GOVERNMENT POLYTECHNIC FOR GIRLS AHMEDABAD 380015

ADVANCE CONSTRUCTION TECHNOLOGY (3350605)

GOVERNMENT POLYTECHNIC FOR GIRLS

AHMEDABAD

COURSE: ADVANCE CONSTRUCTION TECHNOLOGY

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TOPIC: FORM WORK

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FORMWORK

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- Trestle centering
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INTRODUCTION

- **'Temporary supporting structures**' are those structures which are temporarily required in building construction either for supporting the laying of concrete till it gets matured,such as **'formwork'** or **'forms**' or **'shuttering**' or for supporting the material and labour for execution of some construction work,,such as **scaffolding** , **shoring** or **underpinning**.
- In case of circular works , such as arches and lintels , the term **centering** is used in place of formwork.
- The term **moulds** is used for forms when they are used for precasting of concrete units such as lintels, cornices, concrete blocks, beams etc.

MATERIALS USED IN FORMWORK

The various materials used in formwork are:

1. Timber formwork
2. Steel formwork
3. Aluminum sheet formwork
4. Fibreglass sheet formwork
5. Plywood formwork

TIMBER FORMWORK

Timber used for the formwork should satisfy the following requirement

- It should be well seasoned.
- It should be light in weight.
- It should be easily workable with nails without splitting.
- It should be free from knots.

- The sizes of timber sections for different components of formwork depend upon the span of the slab or beam, floor to floor height and the centre to centre spacing of the centering supports.
- For normal construction work where repetitive use of shuttering is possible,the quantity of timber shuttering can be worked out on the assumption that one set of shuttering can be used 10 to 12 times.
- This timber used for shuttering for exposed concrete work should have smooth and even surface on all faces which are to come in contact with concrete. In situations where concrete surfaces are not exposed as in case of foundation etc., undressed timber can be used to effect economy. The timber planks for the shuttering should be jointed by providing toungued and grooved joints so as ensure adequate tightness against leakage of cement grout.

STEEL FORMWORK

- This consists of panels fabricated out of thin steel plates stiffened along the edges by small steel angles. The panels units can be held together by two or more clamps or bolts provided along each edge and the shuttering can be assembled and kept in alignment by use of horizontal or vertical centering of timber or steel. The usual size for wall or slab panel varies from 60cm× 60cm to 60 cm× 120 cm.

- Steel forms are mostly used in large construction projects or in situations where large number of re-uses of the same shuttering are possible. Steel forms are extensively used in repetition casting products. This type of shuttering is considered most suitable for circular or curved shaped structures such as tanks, columns, chimney etc. and for structures like large sewers, tunnels and retaining walls.
- Although steel shuttering costs more initially but in view of its various advantages it may work out to be economical for a medium sized work in the large run.

COMPARISON BETWEEN STEEL AND TIMBER FORMWORK :-

STEEL FORMWORK

- Steel structures are very much costly than the timber structures because of their metallic behavior and used for high structural variations such as loods, span and strength.
- Steel structures are more durable than timber because these structures got extra strength which against natural agents such as wind, rain, earthquake etc. The life time steel structures may be up to 50 years.
- Steel structures are liable to be corroded this my reduce Me span but a steel coated with pants then corrosion is reduced at great extent.

TIMBER FORMWORK

- The cost of timber structures is very low because these structures are design for low loads, strength and span.
- Timber structures are less durable than steel structures because they have properties to against natural phenomenon.Life time may be up to 15 to 20 time.
- Timber deteriorates more than steel because termites badly affect, the timber which makes turmel through it and make a weak enough. It can be reduced by painting.

STEEL FORMWORK

- The coefficient of expansion of steel is very high as compare to wood so they cause failure of structures when increases. Faire may occur due to deflection structural member which are subjected to high temperature.
- Steel structures may produce sound le. Echo because they have less properties of absorption of sound waves so sound proof material may be used in these structures.
- Varieties of steel is limited, they can be made variable by industrial agents i.e by booking adding different metals, alloys etc. Which may get its variation.

TIMBER FORMWORK

- The coefficient of expansion of wood is very low le, it does not provide increase in length when temperature is raised so this may provide safety to structures and make to cool enough as compare to steel. However contraction may be danger full to timber structures because below 0 Cits starts contract rapidly.
- Timber don't reflect sound waves rather à has greater intensity to absorb sound waves so no need of providing sound proof materials in buildings which reduce cost.
- More than 5000 kinds of wood are available in the world with different etemal structures.

ALUMINIUM SHEET FORMWORK :-

- Aluminium Formwork System is a construction system for forming cast in place concrete structure of a building. It is also a system for scheduling and controlling the work of other construction trades. such as steel reinforcement, concrete placement and mechanical and electrical conduits.
- Aluminium Formwork System provides Aluminium Formwork for RCC load bearing or RCC framed multi-storied buildings and enables the walls and slabs to be poured in the same operation. These increases efficiency and also produces an extraordinarily strong structure with excellent concrete finish. Due to the fine tolerance achieved in the machined metal formwork components, consistent concrete shapes and finishes are obtained floor after floor. This allows plumbing and electrical fittings to be prefabricated with the certain knowledge that there will be an exact fit when assembled.

FIBREGLASS SHEET FORMWORK :-

- Fiberglass is lightweight, strong and less brittle. One of the most appealing features of fiberglass is that it can be molded into different shapes. This explains why fiberglass is widely used in construction, civil engineering.

PLYWOOD FORMWORK :-

- Use of plywood instead of timber planks is getting popular these days.
- In this case resin bonded plywood sheets are attached to timber frames to make up panels of required sizes.the panels thus formed can be easily essembled by bolting in the form of shuttering.
- This type of shuttering ensures quality surface finish and it specially recommend in works where large exposed areas of the concrete are to be constructed such as floor slabs, faces of retaining walls etc.

REQUIREMENTS OF GOOD FORMWORK:

A good formwork should satisfy the following requirements:

1. Easy removal :- The design of formwork should be such that it can be removed easily with least amount of hammering.
2. Economy :- As the formwork does not contribute anything to the stability of the finished structure, it should therefore, be made economical by reducing the cost through proper design and construction.
3. Strength :- The formwork should be strong enough to withstand all loads coming on it, such as dead load of concrete, and live load during its pouring, compaction and curing.
4. Rigidity :- The formwork should be rigid (stiff) enough so that deflection is minimum.

For visible surface in the completed work, the deflection is limited to 1/300 of span and for hidden surface, it is limited to 1/150 of span. It should be noted that a rigid formwork will be robust and stiff enough to allow repeated use.

5. Less leakage :- The formwork should be so arranged that there is minimum of leakage through the joints. This is achieved by providing tight joints between adjacent sections of the formwork.

6. Smooth surface :- The surface of the formwork should be smooth, and it should afford easy stripping. This is achieved by applying crude oil or soft soap solution to the inside surface of formwork.

7. Light weight :- The formwork should be as light as possible.

8. Quality :- The forms should be designed and built accurately so that the desired size, shape and finish of the concrete is attained.

9. Supports :- The formwork should rest on sound, hard and non-yeilding supports.

LOADS ON FORMWORK

The formwork has to bear mainly the following loads:

1. Dead weight of wet concrete
2. Live load due to labour
3. Loads due to placing and compacting equipments
4. Hydrostatic pressure of the fluid concrete
5. Impact due to pouring concrete

GUIDING POINTS OF THE DESIGN OF FORMWORK:

The following points should be kept in mind while designing a formwork.

1. The design of formwork should be such that it can be easily erected and easily removed.
2. The design of formwork should be such that it causes least injury or damage to the surface or edges of concrete.
3. The formwork should be rigid enough so that deflection is minimum..

4. If the forms are to be handled manually the weight of single panel should not exceed 35 kg per person.

5. While designing a formwork, the loads on formwork should be estimated carefully. The over estimation of loads results in expensive formwork and the under estimation of loads results in the failure of formwork.

6. The size and shape of formwork should be such that it can be repeatedly used for different jobs.

7. While designing a formwork, irregular shapes should be avoided.

ECONOMY IN FORMWORK

The following measures or steps should be taken to reduce the cost of form work and hence to achieve economy

1. The use of irregular shapes or forms should be avoided as far as possible.
2. It should be fabricated into modular sizes in a larger number so as to allow re-uses of forms, if possible.
3. The structural components should be so designed as to permit the use of commercially available forms.
4. The working drawings of the form work should be prepared and checked before fabricating it.
5. The components of the forms should be prefabricated on ground using power equipment, in order to reduce labour costs and delays on the work. Labour can work more efficiently on the ground than on the scaffold.
6. The removal and re-use of forms should be permitted, if it is safe to do so.
7. The forms should be designed to provide adequate but not excessive strength and rigidity, i.e ., forms should have a balanced design.

8. Where possible adopt assembly line methods in fabricating forms to increase the efficiency of the workers.

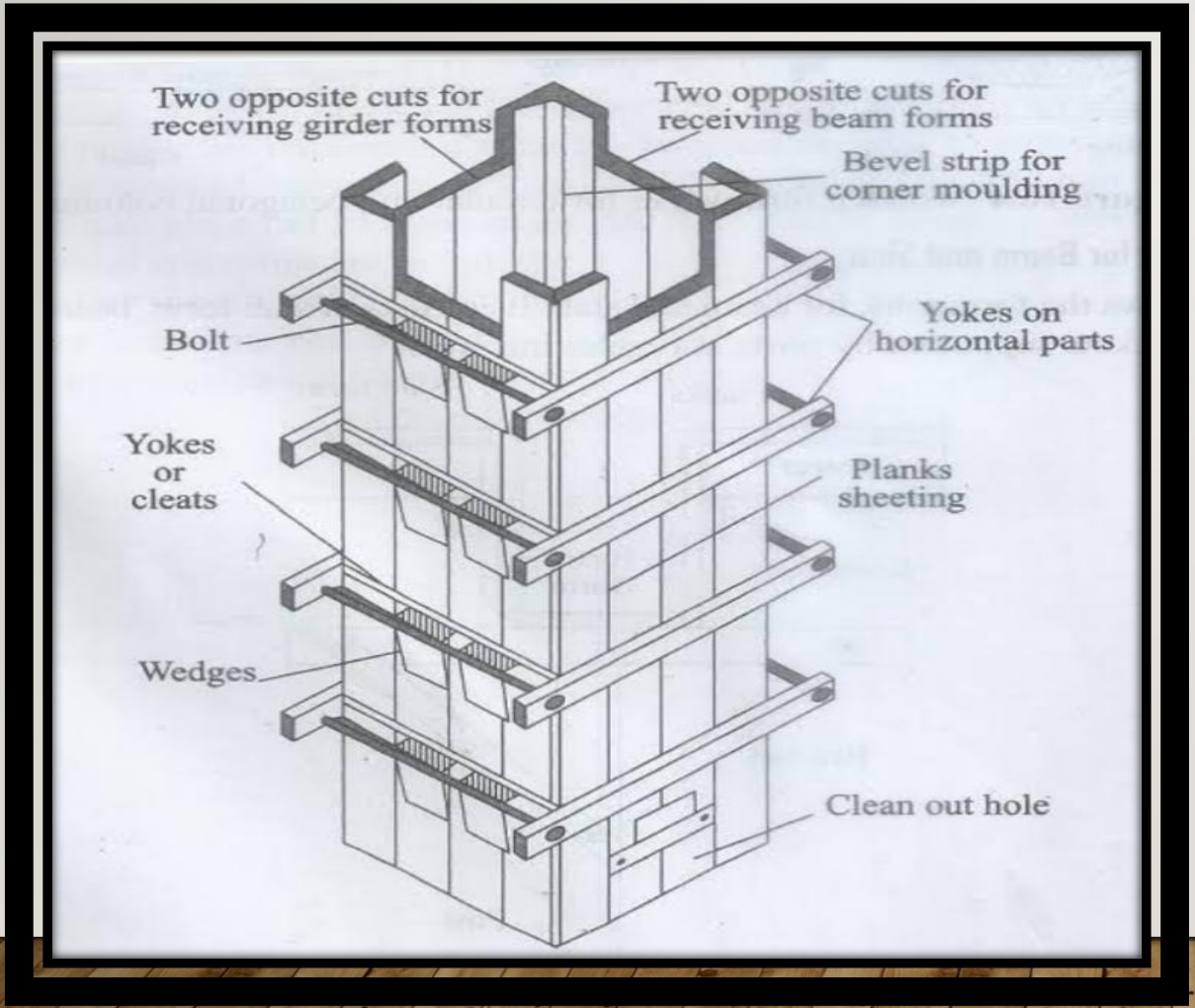
9. If possible, use double-headed nails to facilitate their removal and to reduce the damage to timber.

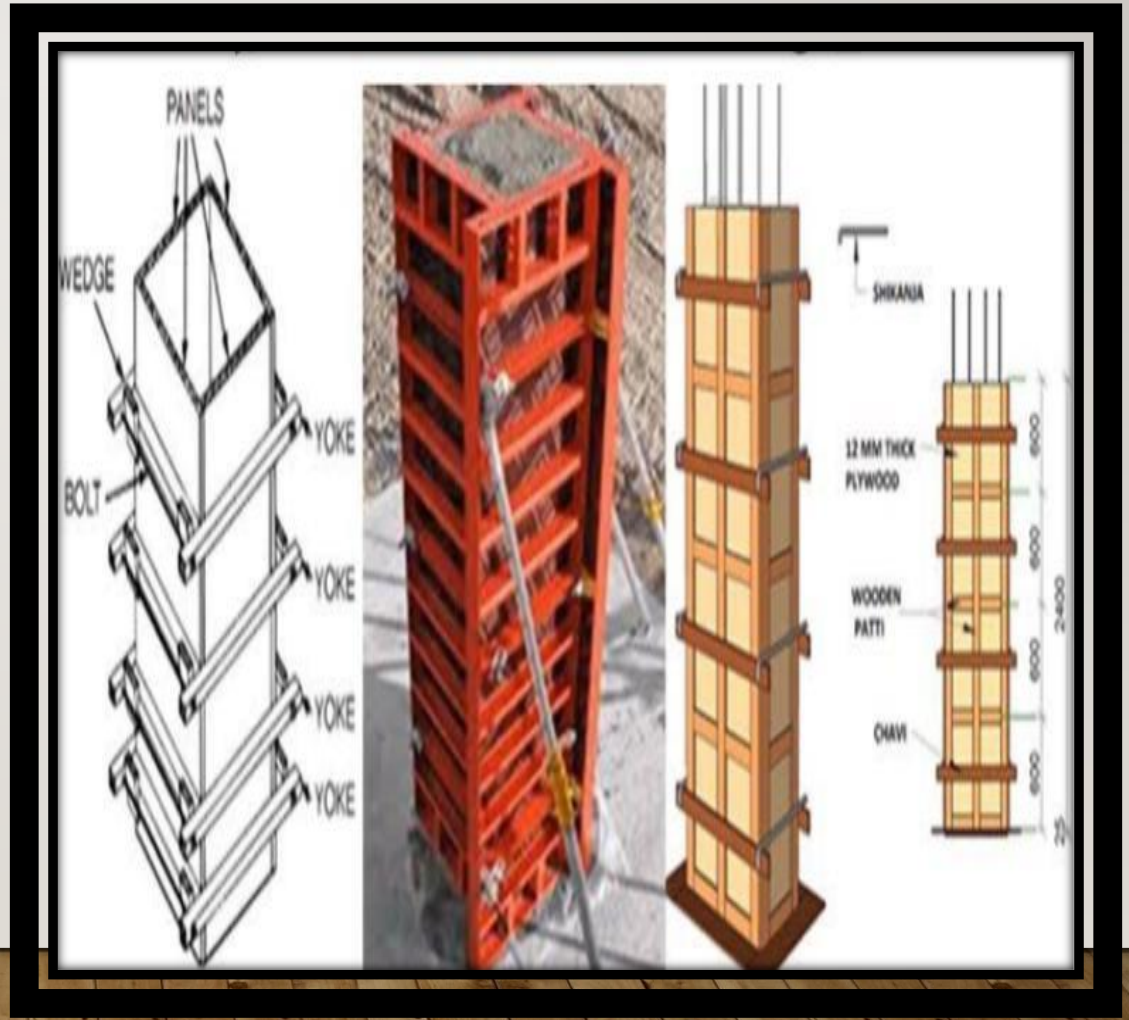
10. The forms should be cleaned and oiled after each use.

11. The use of construction joints should be made to reduce the quantity of forms and to make re-use of forms.

12. If mechanical vibrators are to be used then bolts must be used in place of wire ties or nails to ensure safety.

COLUMN FORMWORK

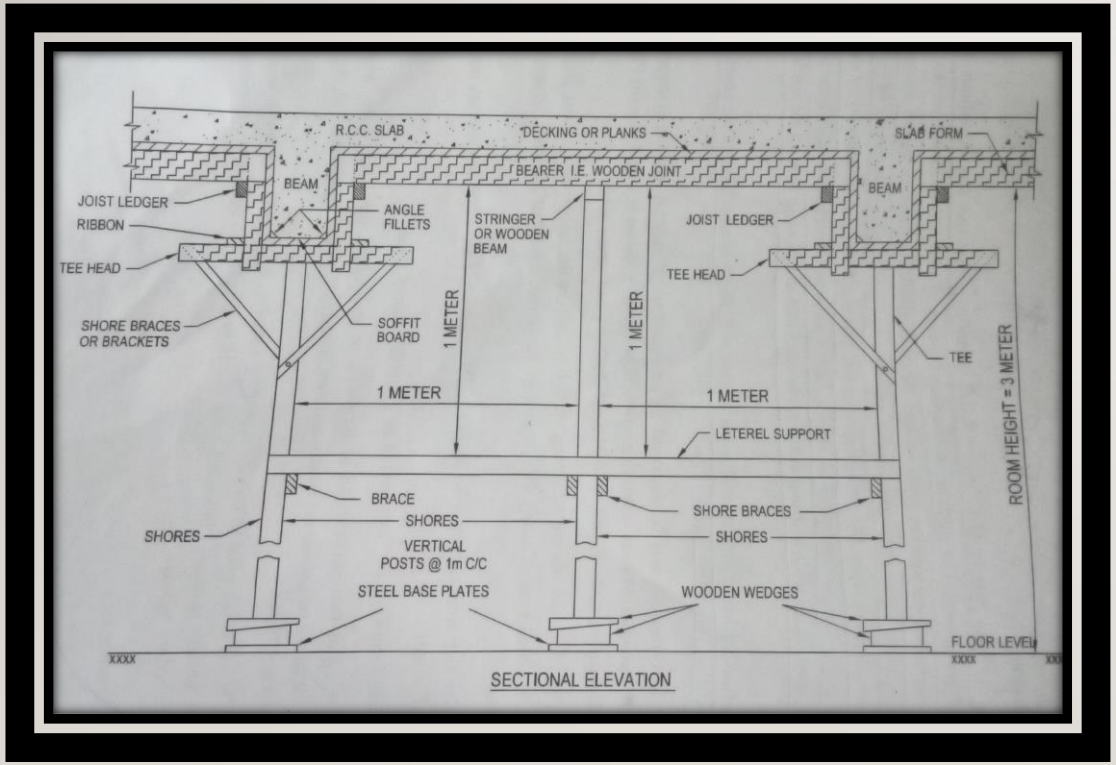




. Following features of the form- work for these R.C.C. Columns should be noted.

- Column box consists of two ends (See Fig. 8.1 plan fixed with wedges) and two sides (with yokes), each built as panel of planks sheeting. At top, cuts are made if column is to receive girder or beam as shown.
- The height of each panel is equal to the storey height minus the slab thickness and the floor sheeting.
- The width between two opposite panels is kept equal to the actual dimension of the column plus twice the thickness of sheeting.
- Yokes are equally spaced on both the sides and ends. They project at both the ends by about 25 cm.
- A hole is usually provided at the bottom of formwork to remove debris, etc ., before placing the concrete. This clean-out hole is covered before starting the concreting work.
- Formwork components for any column are required to be designed properly to resist high pressure resulting from the quick filling of the concrete.

FORMWORK OF SLAB



CONSTRUCTION:

- In Fig. the details of form for R.C.C. Beam or girder and slab monolithic floor construction are shown.
- The decking or sheeting consists of plywood or timber planks. The decking is supported on wooden joists (called bearers) which are properly spaced depending upon the loads to be borne within permissible deflection limits.
- The maximum spacing of vertical posts or shores depends upon the strength of stringers (wooden beams) or the capacity of shores to bear the loads.
- The vertical posts or shores, lateral supports, shorebraces, steel base plates and wooden wedges, provide a strong centering to beam and slab floor to bear all the loads due to them.

The following important features in connection with this formwork for R.C.C. Beam and floor construction should be noted.

1. Slab formwork may be supported by arrangements, namely (a) Decking is supported by means of wooden centering on the floor below as shown in Fig. or (b) Planks decking is made to rest on the top of the beam and girder sides.
2. The formwork should be strong enough to support the weight of concrete plus the additional load of nearly 30% to account for labour, storage of materials, equipments etc.
3. The slab formwork may be made of steel forms while the other components may be of wood.
4. The formwork for floor should be given the desired slope.
5. To avoid the construction of formwork or scaffolding, the beam formwork is fabricated on ground level first,and then hoisted and placed in position with the slab above
6. When it is intended to provide secondary beams on the main beams, proper openings at suitable locations in main beams should be provided to receive the formwork of secondary beams.

FORMWORK OF BEAM

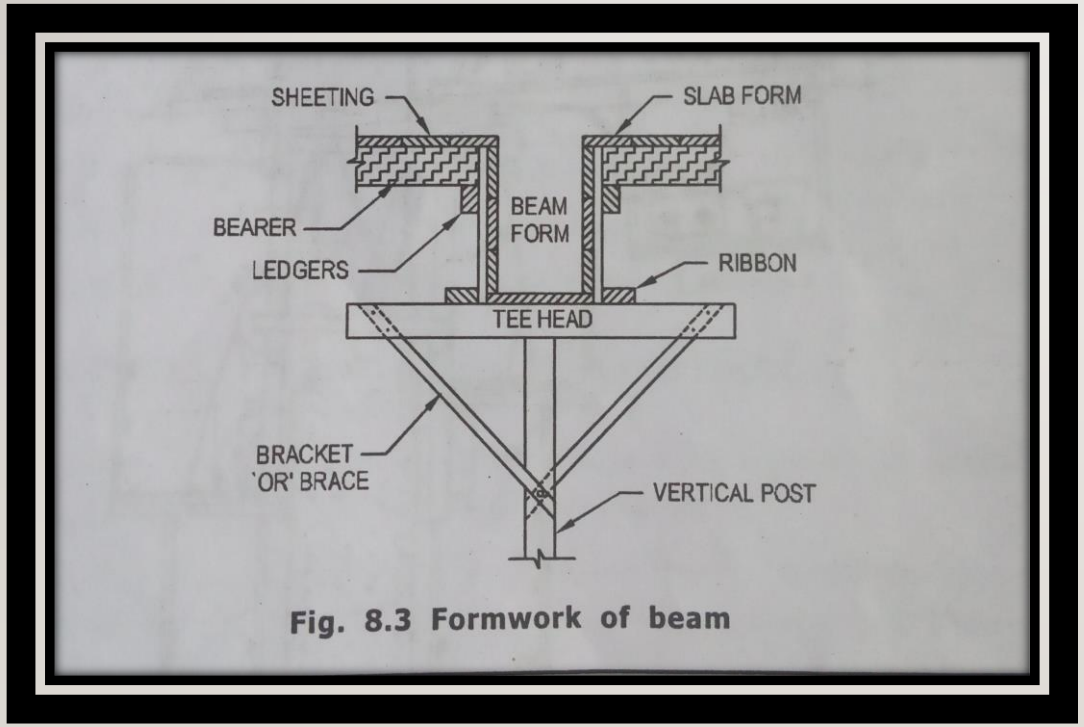
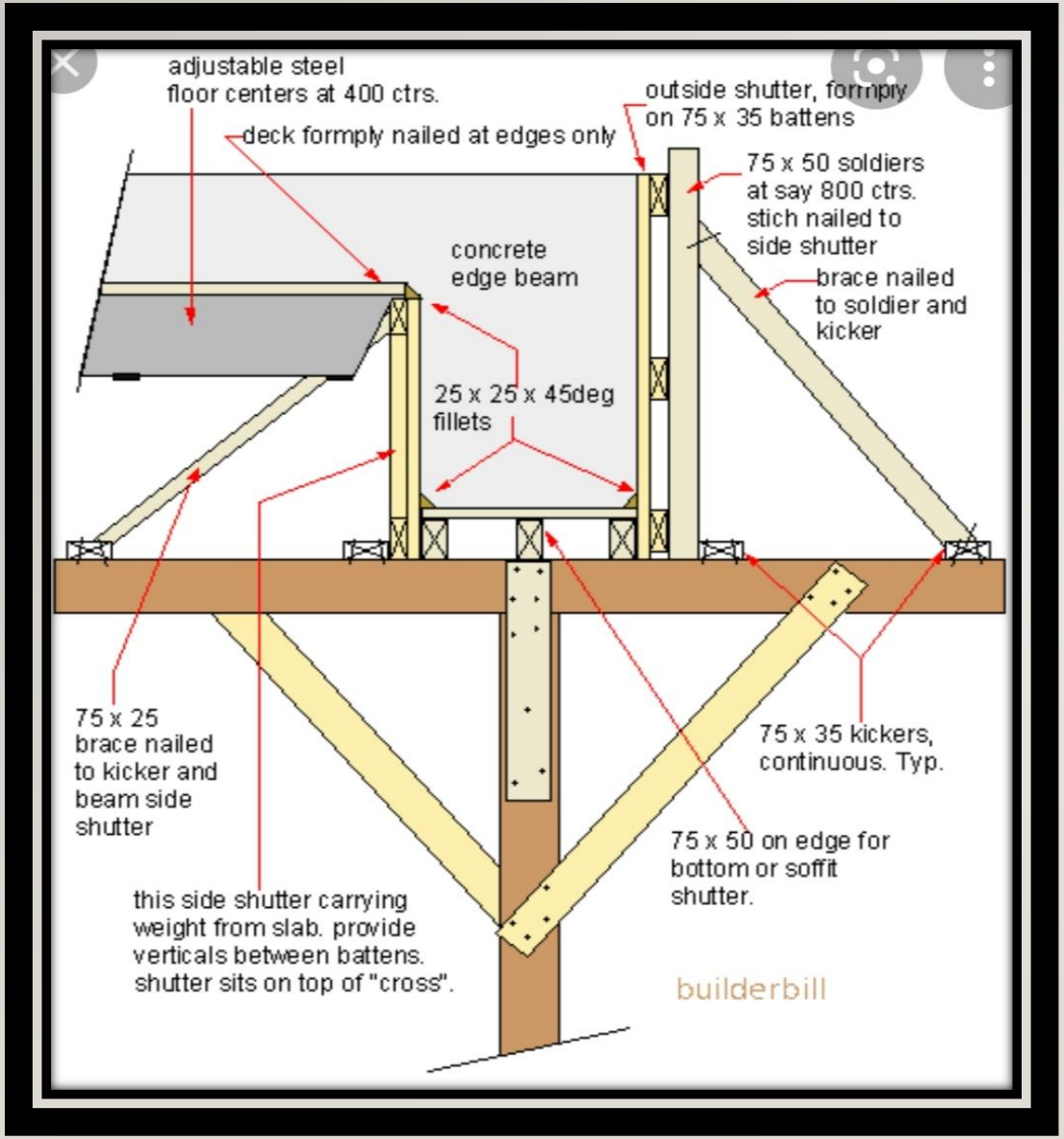


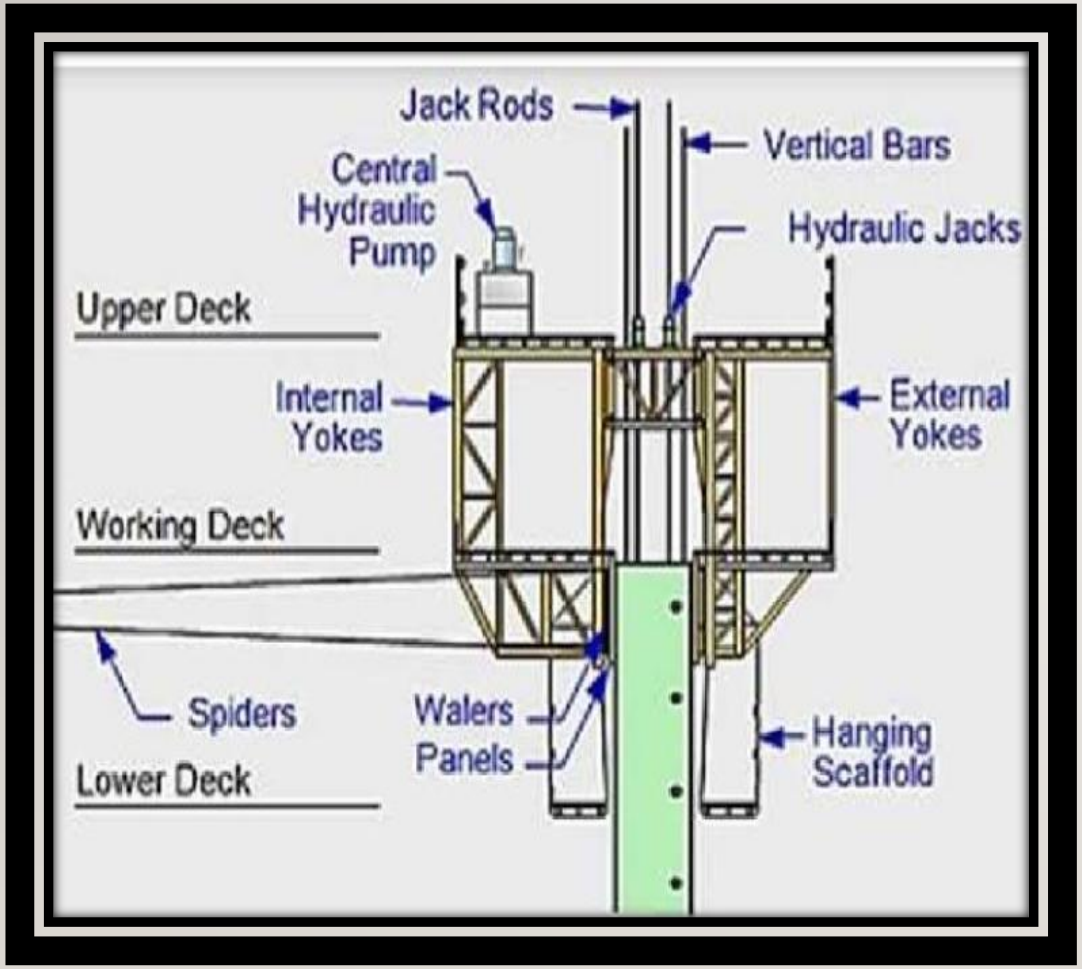
Fig. 8.3 Formwork of beam

- The details of formwork for an R.C.C. Beam which is usually constructed monolithically with a slab, is shown in Fig..The boxes for beam consist of two sides and one bottom supported on vertical posts.These boxes are shaped to the exact dimensions of the rib of the R.C.C. Floor.


adjustable steel
floor centers at 400 ctrs.
deck formply nailed at edges only
outside shutter, formply
on 75 x 35 battens
75 x 50 soldiers
at say 800 ctrs.
stich nailed to
side shutter
concrete
edge beam
brace nailed
to soldier and
kicker
25 x 25 x 45deg
fillets
75 x 25
brace nailed
to kicker and
beam side
shutter
75 x 35 kickers,
continuous. Typ.
75 x 50 on edge for
bottom or soffit
shutter.
this side shutter carrying
weight from slab. provide
verticals between battens.
shutter sits on top of "cross".
builderbill

SLIPFORM

- Slip form technique is a special technique of placing concrete. This technique is generally adopted for tall structures like chimneys and silos. It is also adopted for pavement construction. This technique is useful for vertical construction as well as horizontal construction.
- In case of vertical constructions like chimneys and silos, using slip-forming, concrete is continuously placed, compacted and formwok is pulled up by hydraulic jacks, giving reaction against main reinforcements. The rate of slipping the formwork depends upon the temperature and strength development of concrete to withstand without the support of formwork. This technique is suitable for uniform shaped structures. However, it can be adopted for irregular shaped structures with certain precautions.
- This technique was adopted for the core construction of Bombay stock exchange building having irregular shape and many openings. The core of 380 feet tall structure was completed in 38 days with formwork slipping rate of about 12.5 cm per hour.



Advantage of slip formwork :

1. The construction of joints is eliminated. Hence, for structures which must be watertight, the slip form construction is most desirable.

2. The construction work can be carried out speedily.

3. There is considerable saving in cost of forms as there is less wastage of forms and they can be used several times.

Uses of slip forms :

1. Construction of chimneys, silos, piers, towers etc.

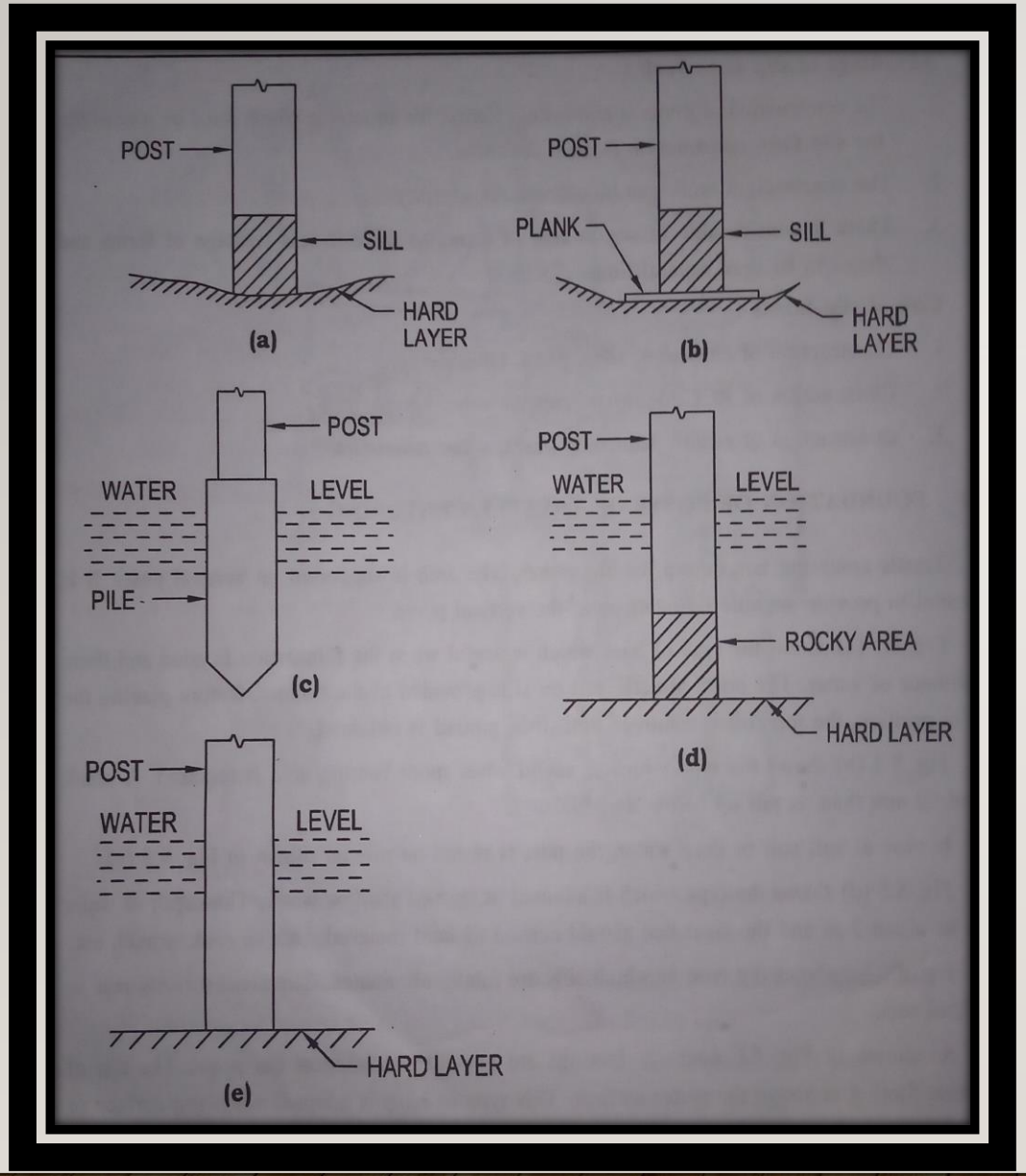
2. Construction of RCC highways, express ways.

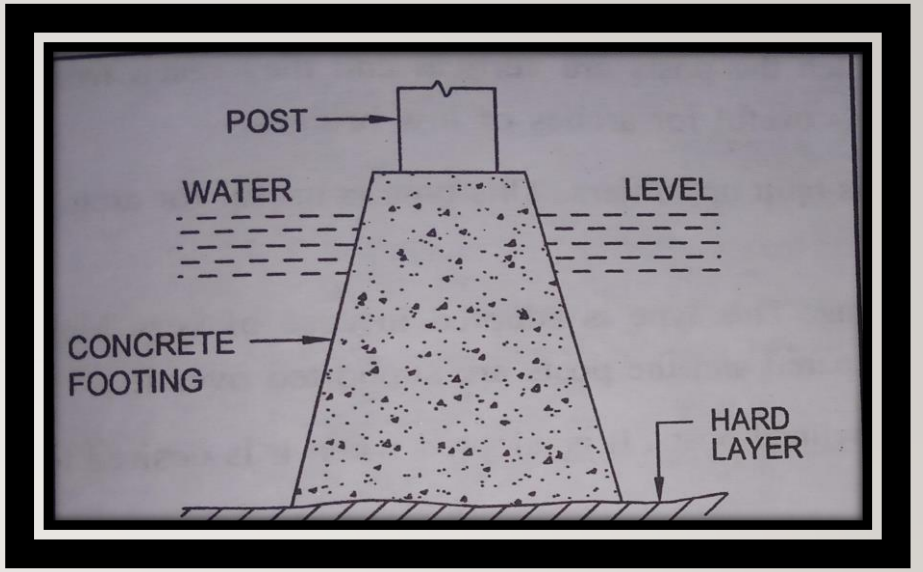
3. Construction of missile launching bases, water reservoirs.

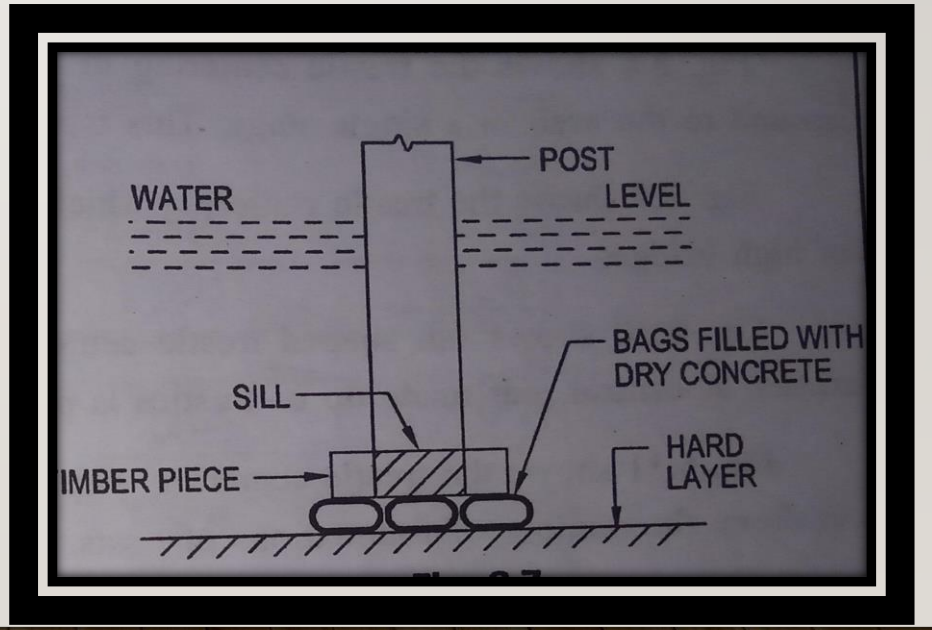
FOUNDATION OF POSTS OF TRESTLE CENTERING

Trestle centering is required for big arches. The arch is supported on vertical posts. It is essential to provide suitable foundations to the vertical posts.

- Fig. (a) shows the type of base which is useful when the foundation is good and there is absence of water. The posts directly rest on sills provided at the bottom. Before placing the sill in position, the top soil is removed until firm ground is obtained.
- Fig. (b) shows the type which is useful when more bearing area is required. A plank about 50 mm thick is put up below the sill.
- In case of soft soil or deep water, the post is rested on pile as shown in Fig. (c).
- Fig. (d) shows the type which is adopted in case of shallow water. The depth of water may be about 2 m and the river bed should consist of hard material such as rock, gravel, etc.
- Fig. (e) shows the type in which sills are totally eliminated. The posts directly rest on the hard rock.


POST
SILL
HARD LAYER
(a)
POST
PLANK
SILL
HARD LAYER
(b)
POST
WATER
LEVEL
PILE
(c)
POST
WATER
LEVEL
ROCKY AREA
HARD LAYER
(d)
POST
WATER
LEVEL
HARD LAYER
(e)

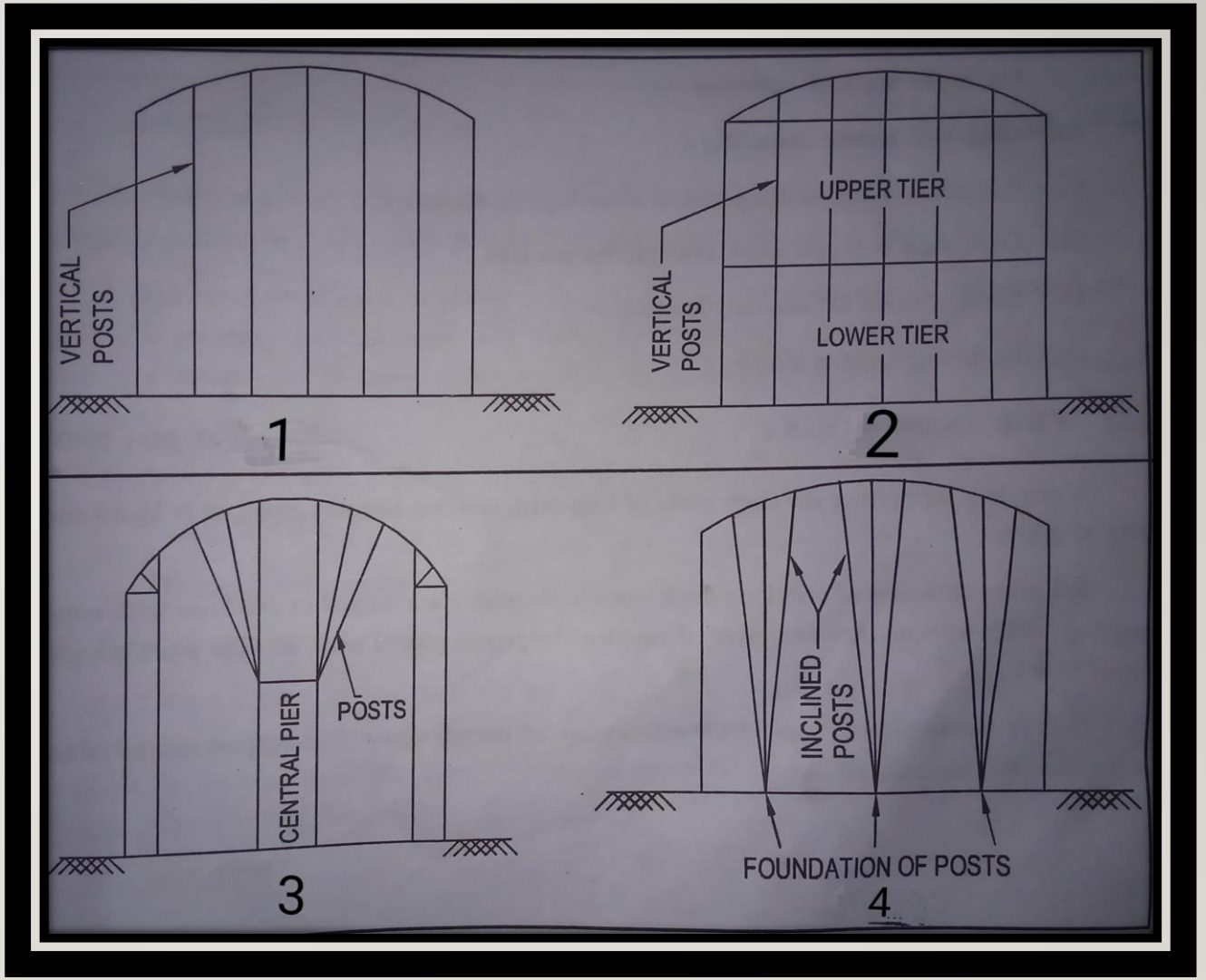

POST
WATER
LEVEL
CONCRETE FOOTING
HARD LAYER


POST
WATER
LEVEL
BAGS FILLED WITH DRY CONCRETE
SILL
IMBER PIECE
HARD LAYER

- As shown in Fig. 1 concrete footings are provided to support the posts. The top of concrete footing is above the water surface. This type of base is adopted when top surface of ground is too soft to use timber sills and it is uneconomical to drive piles.
-
- When the depth of water exceeds 1.2 m but less than 3.0 m the type of base shown in Fig. 2 may be used. In this type, the cross pieces of timber are attached to the bottom of post such that it takes the form of an inverted T. One or more bags filled with dry concrete are then attached to the bottom of post.

TRESTLE CENTERING

The term 'trestle centring' is used to mean that the arch is supported by posts resting on the ground..



- Fig. 1 shows the trestle centering in which the posts are vertical and they reach from ground to the arch in a single stage. This type is useful for arches of low bridges.
- Fig. 2 shows the trestle centering which is built up in tiers. This type is useful for arches of high bridges.
- Fig. 3 shows fan shaped trestle centering. This type is adopted in case of very high arches. A central pier made up of trestles is prepared and the posts are supported over it.
- Fig. 4 shows the trestle centering with inclined posts. It is adopted when it is desired to cut down the number of foundations of posts.

Uses of trestles :

- To support bridge arches

-For painting work at higher elevation inside the building

-For electrification

-For repair work of buildings

Advantages of trestle centering :

-It is ecnomical as compared to other type of centering.

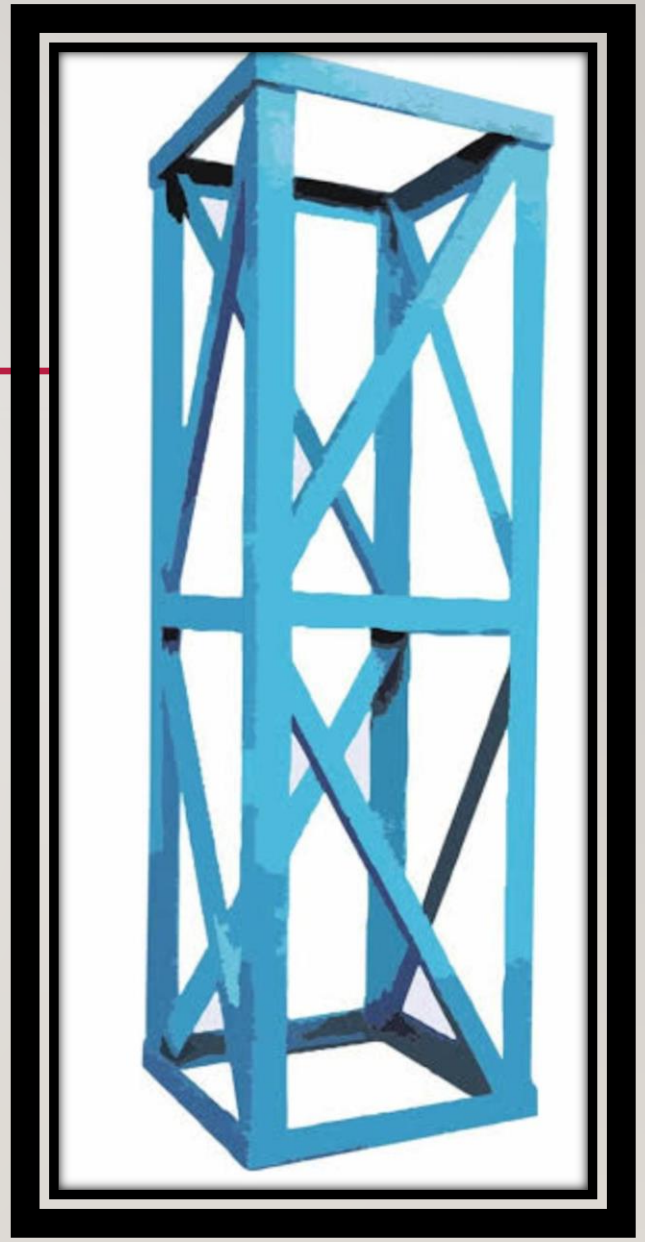
-Deflection is less. Failure possibilities are less.

-Salvage value of materials is more.

-Its arrangement is simple.

CRIB AND IT'S USES:

- A crib is a supporting structure made of long-thick wooden sleepers arranged in layers one over another.
- In the construction of crib long-thick wooden sleepers are arranged in one layer with some spacing between them. Another layer of wooden sleepers is placed over the first layer at right angle to it.
- Crib is mainly used to support the railway culvert during repair or to support the rail when soil below rail has washed out.



FORMWORK OF DOMES

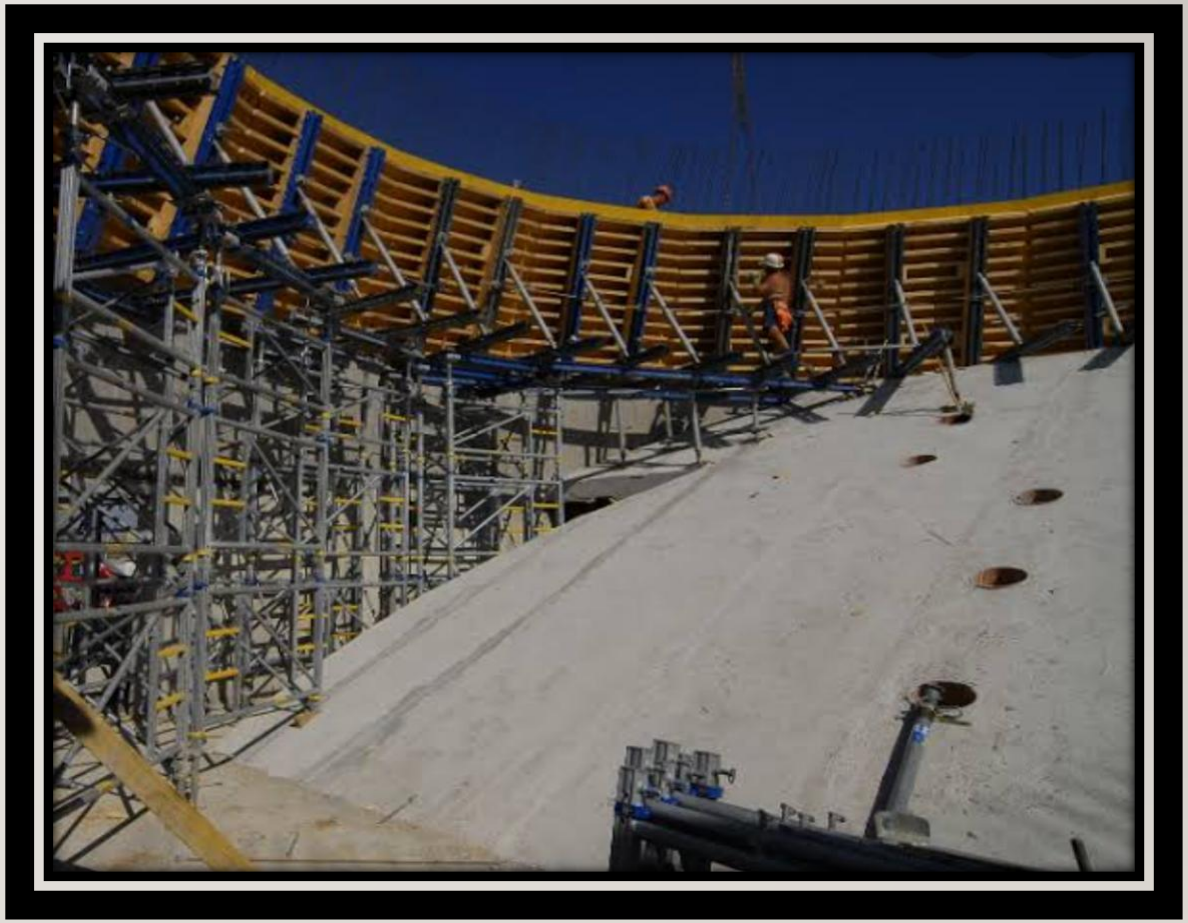
The dome is a three dimensional space which is used to provide an easy and economical method of roofing to a large area. It also gives good appearance to the structure.

A dome roof structure is generally semi-spherical or semi-elliptical in shape and is constructed in masonry, RCC or steel .,The diameter of dome may vary from 12 m to 20 m or more.The construction of dome structure in RCC or masonry requires the use of some type of formwork.

There are two types of dome formwork

(1)Solid formwork

(2)Suspended formwork



(1)SOLID FORMWORK

- In this type, the posts are carried from plinth up to the springing level of the dome. This type of formwork is adopted when there are projections around the dome and no solid walls are available for the support of the formwork. Cross-connections are provided at each floor level to increase the rigidity of formwork.

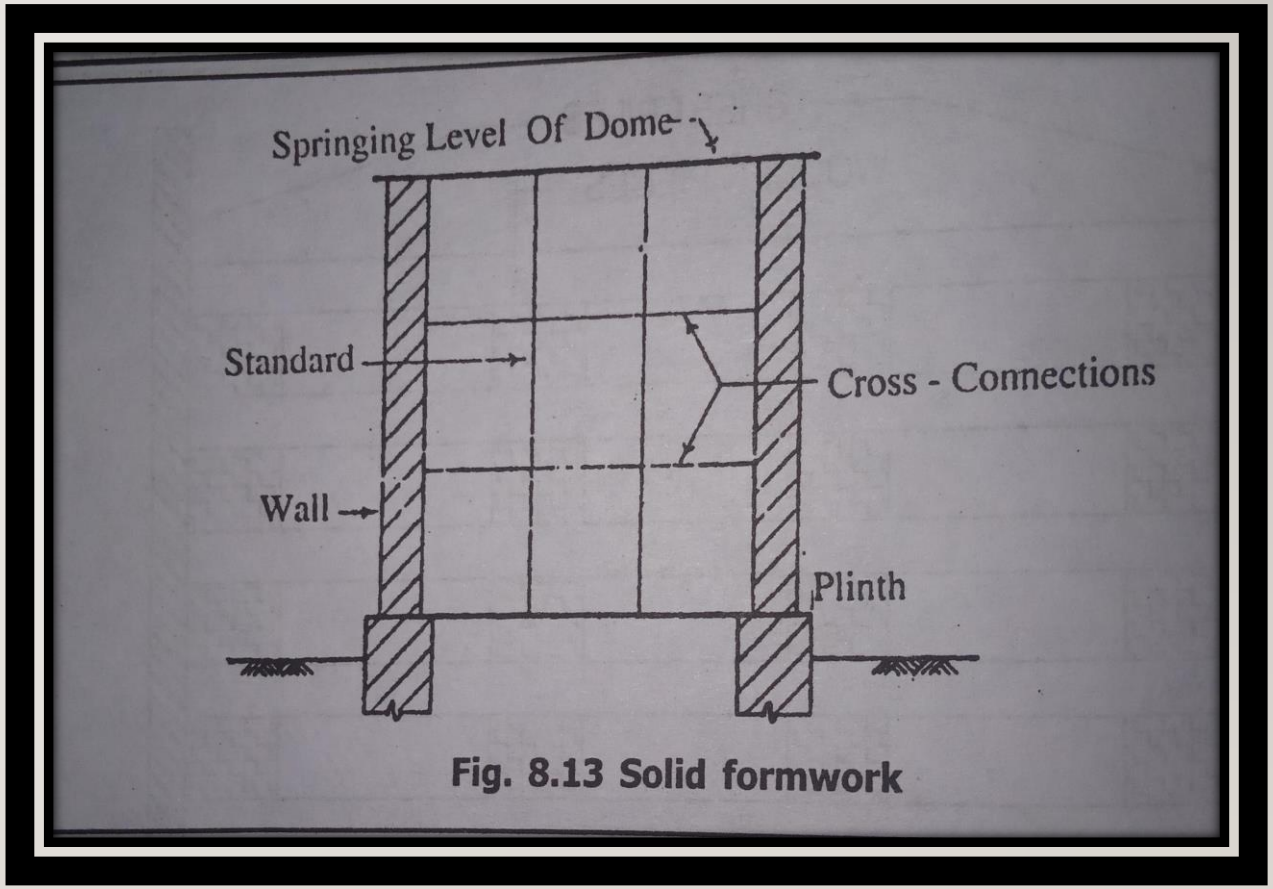
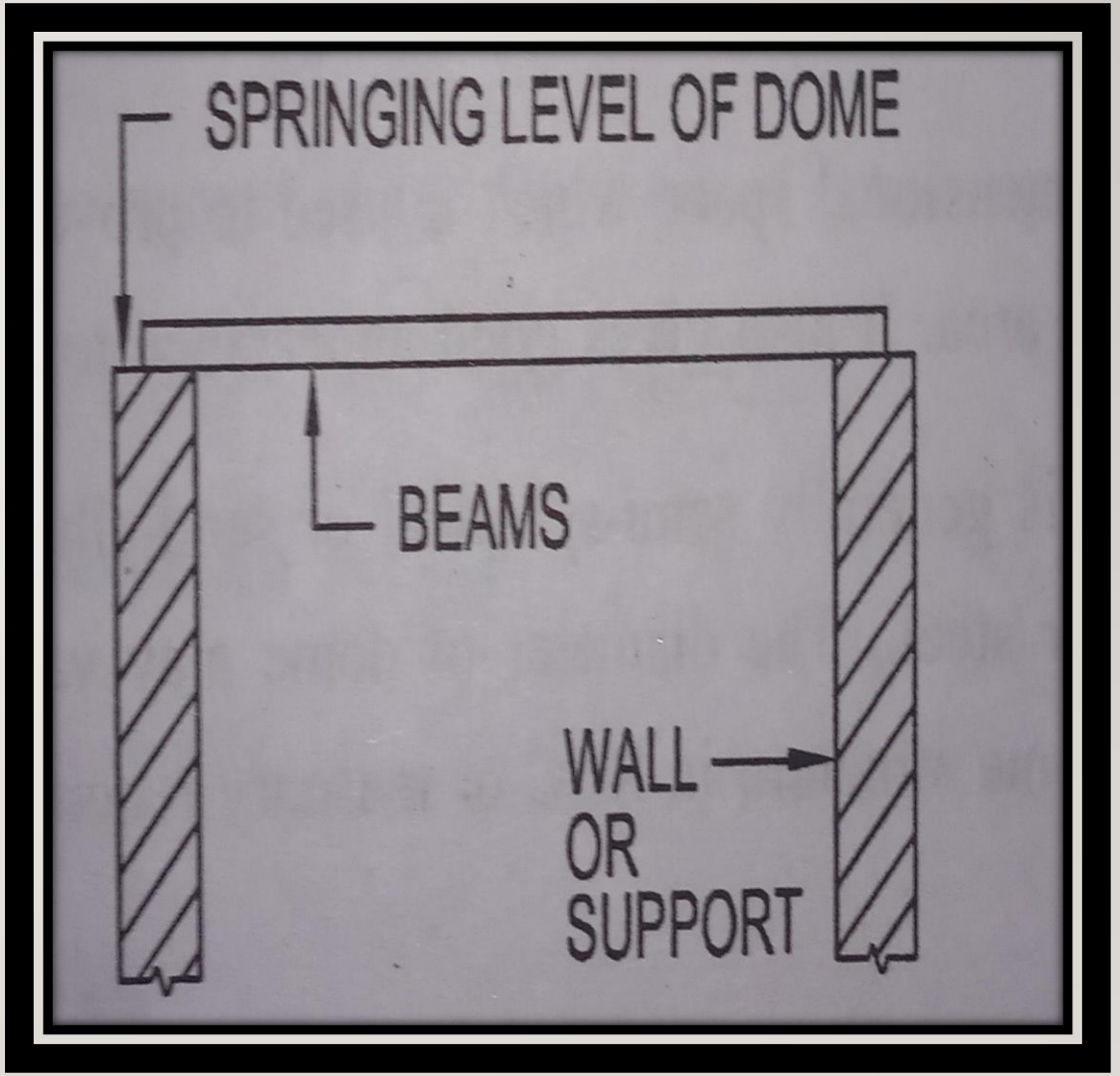


Fig. 8.13 Solid formwork

(2) SUSPENDED FORMWORK

- In this case, a skeleton of formwork is suspended from the springing level of the dome.
- This type of formwork is used when solid walls are available at the springing level of dome for supporting the formwork. Suitable beams of formwork are supported on these solid walls.



CONSTRUCTION OF PRE-STRESSED CONCRETE BRIDGE

- Most of the long span bridges are built using prestressed concrete. These bridges are built by the cantilever method developed by a German engineer Finisterwalder. This method eliminates the use of expensive formwork and scaffolding especially for bridges in deep valleys and rivers with large depth of water.
- There are two major methods of cantilever construction :
- (1)Cast-in-situ construction
- . (2)Construction using precast segments

RIO AND NITEXIO ACROSS GUNABARA BAY IN BRAZIL

(1) CAST-IN-SITU CONSTRUCTION:

- In this method, the bridge is cast in situ with sections 3-6 m long, cantilevering symmetrically on both sides of the pier. The form work for cast in situ construction is supported by steel frame work attached to the completed part of the bridge and the formwork moves from one completed section to the next section.
- The main steps in this method are :
- (1)Fabrication of steel truss and shuttering to suit the length of the cantilever beam.
- (2)Placing of reinforcement and duct tube to house the high tensile cables.
- (3)Concreting using the designed concrete mix.
- (4)Curing of concrete until it develops the desired compressive strength.
- (5)Threading the high tensile cables in the ducts followed by stressing using jacks and anchoring and grouting of the cables.
- (6)Releasing the formwork and moving on to the next section.

(2)CONSTRUCTION USING PRECAST SEGMENTS:

- In this type of construction, the bridge segments comprising structural elements (mainly segmented single or multi cell box girders) are cast in a casting yard using special forms. These segments are cured for specified number of days and transported to the work site.
- The precast segments are placed in position by means of a mobile launching girder or when access under the bridge is possible, with barger or trucks by means of a crane or a mobile hoist located at the extremity of the cantilevers.

TIME OF REMOVAL OF FORMWORK :-

Sr. No	Structural Member	OPC (Ordinary Portland Cement)	Rapid Hardening Cement
1	Beam sides, walls & Columns	2-3 Days	2 Days
2	Slab (Vertical Supports remains intact)	4 Days	3 Days
3	Slab (Complete Formwork removal)	10 Days	5 Days
4	Beams (Removal of Sheeting, Props remains intact)	8 Days	5 Days
5	Beams & Arches (Complete formwork removal) (up to 6 m span)	14 Days	5-8 Days
6	Beams & Arches (Complete formwork removal) (more than 6 m span)	21 Days	8-10 Days

MAINTENANCE OF FORMWORK:-

- Due to continuous use wooden planks & steel plates surfaces become uneven and require maintenance.
- For wooden formwork use cardboard or plastic fiber board. Bolt hole places must also be repaired.
- For steel formwork plates must be leveled by mallet and loose corners must be welded.

SAFETY PRECAUTIONS :-

- Material used for the construction of formwork must fulfill the specification.
- Formwork is fixed firmly & properly.
- Construction area must be protected to prevent of formwork.
- Warning sign must be put up at the area where the formwork is fixed to prevent entrance of people that may damage the formwork.
- The formwork must be inspected before the concrete is poured.

THANK YOU

COURTESY DR R.P.RETHALIYA SIR