower instead of suspended cables. Tension is constantly acting on the cables, which are stretched because they are attached to the roadway. This type of bridge doesn't have any anchorages to bear the compression and has only one tower to carry the compression. **The span length of Cable stayed bridge is in between 500m-1000m.**



Forces on Cable Stayed Bridge

Cantilever bridge:

The word cantilever refers that the beam which has only one support and the other end is kept free in space. Cantilever bridges are same to this but don't think that one end of the bridge is kept free. Cantilever bridges are constructed in parts and the two free ends are connected with suspended deck. **Cantilever bridge has a span in between 150m-500m.**

Forces on Cantilever Bridge

10. Explain the process of installation of offshore platform (Nov/Dec 2018)

The 4 most common types of off-shore platforms

Environmental analyses apart, off-shore oil and gas platform are remarkable constructions. While to the non-expert eye all platforms may look the same, there in fact several different types.

Here you have the most common.

Shallow Water Complex

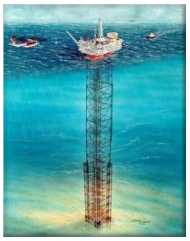
This type of platform is used in shallow waters (100-150 meters max), and it's composed of several single and independent but interconnected platforms, each one with different functions such as extraction and refining.

Gravity Base Complex

The foundation of these structures is made of huge concrete pillars, which lay on the bottom of the seavwithout being fixed. Once a suitable surface is found, gravity will provide stability, thanks to the sheer weight of the pillars.

Compliance Towers

These are truly majestic engineering works as they lay on a steel tower, which is attached to the sea floor, up to 900 meters deep. They're called compliant because they can sway and follow the motion of the ocean. They are suitable for areas subject to hurricanes, such as the Gulf of Mexico for example



For depths over 450 meters, the steel tower is usually supported by additional steel cables.

Floating platforms

There are three types of floating platforms.

Floating Production, Storage and Offloading (FPSO) platforms basically consist of boats of other types of floating platforms.

They're used to store and produce oil and natural gas, and to collect oil from other nearby platforms. They are ideal for those areas where it's impossible or inconvenient to build an oil or gas pipeline for fuel transportation.

The second type of floating off-shore oil platform is the Tension Leg Platform (TLP), whose stability is provided by cables tethered to the seafloor, which can be up to 2000 meters deep.

Finally, the third type is called SPAR, which lays on a floating cylinder which is also it's also tethered to the bottom with cables. Depth can go from 300 to 3000 meters.

Over the years, Cividac deigned several components for off-shore oil and gas platforms. Designing such equipment has to take into account the very limited availability of space, which makes this type of project quite challenging.

Dome construction, an integral part of ancient and religious buildings, is now used even in constructing home residences. So how are these domes built? Find out about the various techniques that are used for constructing this amazing and beneficial design.

Advantageous characteristic of withstanding adverse climatic conditions such as earthquakes, tornadoes, floods, hurricanes and tropical storms. Earlier domes were used only in religious buildings, but more recently they have been found in residential buildings as well. Houses with domes are usually found in regions that experience heavy winds and extreme climatic conditions. The trend can also be seen in public structures such as schools and colleges

Basic Construction

The dome is a structurally sound design. These days they often made of concrete and reinforced by steel. The main advantage of this style of design is that it is heavier in weight, making it difficult to lift it off its base. Moreover, besides the weight of steel and concrete, the shape of the dome itself makes it a very solid structure. According to architects, the arches of the dome are naturally strong and are hardly influenced by extreme external forces like tornadoes. Also with no flat walls, these kinds of structures have very few seams, leading to less penetration of water in the construction especially during tropical storms. Moreover, using archways as gates on either side of the building can also help water to run straight off without causing any lasting damage.

11. Explain the modern construction technique for cast in situ, box girder and multi-span concrete bridge (Nov/Dec 2018)

Box girder bridges may be cast in place using false work supports, removed after completion, or in sections in case of a segmental bridge. It may also be prefabricated in a fabrication yard, then transported and installed using cranes.

Another method of box girder bridge construction is the incremental launching. Under this method, gantry cranes are often used to place new segments onto the completed portions of the bridge until the bridge superstructure is completed.

Fig. 1: Cantilever Construction Method for Box Girder Bridge

Fig. 2: Incremental Lunching Box Girder Construction Method

Specifications

1. It can cover a range of spans from 25m up to the largest non-suspended concrete decks built; of the order of 300m.
2. Single box girders may also carry decks up to 30m wide.
3. For the longer span beams, beyond about 50m, they are practically the only feasible deck section.

4. Below 30m precast beams or voided slab decks are more suitable while above 50m a single cell box arrangement is usually more economical.
5. Single cell box girder cast-in-situ are used for spans from 40m to 270m.
6. The box arrangement is done in order to give aesthetic appearance where the web of the box would act as a slender appearance when combined with a slim parapet profile.
7. Single box arrangements are effective for both the longitudinal and transverse designs, and they produce an economical solution for medium and long span structures.
8. Single box deck is constructed span-by-span, using full-height scaffolding or trusses, or as balanced cantilever using form travelers. This could be particularly important for medium length bridges with spans between 40m and 55m.

Applications

1. It is used for modern elevated structures of light rail transport.
2. Box girders are used for the construction of a cable-supported bridge, curved bridge, and footbridges.
3. It is rarely used in buildings, but they may be used in special circumstances, such as when loads are carried eccentrically to the beam axis.

Different Cast-in-situ methods

The construction of a bridge can be done by the following methods. Each of the following methods can be implemented in different ways. But here we are discussing about the implementation of following methods with cast-in-situ techniques.

1. Incremental launching method
2. Balanced cantilever method
3. Cast-in-Situ Post tensioned method

1.Incremental Launching Method

Incremental launching method is the one in which cast in situ technique is adopted. It is highly mechanized method which saves time and budget. It is generally preferred for the construction of multi span post tensioned bridges.

In this method, bridge piers are built first in required alignment. Then the superstructure part to be built is dived into number of sections. Now an area behind the one of those abutments is selected. In this stationary area, a setup is made to cast the one section of bridge superstructure.

After the casting of one section, it is pushed along the bridge axis using jack system or friction launching system which is arranged prior to the casting of structures. Similarly, all the sections are casted in site and moved forward along the bridge alignment.

Fig 1: Incremental Launching Method of Bridge Construction

To lower the bending moment or cantilever moments in the super structure while moving, a launching nose made of steel trusses is attached to the front of bridge deck. The alignment of

bridge should studied carefully. It should be straight or if it involves curves, then the curvature must be constant.

The presence of casting bed is on the ground which is easily reachable so, this method provides better safety as well as reduces the cost of transporting and lifting. High quality finish can be obtained since the work is done on the good casting platform.

Fig 2: Bridge Constructed Using Cast-in-situ Incremental Launch Method

2. Balanced Cantilever method

Balanced cantilever method is the advanced method of all construction techniques since it does not require any temporary structures for support. The bridges of greater heights can also be built using balanced cantilever method without false work.

Cast- in –place technique for balanced cantilever method of bridge construction is preferred when the bridge is long and contains irregular span lengths. When there are irregular span lengths then the depth of girder will vary for each span length. The molding of girders of varying depth in different depth molds is uneconomical. Hence, cast-in-situ method is preferred for this situation.

At first piers are constructed which are fixed positions for cantilever part. From fixed point, cantilever part is constructed without any temporary support using staged cast-in-situ construction. This is done on both sides of the piers so, it is called balanced cantilever method of construction.

Fig 3: Cast-in-situ Balanced Cantilever Method of Construction

4. **Cast-in-Situ Post Tensioned Method**

Cat-in-situ Post tensioning method of bridge construction is more demanding method because of its durability and applicability to complex bridge curves etc. In this method along with concrete and reinforcement, steel strands or tendons are also used to introduce post tensioning.

When the formwork is prepared, strands are arranged with in the reinforcement and concrete is filled. After the hardening of concrete, the strands which have been passed through the concrete are pulled by the jack up to certain tensile force which was pre-determined. Now, the steel stands should be locked.

This type of construction increases the load carrying capacity of bridge and improves the durability of bridge. Post tensioning eliminates the use of intermediate supports for long span bridges.

Fig 4: Arrangement of Tendons Before Concrete Filling In Post Tensioning Method of Bridge Construction

Advantages of Cast-in-Situ Construction Methods

- This method does not require any heavy lifting equipment or transporting equipment since the casting of super structure is done in the required position.
- The superstructure is safe from transportation and lifting damages.
- It is the best method to construct a bridge in Inaccessible areas.
- This method is used for Cost effective construction of solid, voided or ribbed reinforced concrete slab bridges.

Fig 5: Cast-in-situ Concrete Filling

Disadvantages of Cast-in-Situ Construction Methods

- It is time consuming as compared to precast construction methods.
- If the bridge is constructing over water bodies, severe damage may occur to the unset concrete during flood conditions.
- This method requires large number of workers and requires skilled suprvision.

Multi span concrete bridge

The span-by-span method is used for multi-span viaducts, where the individual span can be up to 60m.

These bridges are usually constructed in-situ with the falsework moved forward span by span, but can be built of precast sections, put together as single spans and dropped into place, span by span.

12. What is sheet pile? List the factors for selection of sheet pile ? Explain its types (April/May 2019)

Sheet Piling is used to provide temporary and permanent walls in the construction industry. Sheet piling is used as excavation support and for soil retention. It creates a border which keeps the soil back, away from the structure.

Sheet piles are designed to interlock with each other. They are installed in sequence along the planned excavation perimeter. When arranged together, they form a wall for permanent or temporary earth support, along with anchors to provide extra lateral support.

Permanent sheet piles are designed to provide a long service life; installed with the help of vibratory hammers. If the soil is too dense or hard, impact hammers are used. Depending on the condition of the site, the sheet piles can be hydraulically pushed into the ground.

They can be made of recycled steel, and can be reused for other purposes; making them a sustainable option.

Usually, the material used to make piling sheets is steel, but wood and vinyl sheets are also used at times. The concept is to design narrow, interlocking sheets that can be connected and driven into the ground to form a wall. Stability and strength are defined by the shape and material of the sheets. Steel is considered to be the most appropriate material if the requirement is to withstand large bending forces and pressure.

Uses of sheet piling

- When construction is taking place in a confined space, then temporary walls are used to prevent cave-ins; offering protection to the workers working in the vicinity of the area.
- In a home environment, sheet piling is used as permanent walls as they provide stability and durability to the interior walls (especially basement walls).
- Pilling is also used to prevent floods to structures close to shorelines.
- To protect foundations from water damage.
- To support excavations for parking structures, basements, foundations, pump houses, and to construct cofferdams, seawalls and bulkheads.

Types of sheet piling

Anchored sheet piles

Anchoring the sheet piles causes less penetration, which is economical when the height is less than 6m. This is because the anchor walls are pre-stressed to remove the slack from the system. It remains as it is until creep occurs. Anchor walls provide better back-slope subsidence because they undergo less lateral deflection. There are two major reasons for subsidence:

- If the anchor holes cave before grouting.

- If the cohesion material flows into the excavation through the opening which was earlier made for anchor installation.

The anchors create a large gravity wall by holding the soil mass between the anchors and the wall in compression.

Cantilever sheet piles

These are usually used for heights of 6m or less. In geotechnical practices, cantilever embedded retaining structures are used as sheet walls for temporary retaining structures and diaphragms & pile walls as permanent retaining structures.

Cofferdams

When a bridge is being built, cofferdams can be used as a temporary structure designed to keep soil and water out of the excavation. It provides a dry work environment underwater by sealing the structure with concrete to prevent water from seeping in.

Advantages of sheet piling

- It is light in weight, making it easy to lift and handle.
- It is recyclable and reusable.
- The pile length and design are easily adaptable.
- Joints are designed to withstand the high-pressure required to drive them into place.
- It requires only a little maintenance above and underwater.

Disadvantages

- If the soil is rocky or has large boulders, it becomes difficult to installs sheets into it.
- If you are going to use vibratory hammers or impact hammers to install the sheets into the ground, this can cause neighborhood disturbance.
- Most of the sheets are used as temporary structures. After the project is completed, the sheets are removed, which can be costly.

Construction steps

- Arrange the sheets in sections to check if the piles will interlock correctly or not.
- Hammer the first sheet to the defined depth as per the design.
- Use vibratory hammers for installation, but use impact hammers if the soil is hard or dense.
- Use hydraulics to push the sheets into place if vibrations are prohibited at that particular site.
- After the first sheet is placed, drive the second sheet so that it interlocks with the first one.
- Repeat the process until the wall is completed.
- Use connector elements to maintain the integrity of the wall if it requires complex shapes.