TVET CERTIFICATE IV in ROAD CONSTRUCTION

SUSPENDED BRIDGE CONSTRUCTION

RCTSB401

Perform suspended bridge construction

Competence

Learning hours: 90

Credits: 9

Sector: Construction and Building Services

Sub-sector: Road construction

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Purpose statement

This is a core module which describes the performance outcomes, skills knowledge and attitude required to perform suspended bridge construction, the design of modern suspension bridges allows them to cover longer distances than other types of bridges. The main element of a cable suspended bridge is the cable system; bridges are normally designed for dead load, live load and other occasional loads.

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Learning Unit 1 – Excavate for Foundation

1. Introduction to suspension bridge

A suspension bridge is a type of bridge in which the deck (the load-bearing portion) is hung belowsuspension cables on vertical suspenders. The design of modern suspension bridges allows them to cover longerdistances than other types of bridges. The main element of a cable suspended bridge is the cable system. Bridges are normally designed for dead load, live load and other occasional loads.

Suspended bridge manages the required load successfully dealing with two important forces called compression and tension. Compression isa force that acts to compress or shorten the thing it is acting on. Compression and tension are present in all bridges,and it's the activities of the bridge design and construct to handlethese forces without buckling or snapping.

Basic Components and Parts of suspended bridge Structures

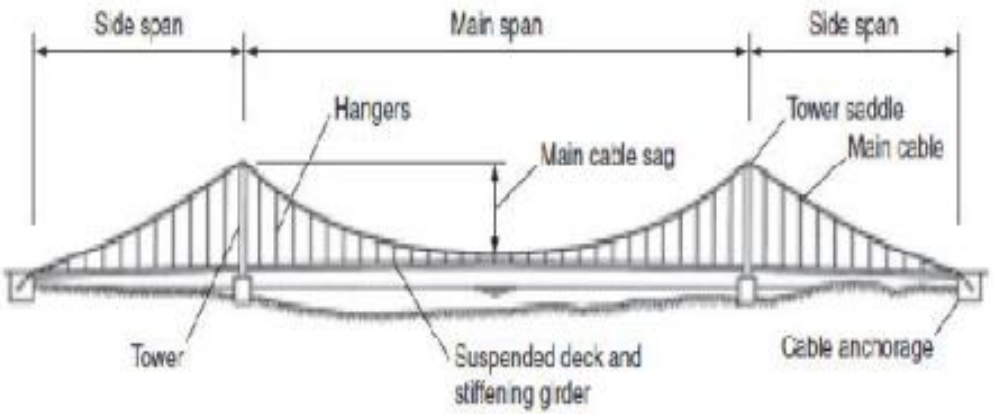


Fig. Main components of suspended bridge

LO 1.1 – PREPARE MATERIALS, TOOLS, EQUIPMENT AND WORKPLACE

Topic: Description ofthe elements of foundation for suspendedbridge

1.1.1. Identification of suspendedbridgefoundation elements

A.Pile

Pile foundations are deep foundations. They are formed by long, slender, columnar elements typically made from steel for suspended bridge. A foundation is described as 'piled' when its depth is more than three times its breadth.

A reinforced concrete slab or block which interconnects a group of piles and acts as a medium to transmit the load from wall or column to the Piles is called a Pile Cap. The capping beam should be kept clear of the ground where the purpose of the piles is to overcome the problem of the subsoil swell and shrinkage.

B.Pier

The piers are vertical structures used to support deck or the bearings provided for load transmission to underground soil through foundation. These structures serve as supports for the bridge spans at intermediate points.

The pier structure has mainly two functions:

- Load transmission to the Foundation
- Resistance to the horizontal forces

Most of the cases, piers are designed to resist the vertical loads alone. In areas which lie in the seismic zone, it is recommended to design the pier for lateral loads also.

Most of the piers are constructed using concrete. Steel for the construction of pier is used in very few cases till now. Use of composite columns i.e. steel columns filled with concrete is used as new technology of pier construction.

The pier is a vertical member that resist the forces by means of shear mechanism. These forces are mainly lateral forces. The pier that consist of multiple columns are called as bent.

Types of Piers in Bridge Construction

There are different types of piers based on the structural connectivity, the shape of the section and the framing configuration.

- Based on the structural connectivity, the pier can be classified as monolithic or cantilevered.
- Based on the shape of the section pier can be classified as solid or hollow, hexagonal, round or octagonal or rectangular.

- Based on the framing configuration the pier can be classified as single or multiple column bent, hammerhead or pier wall type.

C.Abutments

Abutments are vertical structures used to retain the earth behind the structure. The dead and the live loads from the bridge superstructure is supported by the bridge abutments.

The abutments are also subjected to lateral pressures mainly from the approach embankment. The design loads on the abutment is mainly dependent on the:

- Type of abutment selected
- The sequence of construction

Fig. bridge abutment

As seen from the above figure, the abutments have the design requirements similar to retaining walls as well as in pier construction. The abutments are primarily designed to resists the overturning and sliding. More focus is on the stability of the whole system.

The special care has to be provided for the foundations of abutments. The abutment foundation must overcome the problems of differential settlement and excessive movements caused due to lateral forces or loads.

The below figure shows the components of abutments.

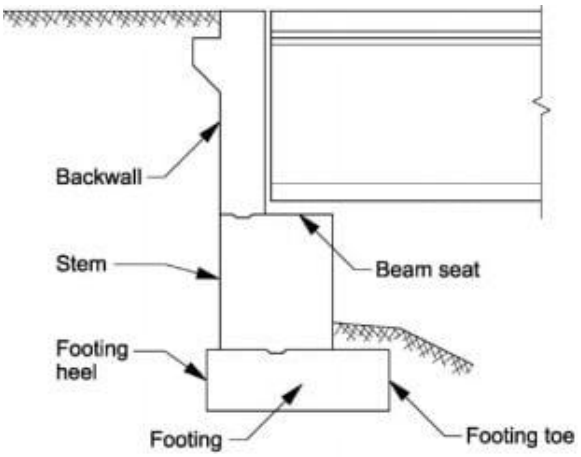


Fig. components of suspended bridge

D.Pile cap

A reinforced concrete slab or block which interconnects a group of piles and acts as a medium to transmit the load from wall or column to the Piles is called a Pile Cap.

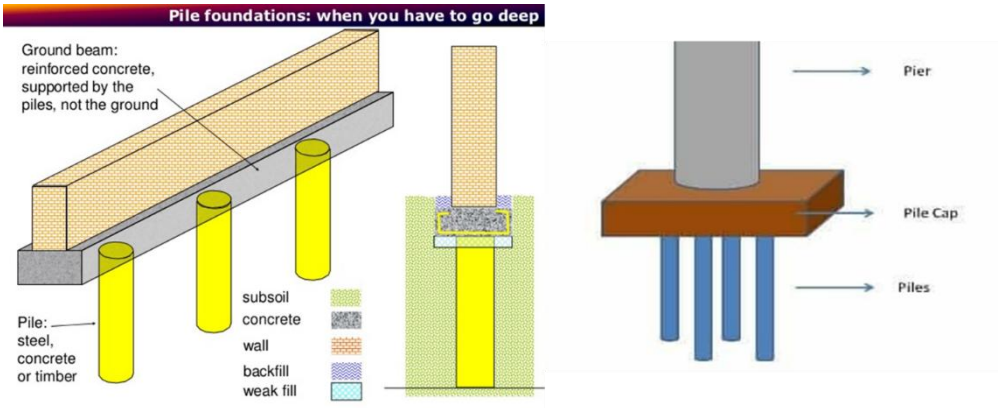


Fig. pile cap of bridge

1.1.2. Materials used in excavation of suspended bridge foundation

1. Caisson/formwork

A caisson is a watertight retaining structure used, for example, to work on the foundations of a bridge pier, for the construction of a concrete dam. These are constructed such that the water can be pumped out, keeping the working environment dry.

Formwork is the term used for the process of creating a temporary watertight mould into which concrete is poured and formed. Traditional formwork is fabricated using timber, but it can also be constructed from steel, glass fibre reinforced plastics and other materials.

Fig. bridge formwork

Installation

To install a caisson in place, it is brought down through soft mud until a suitable foundation material is encountered. While bedrock is preferred, a stable, hard mud is sometimes used when bedrock is too deep.

Requirements of good caisson /formwork

- The following requirements should be satisfied by good formwork:
- Strong enough to withstand dead and live loads.
- Capable of retaining its shape by being efficiently propped and braced horizontally and vertically.
- Joints should prevent leakage of cement grout.
- Should be capable of being removed in various parts without damaging the concrete.
- Material used to be suitable for reuse.
- Should be set accurately to the desired line.
- As lightweight as possible.

2. Pegs

Is the cylindrical wooden,metal or other object used to in the setting out of suspended bridge,peg moved on a crib board for facilitate the required set out.Peg mark out boundaries of suspended bridge and position of a site.

Pegging:Is the process of driving or inserting pegs into the ground while setting out

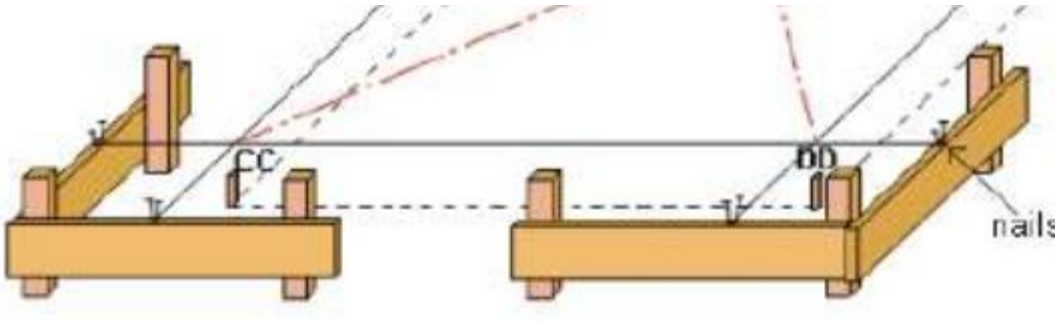


Fig. pegs

3. **Building line**
   Is the masons line used in construction works especially in set out of suspended bridge usually set with the respect to the frontage of plot of the bridge which is fixed on pegs for ensuring the trench of bridge to be excavated.

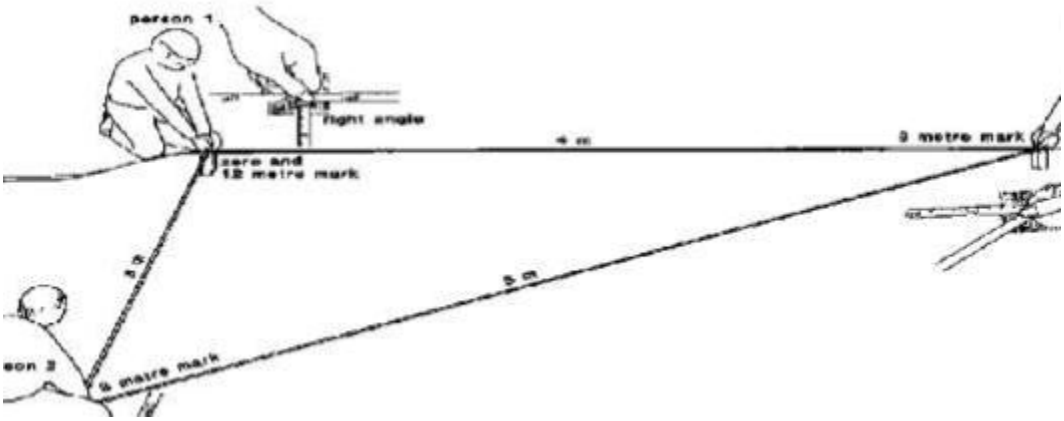


Fig. building lines

4.Nails

Is the slender metal shaft that is pointed at one end and flattened at the other end ,nails are commonly used to fasten pieces of wood together and are used to fix the pegs and boards of suspended bridge during bridge foundation excavation. There are different sizes of nails such as 5mm,6mm,7mm,8mm,12mm,15mm,….

1.1.3. Equipmentused in excavation of foundation

- **Excavator machines:**hydraulic excavators are widely used in earthmoving or digging the foundations for bridge.

Following are the equipment that can be used for various types of work.
✓ A bulldozer can quickly push the topsoil
✓ A back actor is used for digging pits for column or piers

✓ A mechanical auger is used for digging holes for piles
✓ Tipper truck for transporting large amount of soil
✓ Dump truck for transporting small quantity of soil at a short distance
✓ Draglines for digging deep foundations
✓Face shovel: for pushing the soil forward
✓ Pneumatic drill for drilling into solid rock

Fig. Excavator machine

Compaction machines: Soil can be compacted by using high frequency plate vibrators. Plate reduces the friction between the particles and set the motion of particles. As a result, entrapped air is removed and the soil is compacted. The use of compaction machine reduces the compaction time.The machine used to compact the soil is roller, to expel air from a soil mass and so achieve a high density. Smooth-wheel rollers are best for gravels, sands, and gravels-and-clay soils with reasonably high moisture contents. The method of compaction is primarily of four types such as kneading, static, dynamic or impact and vibratory compaction.

Fig. compact machine

1.1.5. Types of toolsused in excavation of foundation

a) **Cutting tools:**It is a sharp edged wedged small machine or device used to remove or cut excess materials like to reduce metal dimensions during excavation of metal bridge.Cutting tool or cutter is any tool that is used to remove material from the wall or road by means of shear deformation
Example: hack saw.

b) **excavating tools**:Are tools or small machine used to dig the earth during excavation of foundation.
Example:hoe

1.1.6. Preparation of workplace step

1.Demarcation of work area: Thisthe act of establishing limits or boundaries of working place.

2.Addressing of obstacles: Giving a full information about what happen.

3.Positioning signs for safety measures

The use of symbols and graphical images is a simple safety system used to convey safety messages at a glance.

Colours and symbols appropriately used can provide information and warnings of hazards which are essential to safety at work, and in some instances may be independent of language.

4.Site installation: is the process of interpreting construction plans and marking thelocation of proposed new structures such as roads or buildings. Construction staking is performed to

ensure a project is built according to engineering design plans

Why is a site layout important?

Site layout and organization are important management functions which influence all aspects of work on a construction site - from construction methods and sequence to health, safety, and productivity.

LO 1.2 – SET OUT FOUNDATION

Topic: Interpretation of drawingand theset out offoundation for suspended bridge

1.2.1 Set out foundation

It is the process of developing the physical positions of corners and walls (abutment, pier) of a bridge, and it's done by transferring dimensions from the layout plan (also called as setting out plan, demarcation plan) to the ground.

It is a process of transferring the distance from the plan already prepared, to the ground before starting the construction. The plan as designed and prepared is set out on the ground in the correct position.

1.2.2. Interpretation of drawing

Interpretation in drawing is bending some of the rules, once you know them, to fit your own artistic style.

A.Dimensioning

A DIMENSION is a numerical value expressed in appropriate units of measurement and used to define the size, location, orientation, form or other geometric characteristics of a part.

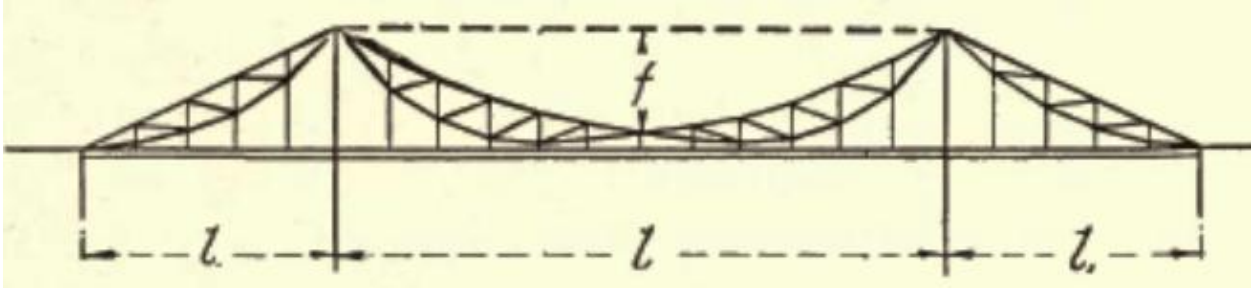


Fig. bridge dimensioning

B.Views

This is an overall elevation view showing the general appearance, grade and type of structure to be built. Number spans and bents to agree with the plan view.

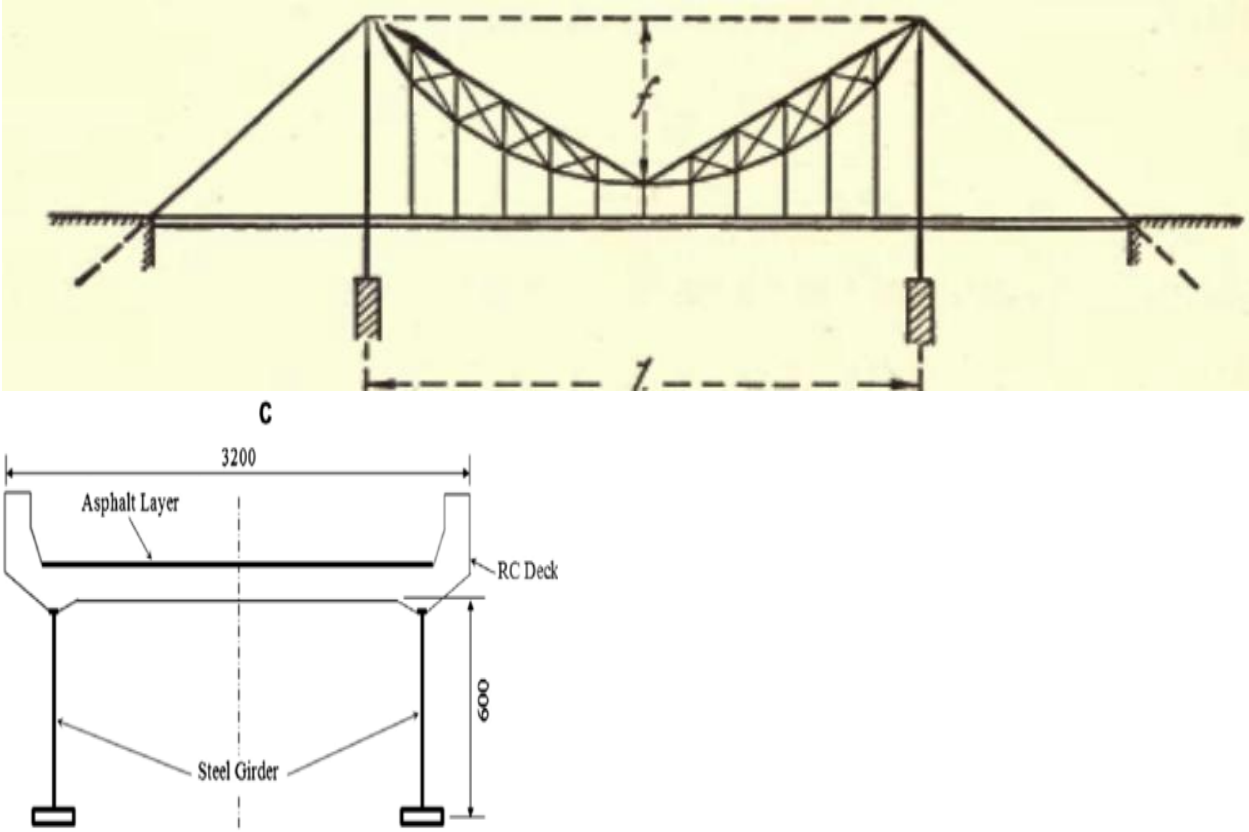


Fig. side view of bridge

C.Section

A “Typical Deck Section” is a transverse cross -section of the superstructure showing the deck, girders, curbs and railing or parapets, if any. Required dimensions include the out-out width of the structure, roadway width, girder spacing, the location of these with respect to the designated alignment centreline and the deck thickness, reinforcement bends and bar spacing and clearances.

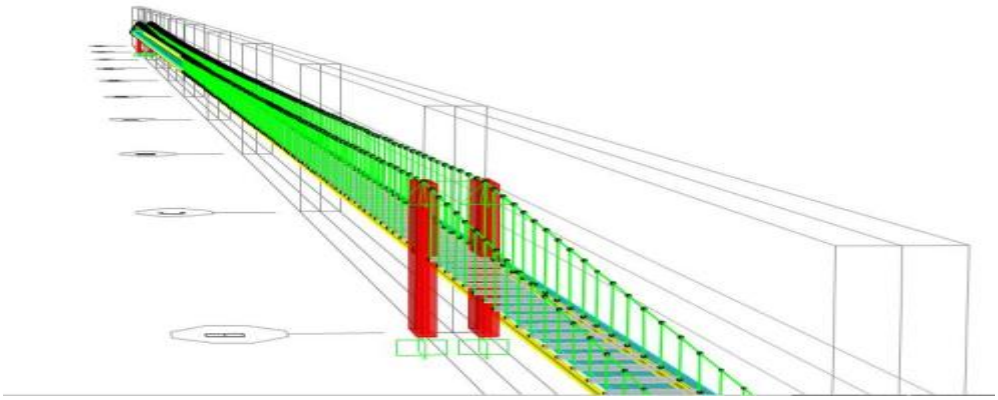


Fig. section of suspended bridge

D.Verification

- ❖ The functioning of the structure or structural members under normal use.
- ❖ The comfort of people.
- ❖ The “appearance” of the construction work. This is related with such criteria as high
- ❖ Deflections and extensive cracking, rather than aesthetics.
- ❖ Stress limitation,
- ❖ Deformations: deflections and vibrations

1.2.3. Setting out of the site datum

Datum is an abstract coordinate system with a reference surface (such as sea level) that serves to provide known locations to begin surveys and create maps. In this way, datum act similar to starting points when you give someone direction.

The Datum used to establish the elevations shown on the drawing should be indicated.

1.2.3. Marking of the profile positions

The profiles are positioned well away from the proposed excavations to allow an adequate working space. This is even more important when the excavations are to be carried out by a mechanical means. While setting up profiles, it is essential that they are as level as possible. This avoids inaccuracies when re measuring the walls and diagonals before commencing work.

Procedures to consider while marking the dimension on the ground

- ♦ checking Measurements
- ♦ marking the position of pegs
- ♦ Fixing of the pegs
- ♦ Fixing profile board
- ♦ Fixing of building line

The following points should be observed while setting out trenches:

1. In order to set out foundation plan, nails, pegs, profiles, strings, and lime are used.
2. In order to correctly determine the position of trenches, the sight rails have to be properly erected at the corners of the building.
3. Accurate center lines or axial lines can be determined and marked by using a theodolite.
4. To the nails or pegs on the profiles, strings are tied and stretched to achieve horizontal control of dimensions.
5. At a distance of 1 meter from the edges of excavation vertical reference pillars are erected. Hence vertical control is achieved during building construction.

6. A standard datum is previously determined and marked by the surveyor, based on which the levels on the site are obtained. The depth of trenches and other levels should also be regulated by measurements from this point.
7. Before placing the concrete into the trenches, the bottom must be properly rammed and compact.
8. The width is marked by means of lime powder when the excavation is performed by hand. These markings give accurate cutting.
9. Centreline is marked when the excavations are performed by a machine

LO 1.3 – EXCAVATE FOR FOUNDATION

Topic: Description the excavation method for suspended bridge

In the suspended bridge construction, excavation consists of using tools, equipment, or explosives for the purposes of moving soil, rocks, or other materials.

Excavation is undertaken for a number of purposes, and different types of excavation are classified either by their specific purpose or the type of material being excavated.

Below are twelve common types of excavation, by both type and material.

Bridge, Borrow, Channel, Drainage/Structure, Dredge, Earth, Footing, Muck, Roadway, Rock, Topsoil, Underground.

1.3.1. Earth Excavation Method

1. **Manual**

In construction terms, excavation is the process of removing earth to form a cavity in the ground. On small sites or in confined spaces, excavation may be carried out by manual means using tools such as: **Warning tape, Tape measure, Pickaxe, Hoe, Fork hoe, Hummer, Spade, Levels, Pang, Axes**

2. **Mechanical**

Through this Excavation is done by using mechanical equipment such as: **Jack hummer, Boring machine, Excavator machine, Compactor machine, Backhoe and Wheel loader**

L.O 1.4 – INSTALL GROUND SUPPORT

Topic: Description of the installation of ground support for suspended bridge

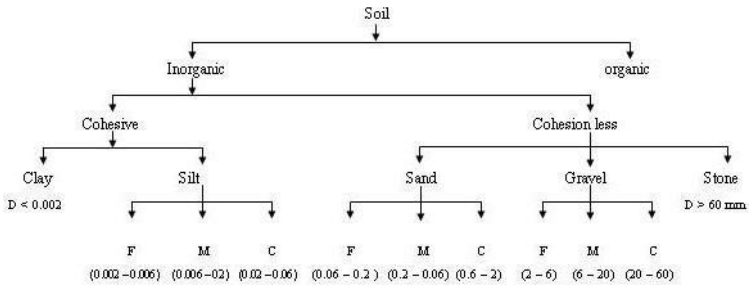
1.4.1. Requirements of soil protection:

a. Cohesive soil

Cohesion as the word itself denotes, is the attraction between particles of same type/origin/nature. Hence cohesive soil is a type of soil where there is inter-particular attraction. Clay is a very good example for a cohesive soil.

b. Non cohesive soil

Non-cohesive soil as the name indicates do not have cohesive forces. They are comparatively coarser particles with self-weight governing their behaviour. The particles have internal friction and their shear strength depends upon the angle of internal friction between particles. Sand is a typical example. Exclusively non-cohesive soils will have zero cohesion.



The size of particles in mm
Fig. (1) : Classification of Soil

c. Slope of existing soil

The slope of the soil is an important soil property to consider when building or planting. The slope gradient is the angle of incline or decline, expressed in the percent of rise or fall of the soil surface from horizontal over a distance of 100feet. Soil slope affects the flow of water that can erode the soil.

1.4.2. Protection of wall

What is retaining wall and types? A retaining wall is a structure designed and constructed to resist the lateral pressure of soil, when there is a desired change in ground elevation that exceeds the angle of repose of the soil. A basement wall is thus one kind of retaining wall.

A retaining wall is a structure that holds or retains soil behind it. There are many types of materials that can be used to create retaining walls like concrete blocks, poured concrete, treated timbers, rocks or boulders.

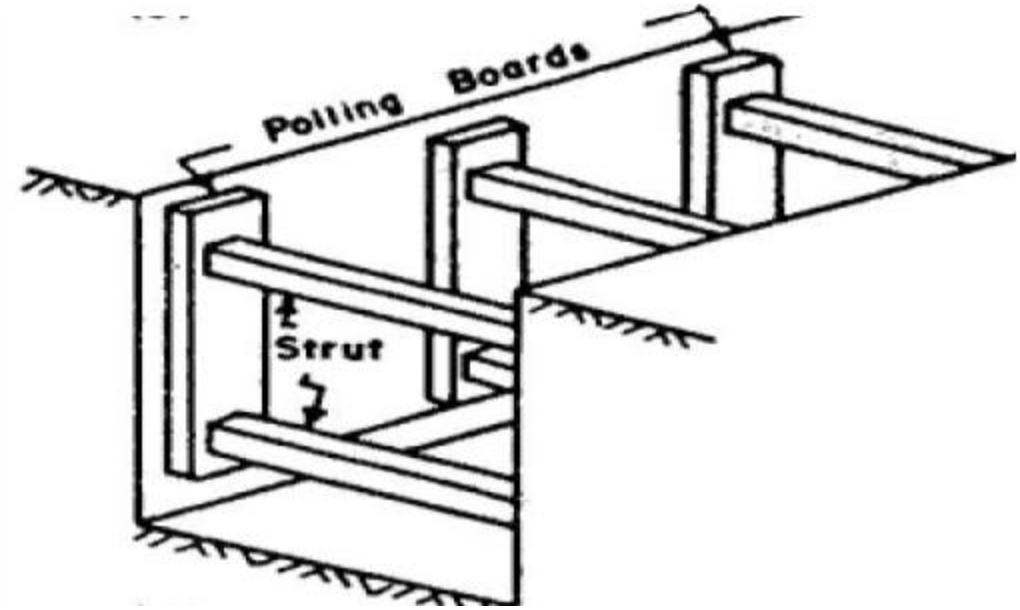


Fig. wall protection by using wood

Timbering: Supporting the sides of an excavation, When the depth of trench is large, or when the sub-soil is loose, the sides of the trench may cavein.The problem can be solved by adopting a suitable method of timbering. Timbering of trenches, Sometimes also known as shoring consists of providing timber planks or boards and struts to give temporary support to the sides of the trench.

1.4.3. Classification of ground supports:

- **Temporary support:** this is used to provide a short-term support only during construction and removed at the completion of the structure.

Fig. shuttering support

- **Permanent support:** this is used to provide a long-term support not only during construction but also during service life of the structure.

Fig. permanent support

LEARNING UNIT 2 –CONSTRUCT FOR FOUNDATION

LO 2.1 – PREPARE MATERIALS, TOOLS, EQUIPMENT AND WORKPLACE

Topic : Explanation of materials,tools and equipment used in construction of suspended bridge

2.1.1. Materials used in construction of suspended bridge foundation

1. **Cement:** is a binder, a substance that sets and hardens independently, and can bind other materials together**.Cement used in bridge construction is characterized as hydraulic or non-hydraulic.**
   - **Hydraulic cements** (e.g.,Portland cement) harden because of hydration, chemical reactions that occur independently of the mixture's water content; they can harden even underwater or when constantly exposed to wet weather.
   - **Non-hydrauliccements** (e.g.gypsumplaster) must be kept dry in order to retain their strength**.**
2. **Sand:**Is the fine aggregates generally consist of natural sand or crushed stone with most particles smaller than 4.75mm in diameter. The material, most of when passes through 4.75mm I.S. sieve size, is termed as fine aggregates.
3. **Aggregates:**Are the construction materials include sand and gravels make up from 60 to 80 percent of concrete volume.
   Aggregates are of two basic types:
   Coarse aggregates: crushed rock, gravel or screenings.
   Fine aggregates: fine and coarse sands and crusher fines.Sand should be concreting sand and not bricks sand or plasterer's sand.
4. **Water**: is mixed with the cement powder to form a paste which holds the aggregates together like glue. Water has two functions in the concrete mix, to effect hydration and to improve workability. Water must be clean, fresh and free from any dirt, unwanted chemicals or rubbish that may affect concrete. The most preferable is potable water. Many concrete plants now use recycled water after being treated. Always check bore water before use.
   Don't use seawater (salt water with sulfates) in reinforced concrete as it may rust the reinforcing steel.
5. **Additives**: are those ingredients in concrete other than Portland cement, water, and aggregates that are added to the mixture immediately before or during mixing to change or alter its properties, ie the time concrete takes to set and harden, or its workability.
   Admixtures can be classified by function as follows:
   - Air-entraining admixtures
   - Water-reducing admixtures
   - Plasticizers
   - Accelerating admixtures
   - Retarding admixtures
   - Hydration-control admixtures

6. **Steel bars** is commonly used in the bridge superstructure for armouring expansion joints, beams, bearings, floor beams, girders, reinforcing bars in concrete, traffic barriers and trusses.
7. **Stone:** Stone was commonly used for building the abutments and piers in the 1940's and earlier. This is particularly true where local field stone was readily available.
8. **Wires:** Metal formed into a thin usually by being drawn through a hole in a steel die and are used to tied the steel bar during suspended bridge works.

2.1.2.Equipment used in construction of suspended bridge foundation

- **Excavator machines:**hydraulic excavators are widely used in earthmoving or digging the foundations for bridge.

Following are the equipment that can be used for various types of work.
✓ A bulldozer can quickly push the topsoil
✓ A back actor is used for digging pits for column or piers
✓ A mechanical auger is used for digging holes for piles
✓ Tipper truck for transporting large amount of soil
✓ Dump truck for transporting small quantity of soil at a short distance
✓ Draglines for digging deep foundations
✓Face shovel: for pushing the soil forward
✓ Pneumatic drill for drilling into solid rock

Compaction machines: Soil can be compacted by using high frequency plate vibrators. Plate reduces the friction between the particles and set the motion of particles. As a result, entrapped air is removed and the soil is compacted. The use of compaction machine reduces the compaction time. The machine used to compact the soil is roller, to expel air from a soil mass and so achieve a high density. Smooth-wheel rollers are best for gravels, sands, and gravels-and-clay soils with reasonably high moisture contents. The method of compaction is primarily of four types such as kneading, static, dynamic or impact and vibratory compaction.

2.1.3.Tools used in construction of suspended bridge foundation

A.Selection of tools

1. Measurementtools:Are all tools used to take the dimensions, sizing, and precise the designed distance where bridge must be placed.

Example: tape measure, decameter, laser,micrometer,laser measure

2. Cutting tools : Are construction tools used to cut the steel bars during used for suspended bridge activities.

3. Topographic instrument: This is the process of manually measuring distances and angles using leveling instruments for suspended bridge such as theodolites, dump level. Direct

surveying provides the basic data for all topographic mapping for suspended bridge, including digital imaging systems

2.1.4. Preparation of workplace steps:

1. Positioning signs for safety measures for avoiding accidents at workplace
2. Demarcation of work area for providing workplace boundaries
3. Clearance of work area by remove hazards
4. Site installation

L.O.2.2- MAKE FORM WORK

Topic: Description the formwork used in suspended bridge works

Formwork is a temporary or permanent moulds into which concrete or similar materials are poured.

2.2.1. Setting out of form work

The formwork for the unit to be casted should be positioned within its proper position by considering the following important elements:

a) Measurement: dimensions should be respected as it is indicated according to the drawing.

b) Checking angle: after making the formwork according to the drawing, angles for every corner should be checked to prevent errors

2.2.2. Shuttering assembling

a) **Measurement**: shuttering Formworks are measured in terms of area, But generally, square meter and square foot of the contact area with concrete is taken as the unit of measurement. The dimensions of a formwork should be measure correct to the centimeter or inches whichever the case may be

b) Adjustment: Adjust the column widths so that can view all columns on the screen without scrolling. Not see some column headers in their entirety if their full text doesn't fit in the reduced column width, but making this adjustment will give you the ability to view all the columns.

c) **Supporting:**Formwork is typically supported by several levels of shores that carry the loads until the concrete gains enough strength to support its own weigh

2.2.3. Techniques of fixing Pranks/boards

a) **Screwing:** Is the techniques of fixing boards of suspended bridge by using bolt and nut /screws.

b) **Nailing**:Is the techniques of fixing boards of suspended bridge by nails of different size/diameter based on the thickness of bridge board

c) Gluing: Is the techniques of fixing boards of suspended bridge by glue for plastic or wooden board.

L.O.2.3- MAKE FRAMEWORK

Topic: Description the framework used for suspended bridge

Framework is the arrangement of the supports or components that represent the general shape and size of the structural elements.

2.3.1. Interpretation of framework drawings

a) Dimension
b) Scale
c) Symbols

2.3.2. Cutting of Steel bars

a) **Manual cutting:**Is the techniques of cutting steel bars by using hand tools or small machine during metal bridge works construction.The main purpose of cutting steel bar is to obtain the required dimensions.

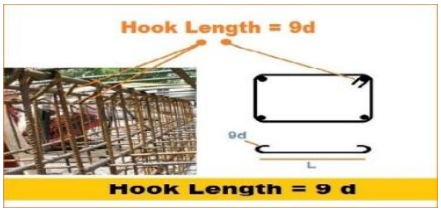
   Example: Hacksaw

b) **Mechanical cutting**:Is the techniques of cutting steel bars by using powered machine or big machine during metal bridge works construction.

   Example: circular saw

2.3.3. Bending of steel bars

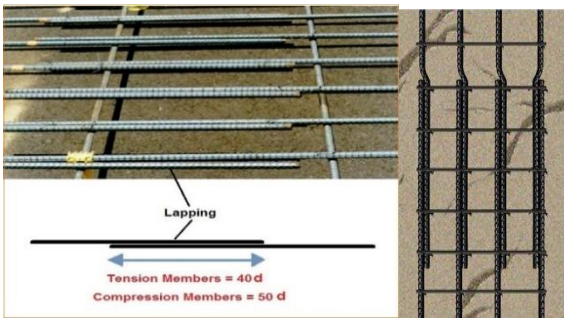
a.Hooks is defined as steel bent into a curved shape,typically with one end free and the other end secured to a rope or other attachment.

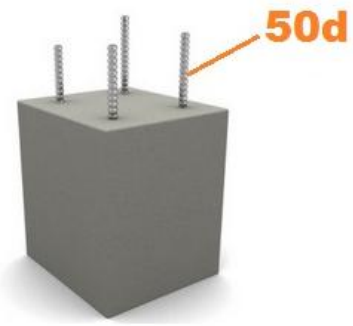


b.overlap

During placing the steel in RC structure if the required length of a bar is not sufficiently available to make a design length then lapping is done. Lapping means overlapping of two bars side by side to achieve required design length.

Lap length for tension members = 40d, Lap length for compression members = 50d., d = Diameter of bars.





2.3.4. Tying of steel bars

a) Fixing of support bars
b) Tying of distribution reinforcements

L.O.2.4- CAST CONCRETE

Topic: Description thecast concrete used in suspended bridge works

Concrete is an intimate mixture of binding material, fine aggregate, coarse aggregate and water. This can be easily moulded to desired shape and size before it loses plasticity and hardens.

Major ingredients of concrete are:

1. Binding material (like cement, lime, polymer)
2. Fine aggregate (sand)
3. Coarse aggregates (crushed stone, jelly)
4. Water.
5. A small quantity of admixtures like air entraining agents, water proofing agents, workability agents etc.

2.4.1. Concrete mixing

1.Mixing ratio: Is defined as amount of concrete components mixture used to make a concrete.

2. Mixing

To produce uniform and good concrete, it is necessary to mix cement, sand and coarse aggregate, first in dry condition and then in wet condition after adding water.

The following methods are practiced:

a) Hand Mixing
b) Machine Mixing.

(a) Hand Mixing: Required amount of coarse aggregate for a batch is weighed and is spread on an impervious platform. Then the sand required for the batch is spread over coarse aggregate. They are mixed in dry condition by overturning the mix with shovels. Then the cement required for the batch is spread over the dry mix and mixed by shovels. After uniform texture is observed water is added gradually and mixing is continued. Full amount of water is added and mixing is

completed when uniform colour and consistency is observed. This method of mixing is not very good but for small works it is commonly adopted.

(b) Machine Mixing: In large and important works machine mixing is preferred. Required quantities if sand and coarse aggregates are placed in the drum of the mixer. 4 to 5 rotations are made for dry mixing and then required quantity of cement is added and dry mixing is made with another 4 to 5 rotations. Water is gradually added and drum is rotated for 2 to 3 minutes during which period it makes about 50 rotations. At this stage uniform and homogeneous mix is obtained.

2.4.2. Setting time of concrete

1.Initial setting time:is the time when the paste starts losing its plasticity. Initial setting time test is important for transportation, placing and compaction of cement concrete. Initial setting time duration is required to delay the process of hydration or hardening.

2.Final setting time:is the time when the paste completely loses its plasticity. It is the time taken for the cement paste or cement concrete to harden sufficiently and attain the shape of the mould in which it is cast. The Final Setting Time is 600 minutes (10hrs)

2.4.3.CONCRETE VIBRATION

Vibration of concrete is carried out for the sake of consolidation. The main objective of vibration is to compact the concrete and to achieve the maximum possible density of concrete. Almost 5 to 8% by volume of freshly placed concrete in the form is occupied by air bubbles.

A concrete vibrator is a construction tool typically used on concrete pouring sites. These machines and an assortment of attachments are designed for multiple

applications built by a variety of manufacturers. The vibrators are used to ensure that the pour is free of air bubbles and are even.

2.4.4. Types of Concrete Vibrators

Concrete particles are different sizes and it is best to use vibrators that have different speeds. Vibrators that are used for compacting concrete are many times referred to as poly-frequency vibrators. These are best used for compacting concrete that is of stiff consistency. The frequencies of vibration used are from between 2800 to 15000 rpm. 4 different types of concrete vibrators used for compaction are described in brief below.

1. Needle Vibrators

These are also known as immersion vibrators. It has a steel tube, called a poker, with one end being closed and rounded. There is an eccentric vibrating element inside it. The poker is connected to an electric motor, sometimes a diesel motor, through a flex tube.

These needle vibrators come in a variety of sizes from 40 to 100 mm in diameter. The poker's diameter is determined by the spacing between the reinforcing bars in the form work. The general range of vibrations for a needle vibrator is between 3000 to 6000 rpm. The period of

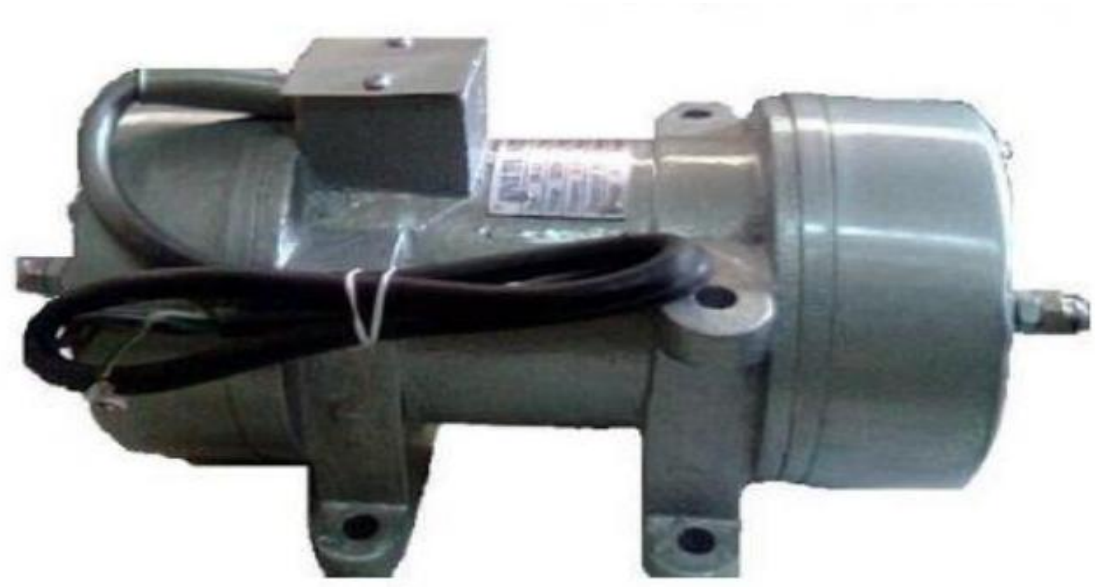
vibration necessary can be from 30 seconds to 2 minutes and the concrete should be placed in layers no more than 600mm high.

Needle Vibrator

2.Shutter Vibrators

A shutter vibrator is also called an external vibrator and is clamped rigidly to the form work at pre-determined points. This allows for the form andconcrete to be vibrated. They are more powerful for a given compaction than an internal vibrator.

These vibrators operate at a frequency of around 3000 to 9000 rpm and an acceleration of 4g. The shutter vibrators are used more often for precasting of thin sections that do not have the thickness needed for internal vibrators.



Shutter Vibrators

3.Surface Vibrators

Surface vibrators are placed on the concrete mass and are best used for the compaction of shallow elements. These should not be used when the depth of the concrete is more than 250mm.

Mixes that are extremely dry can be most effective compacted using surface vibrators. There are two surface vibrators that are most commonly used: pan vibrators and vibrating screeds. Operating frequency for these vibrators is generally 4000 rpm. The best use for surface vibrators includes small slabs that do not exceed 150mm in thickness.

Surface Vibrator

4.Vibrating Table

A vibrating table is a rigidly built steel platform that is mounted on flexible springs. It is driven by an electric motor. A vibrating table has a normal frequency of 4000 rpm

Concrete Vibrating Table

2.4.5. Concrete defects

1.Segregation: Segregation can be defined as separating out of the ingredients of concretemix so that mix is no longer in homogeneous condition. Only stable homogeneous mix can be fully compacted.

causes segregation of concrete

➢ Poorly graded aggregate & excessive water content is the major cause of segregation.

➢ A badly proportioned mix, where sufficient matrix is not there to bond and contain the aggregate cause aggregates to settle down.

➢ Insufficiently mixed concrete with excess water content shows a higher tendency for segregation.

➢ When height of dropping of concrete is more (ex. In case of concreting long column) it will result in segregation.

➢ If a mixer used for mixing concrete is badly designed or a mixer with worn out blades, then the concrete shows a tendency for segregation.

➢ If a high slump concrete or pumpable concrete are not compacted with sufficient care then it is likely to result in segregation of concrete.

➢ Immediate working on the concrete on placing, without any time interval is likely to press the coarse aggregate down, which results in movement of excess matrix or paste towards the surface, resulting segregation.

➢ Chances of segregation are more when concrete is to be placed under water.

➢ Segregation also increases when concrete is placed in heavily reinforced concrete members

2.Bleeding: This refers to the appearance of the water along with cement particles on the surface of the freshly laid concrete. This happens when there is excessive quantity of water in the mix or due to excessive compaction.

Causes of bleeding

- Excess quantity of water in the mix
- Bad mixing ratio
- Excessive compaction
- Unskilled workers

3.Laitance: an accumulation of fine particles on the surface of fresh concrete due to an upward movement of water (as when excessive mixing water is used).

Causes of laitance

- Excessive water used in mixing
- Excessive finishing
- Excessive quantity of water cement ratio
- Bad compaction

2.4.6. Concrete curing technique

Curing may be defined as the process of maintaining satisfactory moisture and temperature conditions for freshly placed concrete for some specified time for proper hardening of concrete. Curing in the early ages of concrete is more important. Curing for 14 days is very important. Better to continue it for 7 to 14 days more.

The concrete hardens because of hydration. The chemical actions, which accompany the setting of concrete, are dependent on the presence of water. It improves properties of concrete such as water-tightness, wear resistance, strength, volume stability and durability.

Concrete curing technique

(a) water curing: Walls, columns, plastered surfaces are cured by sprinkling water.

(b) Membrane curing: Columns and other vertical surfaces may be cured by covering the surfaces with wet gunny bags or straw.

(**c)Master cure or Chemical curing:** Compounds like calcium chloride may be applied on the curing surface. The compound shows affinity to the moisture and retains it on the surface. It keeps the concrete surface wet for a long time.

L.O.2.5-CONSTRUCT ABUTMENT

Topic: Explanation of construction of abutment ofsuspended bridge

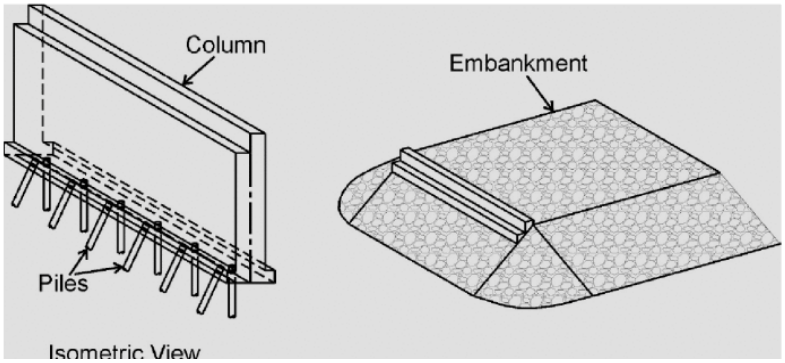
2.5.1. Interpretation of abutment drawings

The construction of abutment are based on interpretation of drawings and analysis the following items:

- ✓ Dimension
- ✓ Scale
- ✓ Symbols

In engineering, abutment refers to the substructure at the ends of a bridge span or dam whereon the structure's superstructure rests or contacts.

It is usual for the top width of the earthfill embankment to accommodate minimally a road width of 7.22m plus two shoulders of width 8ft (2.41m), giving an overall top width of 40ft (12.04m). the side-slopes of earthfill approach embankments commonly are set at 2H:1V, through slopes range from about 2H:1V to 3H:1V



An abutment may be used for the following:

1. To transfer loads from a superstructure to its foundation elements
2. To resist and/or transfer self-weight, lateral loads (such as the earth pressure) and wind loads
3. To support one end of an approach slab
4. To maintain a balance in between the vertical and horizontal force components of an arch bridge.

2.5.2.Types of abutment according to the common material of construction

a) **Concrete abutment**: Is the type of abutment composed of the mixtures of cement, sand,gravel,water and admixtures
b) **Masonry abutment**: Is the type of abutment which composed of stones or bricks.

Types of abutments:According to standard specifications, the abutments are categorized as follow

a) **Gravity abutment**, resists horizontal earth pressure with its own dead weight
b) **U abutment**, U-shaped gravity abutment
c) **Cantilever abutment**, cantilever retaining wall designed for large vertical loads
d) **Full height abutment**, cantilever abutment that extends from the underpass grade line to the grade line of the overpass roadway
e) **Stub abutment**, short abutments at the top of an embankment or slope, usually supported on piles
f) **Semi-stub abutment**, size between full height and stub abutment
g) **Counterfort abutment**, similar to counterfort retaining walls
h) **Spill-through abutment**, vertical buttresses with open spaces between them

Pile bent abutment, similar to spill-through abutment

2.5.3.Erection of abutment walls

How to choose perfect abutments: On the basis of the following factors: -

a) Construction and maintenance cost
b) Cut or fill earthwork situation
c) Traffic maintenance throughout construction
d) Construction period
e) Protection of construction workers
f) Accessibility and cost of backfill material
g) Superstructure depth

h) Size of abutment
i) Horizontal and vertical alignment alterations
j) Area of excavation
k) Attractiveness and conformity with adjoining structures
l) Prior knowledge with the type of abutment
m) Ease of use for assessment and maintenance.
n) Predicted life, loading condition, and acceptability of deformations.

L.O.2.6- EXECUTE BACKFILLING

Topic:Identification the steps of backfilling of soil and thecleaning of tools,equipment ,workplace used in suspended bridge works

2.6.1.Backfilling steps:

✓Cleaning of base of excavated area
✓Laying filling materials (use soil)
✓Curing of soil (layer by layer)
✓Compaction of soil (layer by layer)

L.O.2.7- Clean tools, equipment and workplace

Topic: Identification of methods of cleaning tools and equipment used for suspended bridge

2.7.1.A. Methods of cleaning tools and equipment

1. Wet method: Is the method of cleaning tools and equipment after or before work by using water and oil

2. Dry method: Is the method of cleaning tools and equipment after or before work by using brush and air compressor.This is the best method used to avoid rust which can damage the tools and equipment.

B. Methods of cleaning work place

We don't have to remain the working area dirty, we have to clean the workplace after construction activities.The following are the different methods used to clean the working area:
1. By water 2. By brush 3. By air compressor

2.7.2.A. Storing tools andequipment procedures:

✓ Selection of area for storingtools and equipment
✓ Prioritize tools andequipment
✓ Divide tools and equipment
✓ Discard unused tools andequipment

B.Importance of proper storage of tools and equipment

1. Improve safety and health of the employees
2. Improves appearance of construction areas
3. Reduces overall tool cost through maintenance
4. It ensures that tools are in good repair at hand

LEARNING UNIT 3 –CONSTRUCT BRIDGE TOWERS

LO 3.1 – PREPARE MATERIALS, TOOLS, EQUIPMENT AND WORKPLACE

Topic : Identification of materials,tools,equipment and steel section used in construction ofsuspended bridge towers

Towers can be defined as vertical steel or concrete structures projecting above the deck, supportingcables and carrying the forces to which the bridge is subjected to the ground. By this definition, towers are used only for suspension bridges.

Bridge towers are the most visible structural elements of long-span bridges. They project above thesuperstructure and are seen from all directions by viewers and by users. Towers give bridges their character and a unifying theme.

Fig.Tower of suspended bridge.

3.1.1. Materials used in construction of metal bridge superstructure

1. **Fuel:** is any material that can be made to react with other substances so that it releases energy as heat energy or to be used for work. The heat energy released by reactions of fuels is converted into mechanical energy via a heat engine.
2. **Lubricants:** is a substance which you put onthe surfaces or parts of something, especially something mechanical, to make the parts move smoothly. In bridge construction, lubricant is used in different parts of some equipment to avoid friction.
3. **Structure members:**Are The substructure and the superstructure of suspended bridge which supports allof the bridge loads applied on it.
4. **Bolts:** consist of a head and cylindrical body with screw threads along a portion of its length which is used to fix the traffic barriers for suspended bridge.
5. N**uts:** is fastener material with threaded hole which used to fix rails or traffic barriers for suspended bridge.
6. **Cutting disc:** Are made from solid abrasive disc which are used for cutting metal or steel used for construction of suspended bridge.

3.1.2.Equipment used in construction of suspended bridge tower

a) **Lift crane:** is any work equipment for lifting and lowering loads, and includes any accessories used in doing so (such as attachments to support, fix or anchor the equipment)
   i. overhead cranes and their supporting runways
   ii. motor vehicle lifts
   iii. vehicle tail lifts and cranes fitted to vehicles
   iv. goods and passenger lifts
   v. telehandlers and fork lifts

b) **Cutting equipment:**Are the equipment or powered machine used to cut out parts of steel bar or metal for gaining required dimensions.

   Example: Grinding machine

3.1.3. Types of tools used in construction of suspended bridge tower

a) **Measurement tools**: Are tools used to determine the dimensions(measures) during construction of suspended bridge towers.

Example: Tape measure of 50m

b) **Cutting tools:** Are tools used for cutting out unwanted of steel bars or metal during bridge tower construction.

Example: Hack saw

c) **Levelling instrument:** Are instrument used for determining the relative heights of different points and the angle on the surface which bridge work take the place.

Example: Dumpy level

Fig. Dumpy level

3.1.4.Preparation of workplace steps:

a) Positioning signs for safety measures
b) Demarcation of work area
c) Clearance of work area
d) Site installation

LO 3.2 - Prepare structure

Topic: discussing the Preparationof bridge structure and the Erection of bridge towers

3.2.1.Types of welding of steel joints

Welding is the process of joining two pieces of metal or non-metaltogether by heating them to their melting point. Filler metal may ormay not be used to join two piece

Some of the advantages of welding are:
o Welding is the most economical method to permanently joint two metal parts.
o It provides design flexibility.
o Welding equipment is not so costly.

o It joins all the commercial metals.
o Both similar and dissimilar metals can be joined by welding.
o Portable welding equipment are available.

1.Cylinder welding

Is defined as gases for welding, hot cutting and similar processes. Cylinder welding composed ofOxygen/fuel and acetylene gas cylinderswhich has many uses such:

- welding for steel joining

- cutting steel

- heating steel

- straightening steel
- descaling steel

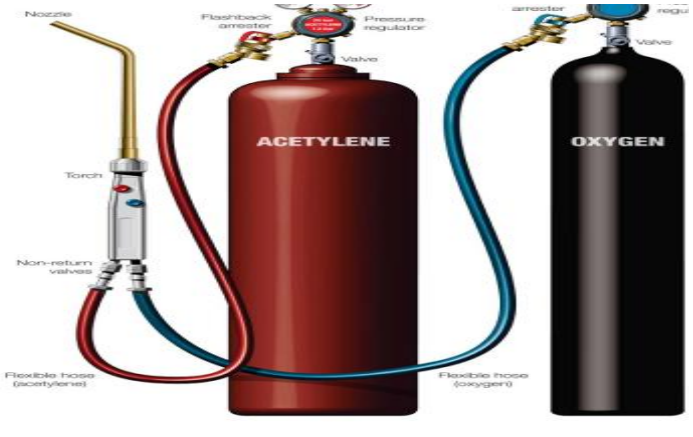


Figure 1 Two cylinders

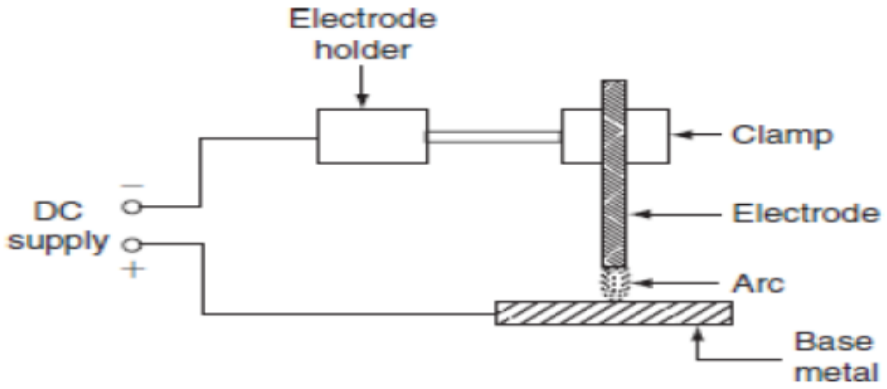
2.Electrical welding

It is defined as the process of joining two metal pieces, in whichthe electrical energy is used to generate heat at the point ofwelding in order to melt the joint.

The physical and mechanical properties of a material to be welded such as melting temperature, density, thermal conductivity, and tensile strength take an important role in welding. Depending upon how the heat applied is created; we get different types of welding such as thermal welding, gas welding, and electric welding.

The selection of proper welding process depends on the following factors.

o The type of metal to be joined.
o The techniques of welding adopted.
o The cost of equipment used.
o The nature of products to be fabricated



3.2.2. Preparation of structure members

The steps of Preparation of structure members are:

✓ Cutting structure members
✓ Drilling members
✓ Welding structures members.

LO 3.3 -ERECT BRIDGE TOWERS

Topic: Description the type of towers for suspended bridge

3.3.1. Types of tower

1. Metal towers

Is defined as vertical metal or steel structures which extended above the bridge decks .It is used in the construction of cable stayed bridge, suspension bridge and hybrid suspension cable stayed structures. The function of metal tower is to safely support bridge loads and traffic load.

Metal towers of suspension bridge increased the aesthetics of bridge and demonstrate satisfactory survivability performance.

Fig. metal tower for suspended bridge

2. Concrete tower

Concrete tower is defined as vertical concrete structures which fabricated in mixtures of cement, fine and coarse aggregates, admixture and water that extended above the bridge decks. It is used in the construction of cable stayed bridge, suspension bridge and hybrid suspension cable stayed structures.

The main structural function of the towers of cable-stayed and suspension bridges is carrying the weight of the bridge, traffic loads, and the forces of nature to the foundations. The towers must perform these functions in a reliable, serviceable, aesthetic, and economical manner for the life of the bridge, as towers, unlike other bridge components, cannot be replaced. Without reliability, towers may become unsafe and the life of the entire bridge could be shortened. Without serviceability being designed into the structure, which means that it is designed for access and ease of maintenance, the bridge will not provide continuing long service to the user. The public demands that long-span bridges be attractive, aesthetic statements with long lives.

Fig.Concrete bridge tower

3.3.2 Procedures of erecting towers

✓assembling of tower structure members

✓ Erection of tower

LEARNING UNIT 4_CONSTRUCT BRIDGE DECK

L.O.4.1_PREPARE MATERIALS, TOOLS, EQUIPMENT AND WORKPLACE

Topic : Identification of materials,tools,equipment used in construction of bridge deck

Bridge deck is defined as the surface of a bridge. A structural element of superstructure, it may be constructed of concrete, steel, or wood.

4.1.1. Materials used in construction of suspended bridge.

- ✓ Fuel
- ✓ Lubricants
- ✓ Steel
- ✓ Bolts
- ✓ Nuts
- ✓ Rivet
- ✓ Cutting disc
- ✓ Cables
- ✓ Timber
- ✓ Aggregates
- ✓ Bitumen
- ✓ Cement
- ✓ Water
- ✓ sand

4.1.2 Equipment used in construction of Suspended bridge

✓ **Lift crane:**is any work equipment for lifting and lowering loads, and includes any accessories used in doing so (such as attachments to support, fix or anchor the equipment)

✓ **Cutting machine:** Are tools used for cutting out unwanted of steel bars or metal during suspended bridge construction, for example **grinder machine** is a metal cutting operation like any other process of machining removing metal in comparatively smaller volume. The cutting tool used is an abrasive wheel having many numbers of cutting edges. The machine on which grinding the operation is performed is called a grinding machine

✓ **Tirfor:** Is defined as a come-a-long chain hand operated with a ratchet used to pull heavy objects, Tirfor machine are lever operated hoists using a separate wire rope, this machine usually facilitate adjustment of structure members of suspended bridge.

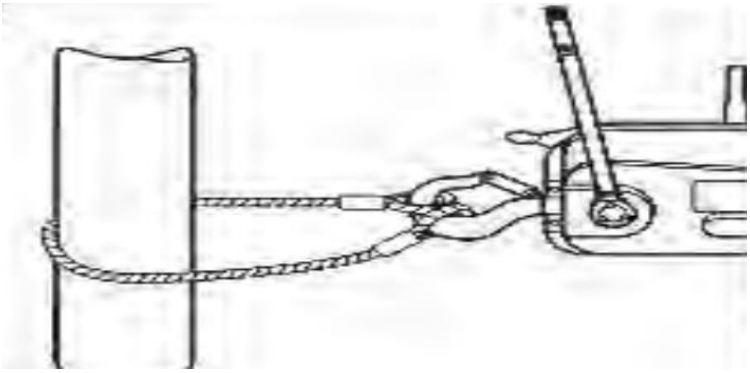


Fig.Tirfor

4.1.3.Types of tools used in construction of suspended bridge

✓ **Measurement tools**: Are tools used to determine the dimensions(measures)andlevellinghorizontal structure members of suspended bridge is being constructed.

Example: hose pipe, spirit level

✓ **Topographic equipment:** Are instrument used for determining the relative heights of different points and the angle on the surface which bridge work take the place.

Example: Dump level,theodolite

✓ **Cutting tools:** Are tools used for cutting out unwanted of steel bars or metal during bridge tower construction.

Example: Hack saw

4.1.4.Preparation of workplace steps:

✓ Positioning signs for safety measures
✓ Demarcation of work area
✓ Clearance of work area
✓ Site installation

L.O.4.2_ 4.2: FIX CABLE

Topic: Description the procedures of fixing cable and slab parts for suspended bridge.

4.2.1. Interpretation of drawing

- ✓ Dimensioning
- ✓ Views
- ✓ Section
- ✓ Verification

4.2.2. Identification of cables

1. **Main cables**

In a suspended bridge, the main cables suspend the decks(girder roadway),The cables are held up only by the bridge towers, which means that the towers support a tremendous weight(load).The steel cables are both strong and flexible. This makes long span suspended bridges susceptible to wind forces, resist to live load of traffic crossing the bridge.

In suspended bridge large main cables normally are two:

A) **Anchored cables:** These cable hang between the towers which anchored at each end to the ground, this cable can be difficult to implement when ground condition ispoor. Anchored cable bear the load of the bridge deck.

B) **Cable-stayed bridge:** This cable primary load-bearing structures that transmitthe bridge loads to the ground, which cable support the bridge decks.

2. **Suspenders cable**

Are vertical cables that transfer the live and dead loads of the deck below, upon which traffic crosses. Suspension cables are freely hanging cable carry its own weight or uniformly distributed load. Those cables include **Tower saddle cable, hang cable**

4.2.3 Procedures of fixing cables

- ✓ Construct mass ofanchorage
- ✓ Fixing of cables undertension

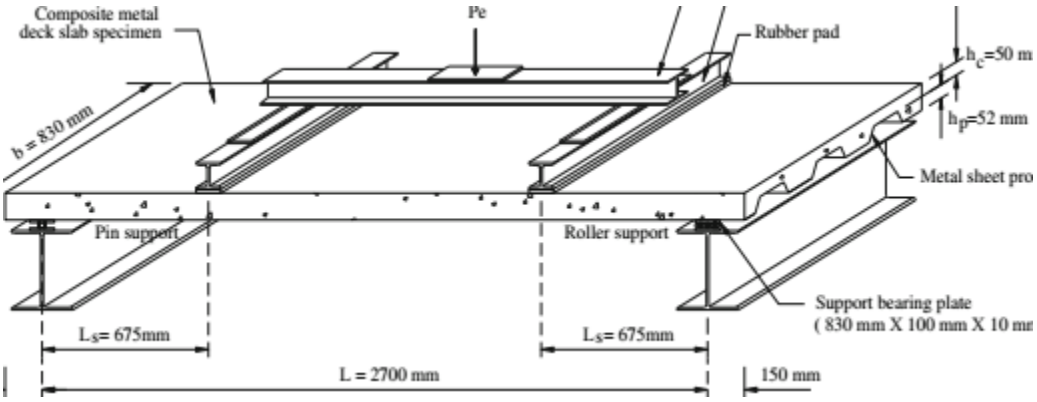
L.O.4.3_ FIX SLAB PARTS

Topic: Description the type of slab used for suspended bridge.

4.3.1.TYPES OF SLABS

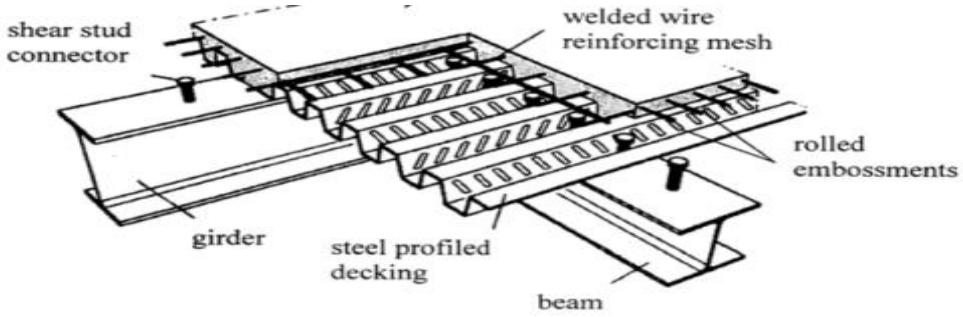
1.Timber slab

Is defined as structural element, made of timber that is used to create flat horizontal surface which support the deck of bridge.



2.Metal slab

A composite slab with profiled steel decking has provedover the years to be one of the simpler, faster, lighter, and economical constructions in steel-framed buildingsystems of construct the bridge.Cold-formed thin-walled profiled steeldecking sheets with embossments on top flanges andwebs are widely used in many composite slab constructions,The profiled decking sheet must provide the resistanceto vertical separation and horizontal slippage



3.concrete slab

Is defined as structural element, made of mixtures of cement, fineaggregate, coarseaggregate, water and admixtures that is used to create flat horizontal surface which bridge deck which resist on traffic load, live and dead load applied on the bridge.

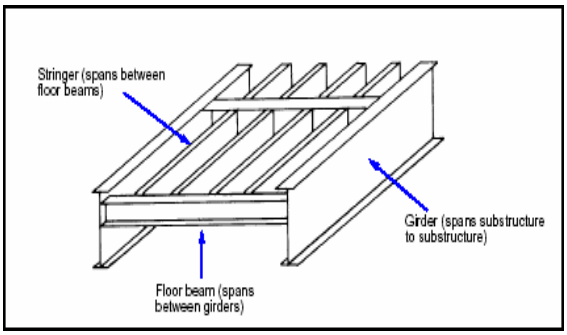
4.Asphalt slab

Is defined as structural element, made of sticky black of highly viscous semi-solid (bitumen)on the top layer of bridge deck that is used to create flat horizontal surface which bridge deck which protect other layers and provide appearance of bridge.

4.3.2.Types of beams

a) Floor beam

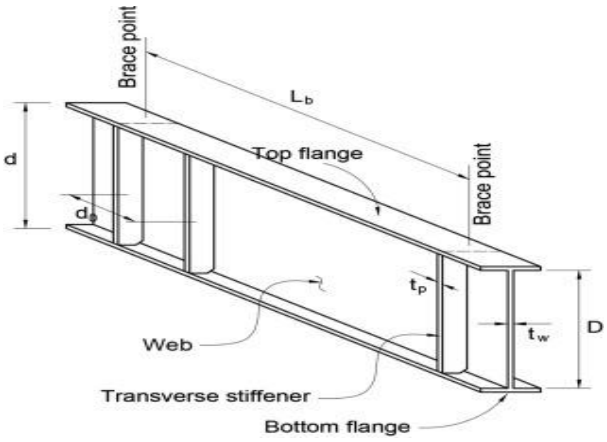
In a bridge deck the lightly loaded longitudinal beams are the stringers; the heavier, transverse members are called floor beams.



b) Stringers beam/ Girder

Girders are the main horizontal supports of a structure, and support smaller beams. All girders are beams, but not all beams are girders.

- Beams are generally milled or rolled sections. They tend to be small in comparison to girders because their size is limited by the capacity of milling equipment.
- Girder is called stringer beam. Main steel member along the longitudinal direction is called stringer beam. Longitudinal beams supporting load from the decking to the floor beams.



4.3.3. Procedures of fixing a metal beam

✓ Fixing of bridge bearing for supporting superstructures parts of bridge.
✓ Cutting steel by using grinding machine.
✓ Drilling steel by using drilling machine.
✓ Fixing steel bars used for upper or lower parts of bridge

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