UNIT 16 FORMWORK AND SCAFFOLDING

Structure

16.1 INTRODUCTION

In previous unit you studied about Piles and Caissons and their construction methods etc. In this unit, you will study Formwork and Scaffolding.

The term "**Formwork**" indicates a temporary structure erected to receive wet concrete and to hold it in place, till it is sufficiently hard and strong to be self-supporting without any deformation. The other synonymous terms used are: shuttering and centering. The formwork can be of different materials and different types depending upon the type of structure and site requirements, economy, safety and quality required in the finished work.

The "**Scaffolding**" is a temporary structure which is used in building construction to support platforms for workers, structural materials and construction equipment required during construction at elevated heights. The scaffolding is useful in building construction, maintenance, demolition and repair works.

Objectives

At the end of this unit, you should be able to :

* distinguish between 'Formwork' and Scaffolding,
* describe different materials used in formwork and scaffolding,
* describe essential requirements of formwork and scaffolding, and
* understand functioning of different types of formwork and scaffolding.

16.2 FORMWORK

The economical design and construction of formwork is of great importance as the cost of formwork is a large proportion of the total cost of the structure and is most difficult part to estimate. The appearance of finished structure and the speed with which the work can be executed also depend mainly on the efficient construction of formwork.

Although the formwork is a temporary structure, which should be readily dismantable and removable, it is designed to withstand the likely pressures and loads coming on the member during concreting. Poor formwork design and performance leaves behind permanent scars on the structure and has led to failures in concrete construction. Some of the common deficiencies noticed are lack of allowance in design for loadings like wind, equipment, temporary material storage, inadequate anchorage against uplift, insufficient slenderness ratio of compression members, impact of construction equipment and leaking joints etc.

Let us now first examine the requirements for a good formwork.

16.2.1 Requirements of Good Formwork

a) It should be carefully designed, so as to be strong enough to resist the pressure of fresh concrete and the super-imposed loads due to men, materials and equipment etc.

b) It should be rigid enough to retain its original shape without undue deformation which is normally restricted to 1/300 th of span in normal cases.

c) It should be tight enough so as not to allow cement and other materials to leak through the joints.

d) The formwork should not warp, bulge, bend or sink and should remain true to the designed size.

e) The inner surface of the formwork should be smooth so as to give pleasing appearance to the finished surface. The inner surface is also applied with mould oil to facilitate its removal.

16.2.2 Economy in Formwork

A formwork system is economical only when it fulfils all the tasks on hand with a few versatile components. You are aware that total cost of concrete construction includes the cost of the formwork. However, sometimes the cost of formwork, which actually does not form part of the finished concrete structure, may exceed the cost of concrete itself. Therefore, we should make all efforts to minimise the cost of formwork while keeping the safety aspects in view. Formwork cost mainly constitutes the cost of materials and labour required for fabrication, erection and removal of forms. These costs can be minimised by keeping some good points in mind which will lead to economy in formwork. These good points, steps or measures are now given below :

a) Avoid use of irregular shapes of forms.

b) The formwork should be fabricated into modular sizes and in sufficient numbers so as to allow re-use.

c) The structure components of the building should be so dimensioned and designed, so as to permit use of commercially available forms in the market.

d) The working drawings of the formwork should be properly prepared and checked before fabricating the same.

e) The various components of the formwork should be prefabricated on the ground, using power equipment. This will reduce labour costs and delays and holdups in the work. Also, the labour can work more efficiently on the ground than on the scaffolding at an elevated level.

f) The formwork design should be balanced design so as to provide adequate and not excessive strength and rigidity.

g) Where possible, adopt assembly line methods in fabricating formwork to increase the efficiency of the labourers.

h) In timber formwork, where possible, use double headed nails to facilitate their removal.

i) Construction joints should be judiciously incorporated to reduce the quantity of forms required in one operation thus enabling re-use.

j) When mechanical vibrators are used, bolts must be employed instead of wire ties or nails to ensure safety.

k) The formwork should be handled and stacked carefully. It should be oiled and cleaned after each use to prolong its usage life.

16.2.3 Materials

The selection of materials to be used for fabrication of formwork is governed by job requirements and economy. The most commonly used materials are timber, plywood, steel and aluminium. When the formwork is to be used for small works and that too a few times, then timber proves to be more economical than steel or aluminium. However, if the formwork is required to be reused several times like in a multistoreyed building, then the use of steel or aluminium is preferred. In case of steel, though the initial cost is very high, but it proves to be economical when it is used repetitively in large works. Also the erection and removal of steel formwork are simple and present a better appearance on removal. Particularly in case of structures like round columns, carved surfaces, monolithic sewers, tunnels and similiar structure, the use of formwork should be made as a matter of expediency.

However, in Indian conditions, timber is still used quite commonly in smaller works. This is due to the fact that it is easily worked and that its use to a degree is traditional. Timber should preferably be softwood usually pine, fir or spruce which has been partially seasoned. Very dry timber will absorb moisture from wet concrete or atmosphere and swell, while green timber will shrink. Hardwood is not normally used as it is expensive, heavy and difficult to work and nail. When appearance of finished concrete is of little or no importance, clean sawn timber may be used, but in view of greater ease of fitting, the use of planed timber will often prove to be economical both in time and labour.

Sizes of forms also play an important role and are linked to the material used for formwork. The sizes should be based on the criteria given below :

a) If forms are prefabricated into panels or sections, it is desirable to fabricate them in sizes as big as the concrete members or the sizes which the adopted method of handling will permit. This helps in reducing the labour and time costs in erection and removal of forms.

b) If the formwork is to be handled manually, then the weight of a single panel should not exceed 35 kgs per person.

c) If the forms are to be handled by mechanized method i.e. power equipment, cranes etc. then the size of formwork is limited by the length of timber available, the dimensions of concrete structure and the capacity of the handling/hoisting equipment. However, timber has been gradually replaced by plywood and today a durable plastic coated material is available to the user. As timber is becoming expensive and rare day by day, the need for steel to replace timber has increased. Aluminium offers a good medium for light structural formwork. In the production of architectural concrete, formwork needs special attention and offers special challenges. For domes, inflatable forms over which concrete is sprayed is a novel technique with an innovative approach and with the range of materials available today, development of other forms is a distinct possibility.

16.3 TYPES OF FORMWORK

There are several types of formwork which are used in construction. Over the years some special forms like slip form, climbing form and permeable formwork have also been developed and are being used. We will now discuss different types of formwork, starting with the most common i.e. Timber Formwork.

16.3.1 Timber Formwork

The sizes of timber commonly used for various parts of formwork are given in Table 16.1.

Let us now examine a few timber formwork details.

a) **Formwork For Columns**

Formwork details for a rectangular or square column is given in Figure 16.1.

You may note some important features :

i) Column box consists of two ends and two sides.

ii) The height of each panel is equal to the storey height minus the slab thickness and the floor sheeting.

iii) The width between two opposite panels is kept equal to the actual dimension of the column plus twice the thickness of sheeting.

iv) Yokes are equally spaced on both sides and ends. They project at both ends by about 25 cm.

v) A hole is usually provided at the bottom of formwork to remove debris etc. before placing the concrete. This cleanout hole is covered before starting the concreting.

vi) The form components of column are required to be designed to resist high pressures which result because of continuous filling/pouring of concrete.

Table 16.1 : Dimension of Commonly Used Formwork Parts

Sl.No.	Part of Formwork	Timber Thickness or size
1)	Sheeting	2.5 to 5 cm
2)	Beam and column sides	2.5 to 5 cm
3)	Beam bottoms	5 cm
4)	Joists	5 cm × 10 cm to 7.5 cm × 22.5 cm
5)	Ledgers	5 cm × 10 cm to 7.5 × 22.5 cm
6)	Posts	7.5 cm × 10 cm to 15 cm × 15 cm
7)	Column Yokes	5 cm × 10 cm to 10 cm × 10 cm.
8)	Steeds and Wailings	5 cm × 10 cm to 15 cm × 15 cm

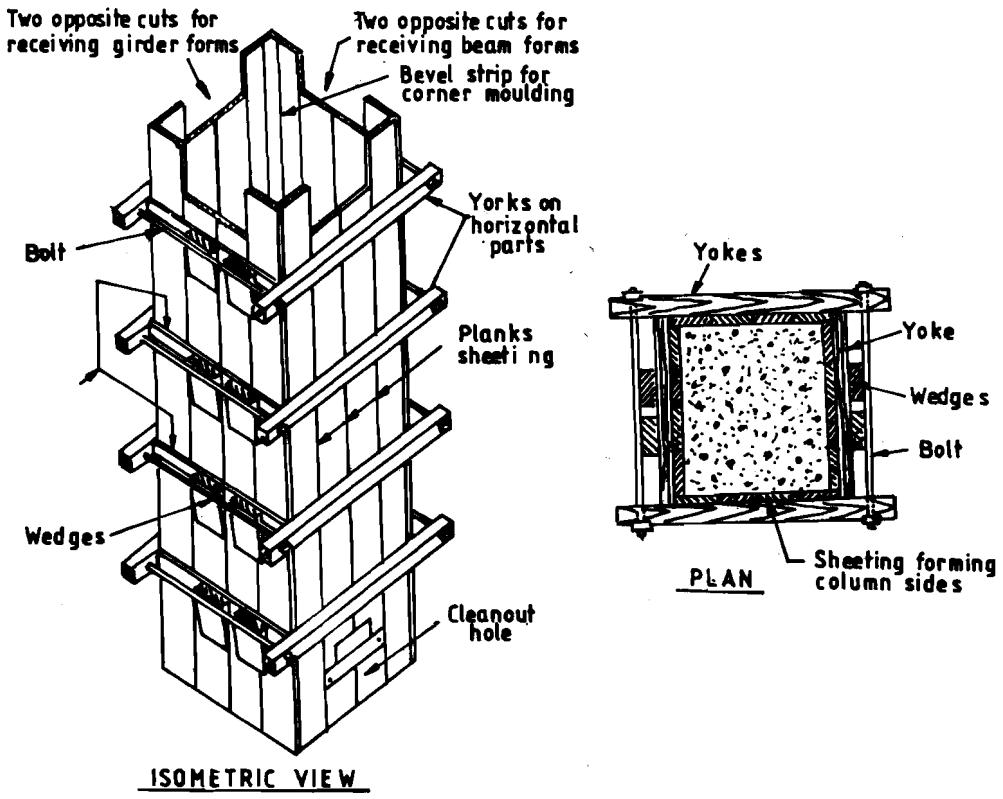


Figure 16.1 : Formwork for Column

b) **Formwork for RCC Beam and Slab Construction**

The details of formwork for this arrangement are shown in Figure 16.2.

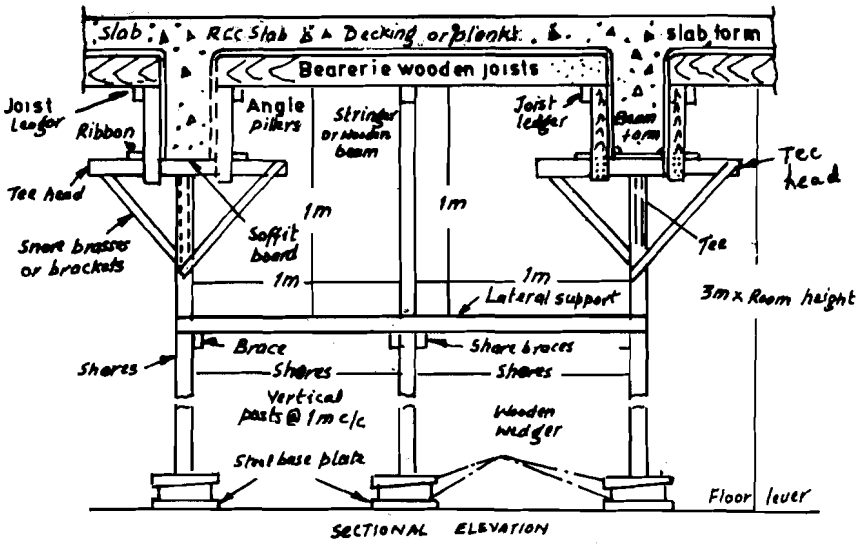


Figure 16.2 : Wooden Formwork for Monolithic R.C.C. Beam and Slab Floor

The important features of this formwork are as follow :

a) The formwork for slab is generally supported by means of wooden centering on the floor below.

b) The formwork should be strong enough to support the weight of conterete and the additional load of approximately 30% to cater for construction loads like labour, equipment and storage of materials, etc.

c) The formwork for slab maybe of steel forms while the other components are wooden.

d) Desired slope should be given in the floor forms itself.

e) Generally, the beam formwork is fabricated on the ground level and then hoisted and placed in position with the slab formwork above it.

f) Openings should be provided in the main beam formwork to receive the formwork for secondary beams.

16.3.2 Steel Formwork

Steel forms are manufactured as proprietary articles by several firms. While constructional details vary with the manufacturer, some details are common in them. The forms may comprise standard flat or curved panel units or be made for a specific purpose. Generally speaking, flat panels maybe adopted to a wide range of usage and the manufacturers normally supply accessories to enable such adaptations to be made conveniently.

The panel units are normally made up of steel sheets reinforced with angle sections and are clipped together by keys and wedges or some such similar device to form panels. Horizontal and vertical stiffening is provided by bearers of angle section which are clipped to the made up panels (See Figure 16.3).

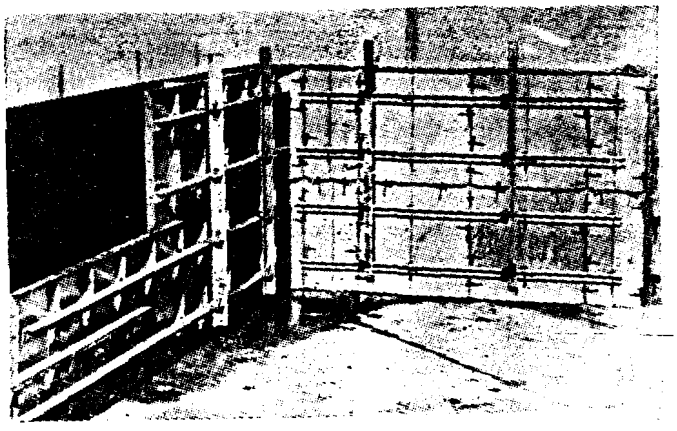


Figure 16.3 : Steel Forms

This method of assembly ensures rigidity and an accurate face. Flat panels are made in a variety of sizes but a common size is 60 cm × 60 cm with a range of narrower sections for use as closures.

The advantages of steel forms in comparison with timber are :

a) They can be easily and rapidly assembled by unskilled labour.

b) They have a long life even with minimum reasonable maintenance. They may be used upto about 50 times before repair becomes necessary whereas timber formwork cannot normally be re-used more than four or five times.

c) May be adapted to a wide variety of usage without alteration.

d) Are non-absorbent.

e) No shrinkage or distortion due to change in moisture content. The main disadvantage in comparison with timber is that initial cost is comparatively high but this is partly offset by reduced labour charges for assembly. Also where forms are repeatedly used their cost is less then that of timber forms.

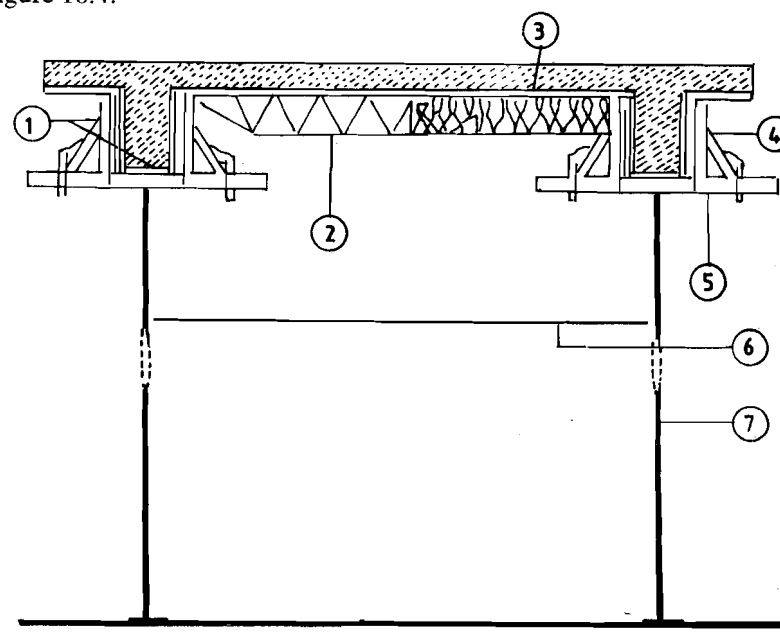
There are several proprietary steel forms available in the market. We will describe briefly a few just to illustrate, and this may not be construed as a recommendation and is only for illustration and information.

I) P - form shuttering

In this type of shuttering pressed steel sections are used to protect the edges of plywood shuttering which always deteriorates from the edges. Thus this system has all the advantages of plywood shuttering as well as normal steel wall - form shuttering as one can use all the accessories of steel shuttering with P - form shuttering.

II) Steel Forms

Steel forms for Reinforced beam and slab construction. A typical steel formwork combined with plywood for a reinforced concrete slab is shown in Figure 16.4.



1. 16 mm Thick Ply 2. Steel Truss Called Acrow Spans
3. Floor Form 4. 7.5 × 7.5 cm Teakwood Runner
5. Beam Clamp 6. Bracing 7. Steel Adjustable Prop.

Figure 16.4 : Centering for Reinforced Concrete Slabs

In the above figure it can be seen that floor forms/slab forms are placed on Acrow spans (steel truss) for reinforced concrete slab construction. The adjustable beam clamp holds timber, plywood or steel firmly and thus prevents bulging. This formwork is supported on adjustable steel props or telescopic props.

III) Grid Decking System

This system is designed for flat slab beams and slab, waffle and trough floor construction (See Figure 16.5).

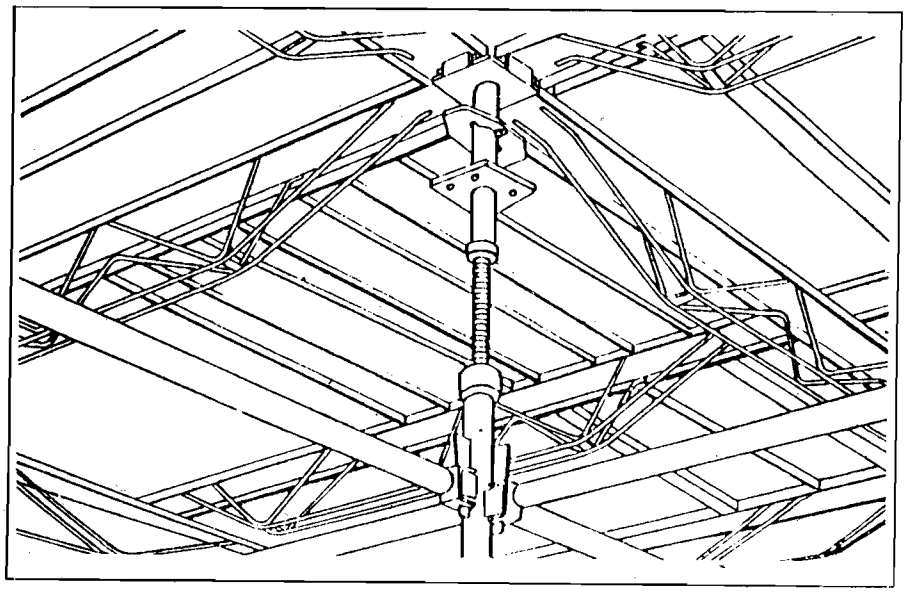


Figure 16.5 : Grid Decking System

The drop heads with their seatings in raised position are erected on adjustable jacks or verticals. Deck beams are secured on the drop head settings. Floorforms or plywood over infile beams at required spacing are placed between deck beams and jacks are adjusted to get the required level. The deck beams drop through 80 mm height after striking drop heads alongwith removal of formwork and thus leaving support to slabs, undisturbed.

IV) Wallform System of Formwork

The Wallform system of formwork with soldiers, walers and clips is a self supporting system. It is available for concreting walls in pour heights such as 1.25 m, 2.5 m, 5 m or more for buildings, water tanks, basement walls etc. One such system is shown in Figure 16.6.

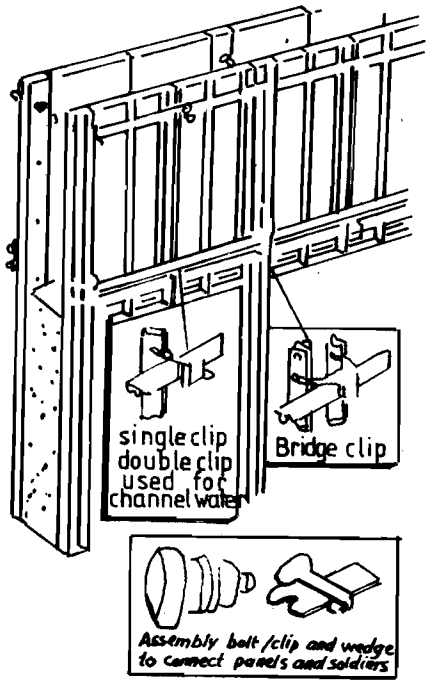
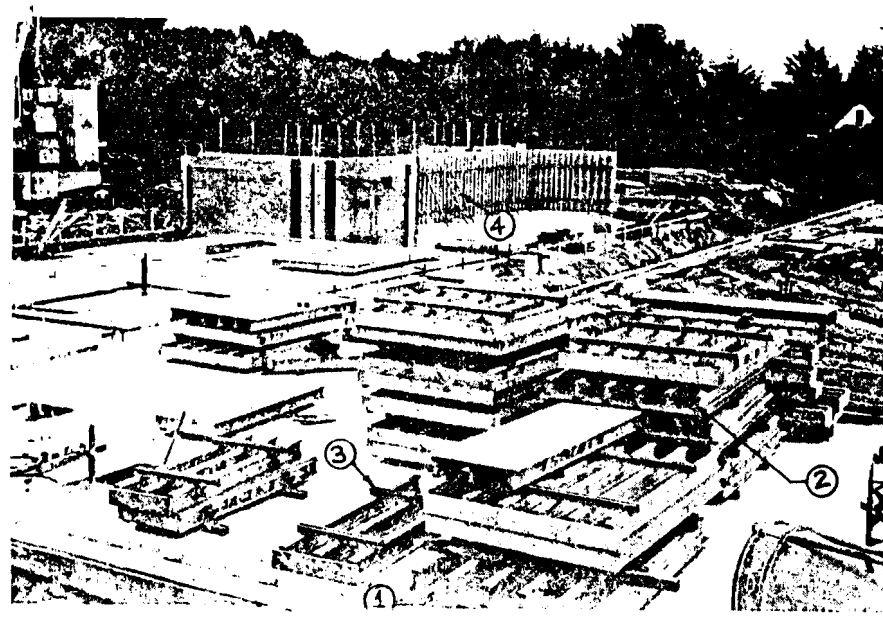


Figure 16.6 : Wallform Climbing Steel Shuttering

This wallform system is either for one sided shuttering or both sided shuttering with loop anchors or wall ties, embedded in concrete for anchorage.

Another system has a basic element called H-16 beam which is I - shaped plywood/timber beam. It is versatile, sturdy and handy, dimensionally stable, uniform in size and possess uniform high strength. For walls, H-16 beams are combined with steel walers to produce a light weight panel which can be easily assembled as required. This enables full size plywood sheets to be used as sheathing without the necessity of cutting them into smaller panels. This minimises the number of sheathing joints and helps in achieving good quality concrete surface. The Figure 16.7 given below will give you some idea of different parts of this system.



1. Plywood 2. H-16 Beam 3. Steel Walers 4. Adjustable Props

Figure 16.7 : Wall Formwork

V) Tubular Steel Formwork

This formwork is well illustrated in the Figure 16.8.

The example shown above is formwork for barrel shell-roofs. This formwork consists of tubular steel fittings and is extensively used for sheet-roof construction in developed countries. In this formwork steel sheet is provided at the top continuing in valley beams to receive the concrete. Adjustable jack bolts and props are provided to obtain varying heights of shell roofs as well as of ribs and valley beams.

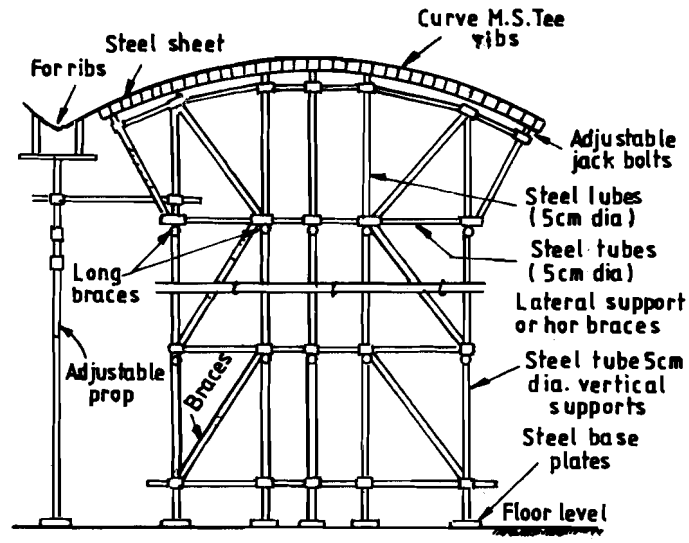


Figure 16.8 : Tubular Steel Formwork for Barrel Shell-roofs

16.3.3 Climbing Formwork

Climbing forms are used for tall structures and consist essentially of a narrow band of formwork encircling the structures, which is raised as work proceeds. They may be made up on site or be specially manufactured. Various proprietary forms are available in the market.

a) In most cases of climbing formwork, the height of concrete lift is restricted between 30 cms to 100 cms but certain types allow for continuous pouring in order to produce a joint free structure. In the latter case the formwork is carried in a yoke supported and raised by jacks resting on rods embedded and left in concrete or on posts erected on both sides of the walls (See Figure 16.9). Slip formwork is a good example of climbing formwork.

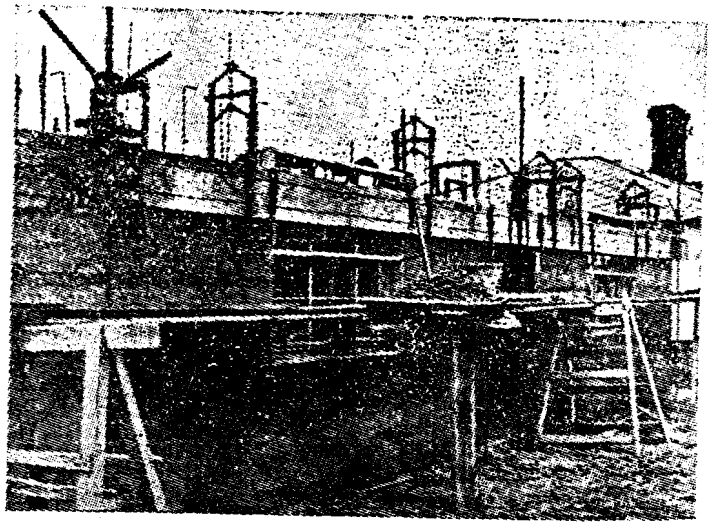


Figure 16.9 : Climbing Formwork

b) Steel forms are particularly suitable for this type of formwork. Two simple arrangements of climbing formwork using steel forms for thick walls are shown in Figure 16.10.

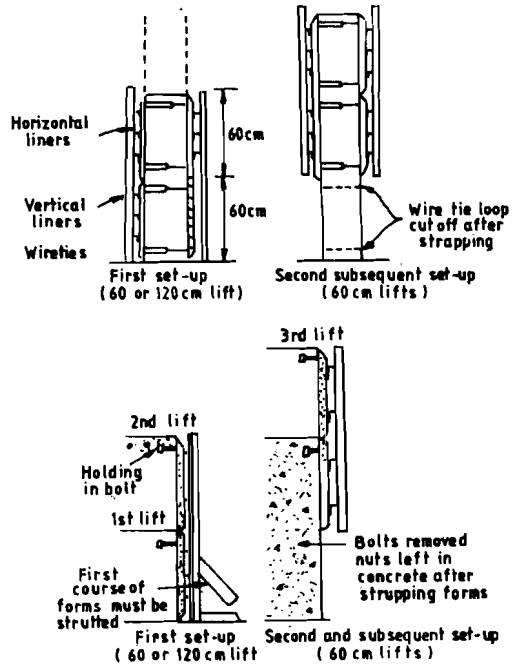


Figure 16.10 : Climbing Formwork of Steel Forms for Thick Walls

c) A sophisticated type of **climbing formwork** is shown in Figure 16.11.

This incorporates a working platform and is fitted with optional accessories like push-pull struts for aligning the formwork assembly. It also has rolling mechanism for side shifting of the formwork assembly to provide working space to fix reinforcement and other inserts in narrow and deep wall construction. The slip form and another type of climbing formwork are shown in Figures 16.11 and 16.12.

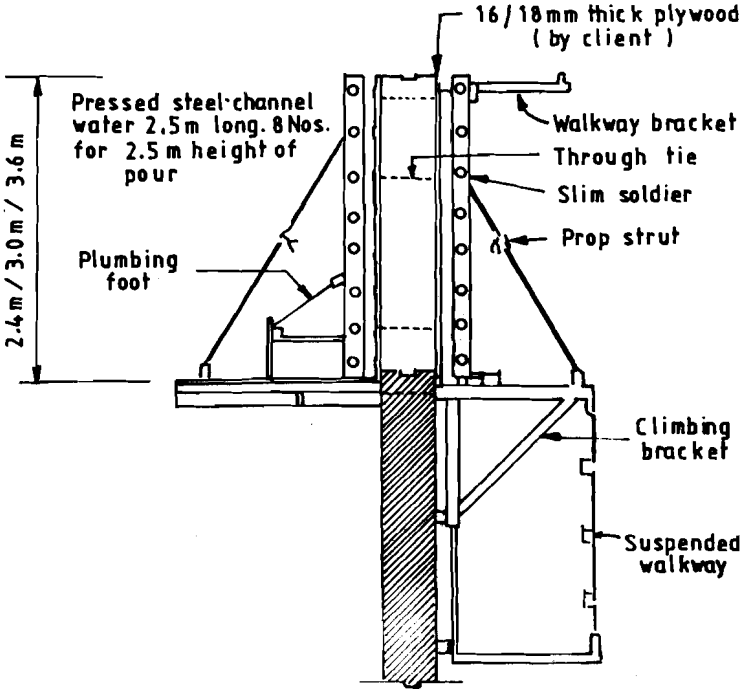
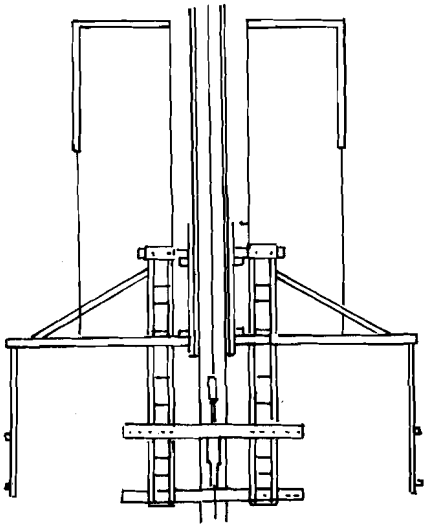


Figure 16.11 : Climbing Formwork



Form panels, straight or curved, are fitted to sturdy yokes with working platform, suspended walkways and safety railings Hydraulic jacks mounted on yoke beams climb on solid jack rods. The slipform is available for tapered structures also.

Figure 16.12 : Slipform

d) Automatic climbing formwork, which is another type of climbing formwork is also called self climbing formwork as it does not need any crane for the climbing operation. This system has certain special features which are enumerated below :

i) This system has automatic climbers which automatically hoist up the formwork step by step.

ii) Formwork for tall structures is solved conveniently and crane costs are cut down and work is speeded up.

iii) The entire work can be performed during the normal day shift and thus costly night and week-end shifts can be dispensed with.

iv) Since it provides stationary platform and formwork, it rationalises reinforcing and pouring operations.

v) The formwork is designed for safeguards against strong winds and other eventualities.

vi) The need for scaffolding is eliminated.

vii) It enables easy and speedy cleaning of form shutters.

viii) Since working space available is sufficient, it also allows better supervision and quality control.

ix) Concreting upto 1.5 metre per day is possible. It also allows adjustments for slope and precision alignments.

Thus, the use of this system is bound to lower the construction costs and result in higher productivity. In this formwork system the need for skilled labour is less as the need to make, fix and remove scaffolding is minimised, which reduces expenses.

A automatic climbing formwork for construction of cooling tower is shown in Figure 16.13. The formwork can be seen at the top of the cooling tower.

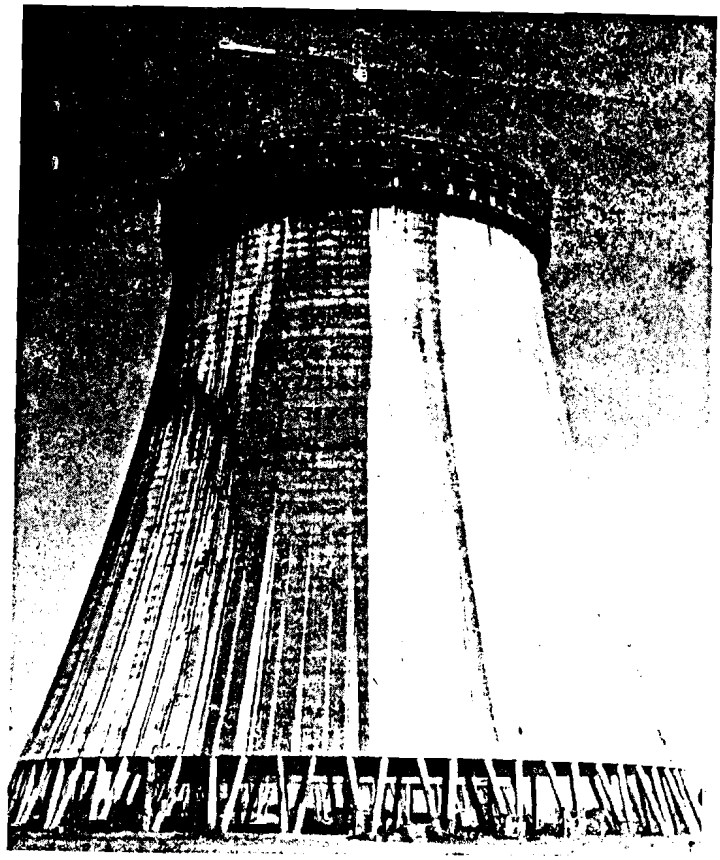


Figure 16.13 : Automatic Climbing Formwork for Cooling Towers

16.3.4 Moving Formwork

Where long lengths of concrete work of constant cross-section have to be constructed, moving or travelling formwork maybe used with advantage. In such cases a complete section of formwork is fabricated and assembled and is carried on some suitable form of travelling carriage running on railway lines or other suitable tracks. A typical example is shown in Figure 16.14.

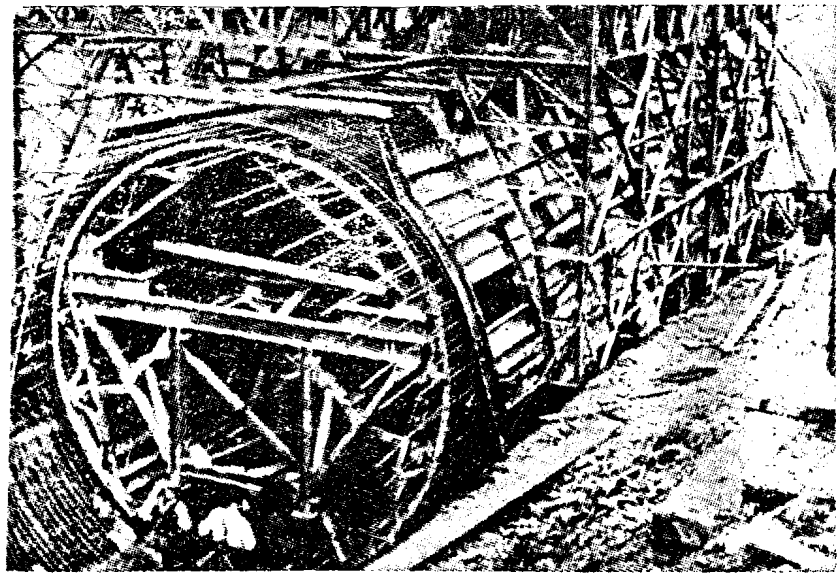


Figure 16.14 : Travelling Formwork

16.3.5 Permeable Formwork

The Japanese have pioneered and perfected the system of permeable formwork for vertical/inclined surfaces to improve the durability of concrete. The formwork is first prepared in the conventional manner. The sheeting of formwork can be of plywood or steel. Now a series of holes are drilled in a grid pattern to facilitate draining of water and

expelling of air when the concrete is placed and vibrated. Generally the hole diameter is 3 mm and their spacing is 100 mm centre to centre. Next, a woven fabric is fixed to the inside face of the sheathing of the formwork, such that no water remains trapped in the interstices between the fabric and the sheathing. For fixing to plywood, staplers may be used while for steel, glue or adhesive is used. The concrete mix used with permeable formwork generally has water-cement ratios in the range of 0.4 to 0.6. The permeable formwork is designed for all pressures as applicable to normal formwork.

When the concrete is placed in the formwork, high pore water pressure forms in the concrete in proportion to its depth. But the use of permeable formwork, allows dissipation of this pressure by draining off water. As a result, pore water in the concrete varies form high pressure in the core of the concrete to a low pressure at the face of the formwork. This movement and drainage of water improves the quality of the concrete for a depth of about 150 mm from the face of the permeable formwork. The lowered water - cement ratio results in reduction of permeability of concrete and improvement of surface quality of concrete.

16.3.6 Permanent Prestressed Concrete Formwork

Permanent forms are forms which are left in place, that may or may not become an integral part of the structural framework. These forms maybe of rigid type like metal deck, precast concrete, brick, ferrocement, wood, plastics and some types of fibre board. The flexible types could be like reinforced water repellent corrugated paper or wire mesh with waterproof paper backing.

Reinforced concrete, fibrous concrete and wood wool concrete have also been reported to be used as permanent formwork to cast structural members such as slabs and beam. Prestressed concrete can also be used in casting as it offers distinct advantages like higher strength to weight ratio over plains or reinforced concrete. The use of permanent formwork would also result in large savings in timber or steel forms and also results in savings in construction time.

SAQ 1

a) What are the advantages of steel forms over timber forms ?

b) Write a short note on the economy in formwork.

c) What materials are commonly used in formwork?

d) What are the constituents of cost of formwork?

16.4 REMOVAL AND MAINTENANCE OF FORMWORK

Formwork should be stripped or removed with care so as not to damage the concrete. Wedges should be slackened gradually to avoid sudden imposition of loads on the structure.

The stripping time for different members has been laid down in 1S:456-1978 which gives general guidelines about the time of removal of formwork, where ordinary portland cement is used. It states that "Forms shall not be struck until the concrete has reached a strength at least twice the stress to which the concrete may be subjected at the time of removal of

formwork. The strength referred to shall be that of concrete using the same cement and aggregates with the same proportions and cured under conditions of temperature and moisture similar to those existing on the work. Where possible the formwork shall be left longer as it would assist the curing."

It further lays down that "In normal circumstances and where ordinary portland cement is used, forms may generally be removed after the expiry of the following periods :

a)	Walls, columns and vertical faces of all structural members	24 to 48 hours as may be decided by the engineer-in-charge
b)	Slabs (props left under)	3 days
c)	Beam soffits (props left under)	7 days
d)	Removal of props under slabs :	
	1) Spanning upto 4.5 m	7 days
	2) Spanning over 4.5 m	14 days
e)	Removal of props under beams and arches :	
	1) Spanning upto 6 m	14 days
	2) Spanning over 6 m	21 days

For other cements, the stripping time recommended for ordinary portland cement may be suitably modified."

It also further lays down that "The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slab, beam or arch as the case may be with any live load likely to occur during curing or further construction."

You may also observe following general points during stripping :

a) Any prising that is necessary, should be done against formwork and not the concrete.

b) As formwork is stripped, it should be cleaned and properly stacked.

c) All small parts such as wedges and bolts etc. should be stored immediately in separate containers. Such a practice reduces loss of material.

d) Steel forms should be greased immediately after cleaning and before stacking.

Let us now examine another important temporary structure called "Scaffolding".

16.5 SCAFFOLDING

The "Scaffolding" is a temporary structure which is employed in building construction operations to support platforms for workmen, materials and equipments. Scaffolding may be erected either on one or both sides of the walls. The height of the scaffolding can be adjusted as the work progresses.

The Figure 16.15 shows an ordinary scaffolding. Different parts of the scaffolding are labelled to enable you to identify them.

The various parts of a scaffolding are generally secured by means of rope-lashings, bolts, etc.

16.5.1 Types of Scaffolding

The different types of scaffoldings which are generally used :

a) Single Scaffolding

b) Double Scaffolding

c) Ladder Scaffolding

d) Cantilever Scaffolding

e) Suspended Scaffolding

f) Steel Scaffolding and Centering

g) Trestle Scaffolding

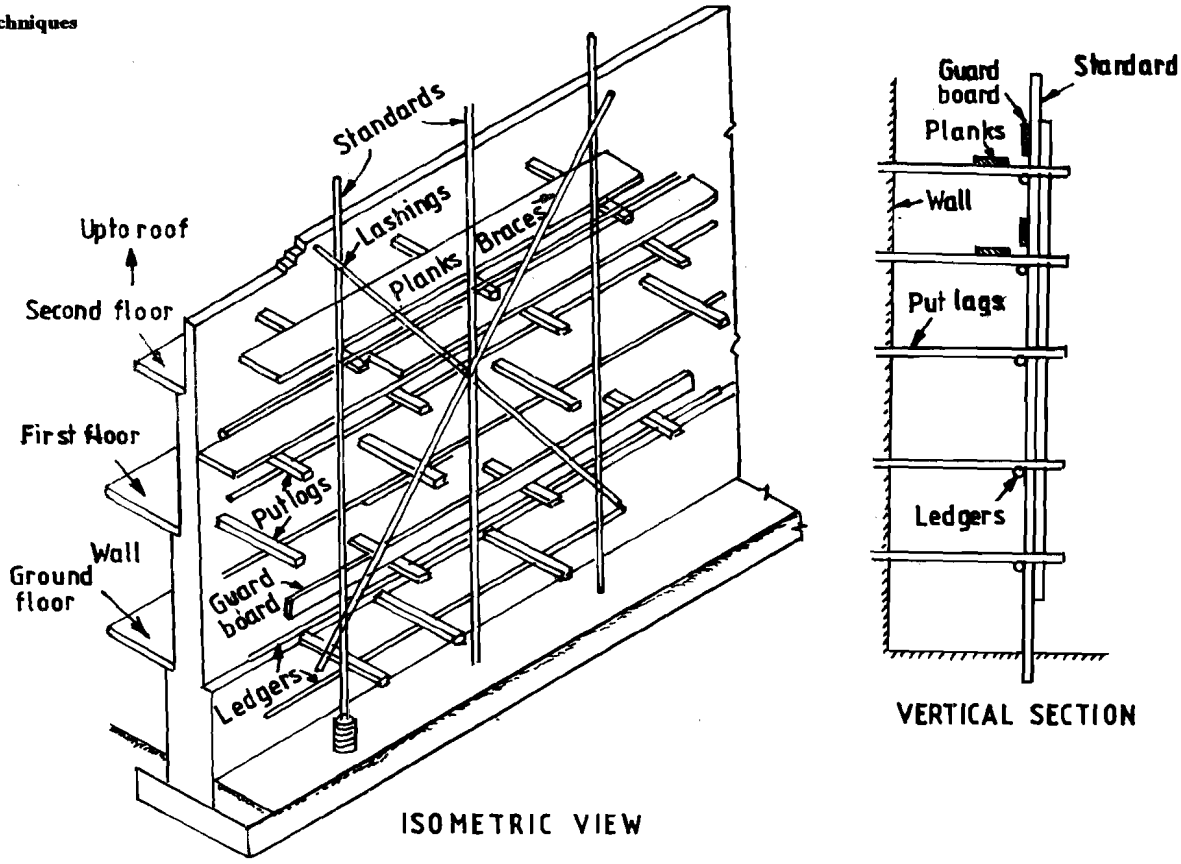


Figure 16.15 : Scaffolding and its Various Parts

We will examine only two of these, i.e. Double Scaffolding and Steel Scaffolding.

16.5.2 Double Scaffolding

This Scaffolding is called Mason's Scaffolding and is shown in Figure 16.16.

This scaffolding is stronger than single scaffolding and does not require to be secured into the wall and hence no holes are to be made in the wall. The first row of standards are kept 15 cm from wall face and the other at 1.2 to 1.5 m away from the face of the wall. The putlogs are supported at both the ends on ledgers.

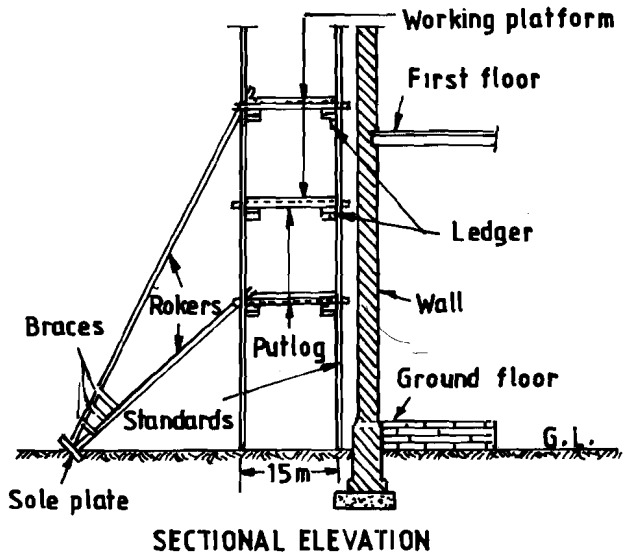


Figure 16.16 : Details of Double or Mason's Scaffolding with Raking Shore

16.5.3 Steel Scaffolding and Centering

Details of tubular steel scaffolding used as centering for slab and beam construction is shown in Figure 16.17.

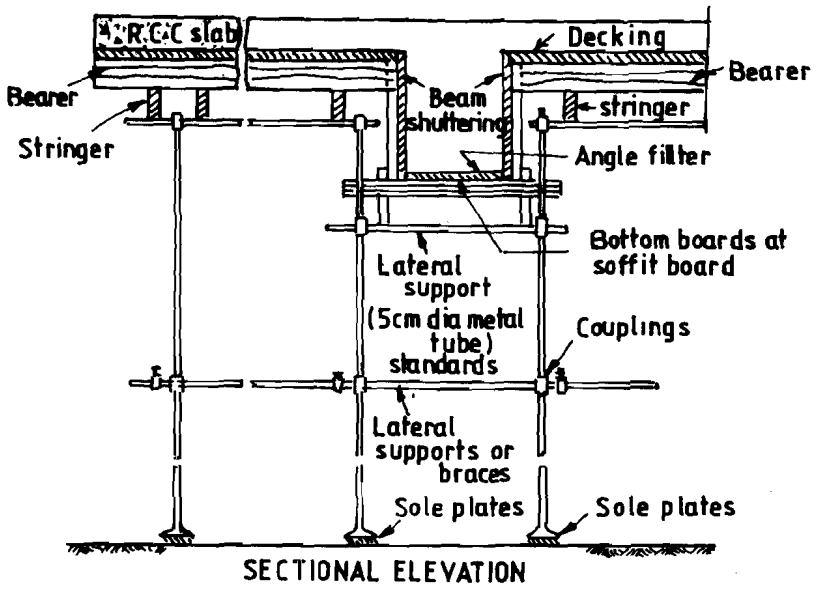


Figure 16.17 : Details of Tabular Steel Scaffolding Used as Centering for Slab and Beam Construction

You would have noticed that the constructional details of steel scaffolding are similar to that of wooden scaffolding except that wooden members are replaced by steel tubes, plates and angles and they are joined by special couplings and screws. The diameter of steel tubes generally used varies from 40 to 60 mm with sheet metal thickness of about 5 mm Steel Scaffolding has several advantages over ordinary timber scaffolding namely :

- It is suitable for any height.
- Though its initial cost is high, but it is economical in the long run.
- Its erection and dismantling is rapid.
- It is strong and durable and has longer life.
- It has better fire-resisting qualities and higher salvage value.
- It can be converted into moving form unit by the use of wheels.

16.5.4 U-Frame Scaffolding

It consists of right welded frame of two verticals and two horizontals. The various frames are interconnected by scissor cross braces through plug welded on frames and are locked in position by spring clips. This imparts very good rigidity and it can be erected even by unskilled labour. It is ideal for heavy structures, high slabs, bridge girders etc. It is shown in the Figure 16.18.

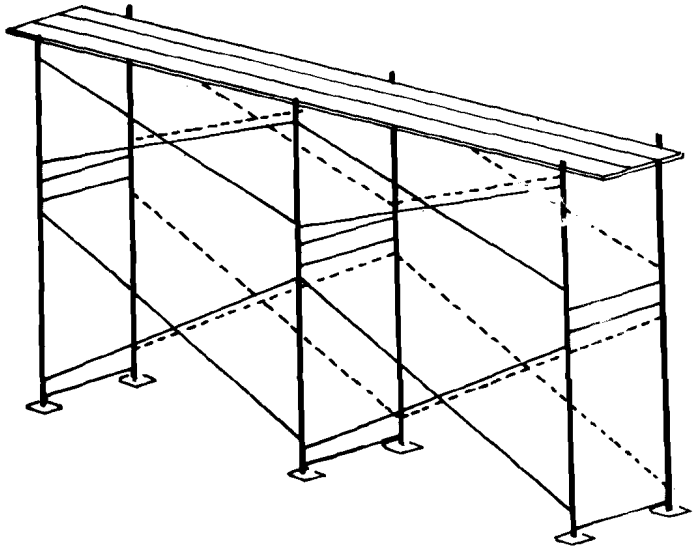


Figure 16.18 : U-Frame Scaffolding

16.6 SUMMARY

The appearance of the finished structure and the speed with which it can be completed are greatly dependent upon the efficient construction and type of forms employed. Several material like timber, plywood, steel and aluminium are being used in formwork. Several types of formwork are now available which are efficient, safe and simple to use. In large and tall structures, moving and travelling formworks are being increasingly used. A major technological advancement is the development of slipforming technique and automatic climbing formwork. Among the recent advancements are the permeable formwork and permanent formworks. The question uppermost in the mind of an engineer is as to whether a revolutionary change in formwork can be done to evolve a formwork which forms an integral part of the concrete and adds to its durability.

Steel scaffolding is becoming most popular, particularly the tubular steel scaffolding because of their light weight, long life and ease of erection. New forms of standardised steel scaffolding have made the task very easy and they help in speeding up the work without sacrificing safety.

Activity

A large number of commercially manufactured formwork and scaffolding systems are now available in India. Compile a data sheet comprising all details about these systems for ready reference.

16.7 KEY WORDS

Formwork : Temporary structure to receive wet concrete and hold it in place.

Scaffolding : Temporary structure to support platform for workers, materials and equipments.

Stripping : Removal of formwork after use.

16.8 ANSWERS TO SAQs

SAQ 1

a) The advantages are :

i) They can be easily and rapidly assembled by unskilled labour.

ii) They have a longlife even with minimum reasonable maintenance.

iii) They can be reused upto 50 times or so before repair becomes necessary.

iv) May be adapted to a wide variety of usage without alteration

v) Are non-absorbent.

vi) No shrinkge or distortion due to change in moisture content.

b) See Section 16.2.2 for details of the answer.

c) The commonly used materials are timber, plywood, boards, steel, aluminium and plastic coated sheets.

d) The constituents of cost of formwork are :

i) Cost of materials,

ii) Cost of labour required for fabrication,

iii) Cost of erection and removal of forms, and

iv) Cost of maintenance of forms.