PERFORMING BUILDIN TEMPORARY WORKS

Unit of learning code: **CON/CU/BUT/CC/05/6**

Related Unit of Competency in Occupational Standard: execute building temporary works

1.1. Introduction to the unit of learning

This Unit describes the competencies required to perform building temporary works. It involves erecting and dismantling building scaffolds and building shores, constructing and dismantling building formwork/shuttering and trench timbering.

1.2. Summary of Learning Outcomes

1. Construct and dismantle building formwork/shuttering
2. Construct and dismantle trench timbering
3. Erect and dismantle building scaffolding
4. Erect and dismantle building shores

1.2.1 Learning outcome 1: Construct and dismantle trench timbering

1.2.1.1 Introduction to the learning outcome

This learning outcome will helps the trainee to construct and dismantle trench timbering. The trainee will learn about timbering materials and tools, soil mechanics, site investigation, timbering methods and timbering dismantling

1.2.1.2 Performance Standard

1.1 Trench timbering materials and tools are determined according to the construction rules and regulations
1.2 Personal protective equipment is selected, fitted and used according to safety rules and regulations
1.3 Trench timbering is constructed as per soil type and site topography
1.4 Trench timbering is dismantled according to site procedures and critical structural safety requirements

1.2.1.3 Information Sheet

Definitions of terms

i. **Timbering** -is a method of providing temporary support to the side of the trench and is sometimes called planking and strutting
ii. **Strut** – it's a piece of wood used to support sheeting/walling with two walls of a trench and to maintain a certain distance between the Wales and the main line of the trench.
iii. **Trench** -is a deep and narrow hole, or ditch, in the ground.
iv. **Battering:** This is the term used to describe the protection given to sides of excavation by sloping the sides to a safe angle to prevent collapse.
v. **Polling board-**A flat wooden plank which is in direct contact with the soil of the trench and is arranged in an vertical position on the side
vi. **Sheeting** is the process of holding a polling board or plank together or using a sheet instead of a plank
vii. **Wales or walling-**The component attached to the trench wall, the sheeting to support the polling board, or the component which is perpendicular to the polling board and parallel to the trench wall.
viii. **Bracing** -The diagonal straightening used between the walls to reinforce the timbering framework

Introduction.

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

The strength of the timbering used for this purpose necessarily depends upon the nature of the soil, the depth of the excavations, and the length of time it is likely to be kept open.

MATERIALS AND TOOLS FOR TIMBERING.

Materials

Timber

Metal plates

Binding wire

Tools

Hammer

Nails

Pliers

Soil Mechanics

A number of stresses and deformations can occur in an open cut or trench. For example, increases or decreases in moisture content can adversely affect the stability of a trench or excavation. The following diagrams show some of the more frequently

- **Tension Cracks.** Tension cracks usually form at a horizontal distance of 0.5 to 0.75 times the depth of the trench, measured from the top of the vertical face of the trench.

Figure 1; **Tension cracks**

Ref; Irvine & Smith (1992). Trenching Practice. (Second Edition). Construction Industry Research and Information Association CIRIA Report 97, UK, 64p.

- **Sliding** or sluffing may occur as a result of tension cracks, as illustrated below.

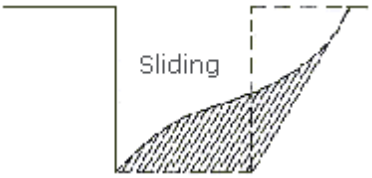


Figure 2; **Sliding**

Ref; Irvine & Smith (1992). Trenching Practice. (Second Edition). Construction Industry Research and Information Association CIRIA Report 97, UK, 64p.

- **Toppling.** In addition to sliding, tension cracks can cause toppling. Toppling occurs when the trench's vertical face shears along the tension crack line and topples into the excavation.

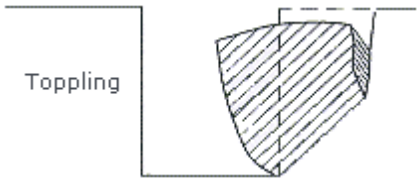


Figure 3; **Toppling**

Ref; Irvine & Smith (1992). Trenching Practice. (Second Edition). Construction Industry Research and Information Association CIRIA Report 97, UK, 64p.

- **Subsidence and Bulging.** An unsupported excavation can create an unbalanced stress in the soil, which, in turn, causes subsidence at the surface and bulging of the vertical face of the trench. If uncorrected, this condition can cause face failure and entrapment of workers in the trench.

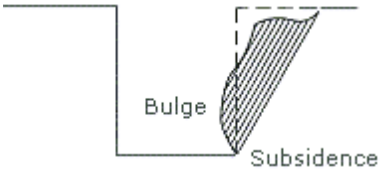


Figure 4; **bulging**

Ref; Irvine & Smith (1992). Trenching Practice. (Second Edition). Construction Industry Research and Information Association CIRIA Report 97, UK, 64p.

- **Heaving or Squeezing.** Bottom heaving or squeezing is caused by the downward pressure created by the weight of adjoining soil. This pressure causes a bulge in the bottom of the cut. Heaving and squeezing can occur even when shoring or shielding has been properly installed.

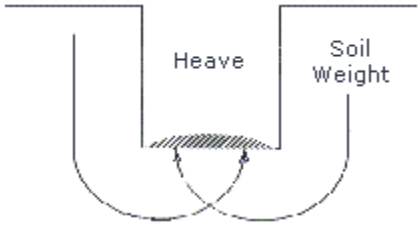


Figure 5; **heaving**

Ref; Irvine & Smith (1992). Trenching Practice. (Second Edition). Construction Industry Research and Information Association CIRIA Report 97, UK, 64p.

- **Boiling** is evidenced by an upward water flow into the bottom of the cut. A high water table is one of the causes of boiling. Boiling produces a "quick" condition in the bottom of the cut, and can occur even when shoring or trench boxes are used.

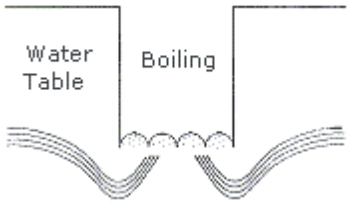


Figure 6; **boiling**

Ref; Irvine & Smith (1992). Trenching Practice. (Second Edition). Construction Industry Research and Information Association CIRIA Report 97, UK, 64p.

Types of soil

- **Stable Rock** is natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed. It is usually identified by a rock name such as granite or sandstone. Determining whether a deposit is of this type may be difficult unless it is known whether cracks exist and whether or not the cracks run into or away from the excavation

- **Type A Soils** are cohesive soils with an unconfined compressive strength of 1.5 tons per square foot (tsf) (144 kPa) or greater. Examples of Type A cohesive soils are often: clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. (No soil is Type A if it is fissured, is subject to vibration of any type, has previously been disturbed, is part of a sloped, layered system where the layers dip into the excavation on a slope of 4 horizontal to 1 vertical (4H:1V) or greater, or has seeping water.

- **Type B Soils** are cohesive soils with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa). Examples of other Type B soils are: angular gravel; silt; silt loam; previously disturbed soils unless otherwise classified as Type C; soils that meet the unconfined compressive strength or cementation requirements of Type A soils but are fissured or subject to vibration; dry unstable rock; and layered systems sloping into the trench at a slope less than 4H:1V .

- **Type C Soils** are cohesive soils with an unconfined compressive strength of 0.5 tsf (48 kPa) or less. Other Type C soils include granular soils such as gravel, sand and loamy sand, submerged soil, soil from which water is freely seeping, and submerged rock that is not stable. Also included in this classification is material in a sloped, layered system where the layers dip into the excavation or have a slope of four horizontal to one vertical (4H:1V) or greater.

- **Layered Geological Strata.** Where soils are configured in layers, i.e., where a layered geologic structure exists, the soil must be classified on the basis of the soil classification of the weakest soil layer. Each layer may be classified individually if a more stable layer lies below a less stable layer, i.e., where a Type C soil rests on top of stable rock.

Methods of timbering

When the depth of trench is large, or when the sub-soil is loose, the sides of the trench may cave in. The problem can be solved by adopting a suitable method of timbering. Timbering of deep trenches can be done with the help of the following methods:

A. **Stay bracing.** This method is used for supporting the sides or a bench excavated in fairly firm soil, when the depth of excavation does not exceed 2 metres. The method consists of placing vertical sheets (called sheathing) or polling boards opposite each other against the two walls of the trench and holding them in position by one or two rows of struts. The sheets are placed at an interval of 2 to 4 metres and generally they extend to the full height of the trench. The polling boards may have width of about 200 mm and thickness of 44 to 50 mm. The struts may have size 100 x 100 mm for trench up to 2 m width and 200 x 200 mm for trench up to 4 m width.

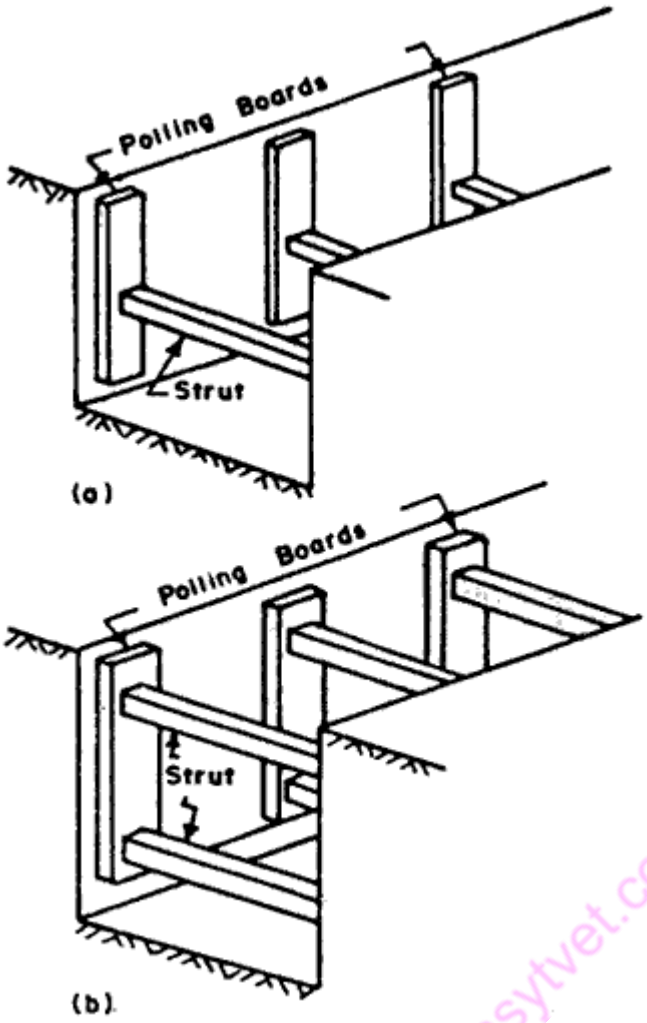


Figure 7; ***stay bracing***

Ref; http://www.abuildersengineer.com/2012/10/timbering-of-trenches-soils.html

B. **Box sheeting.** This method is adopted in loose soils, when the depth of excavation does not exceed 4 metres. **diagram (a)** shows the box like structure, consisting of vertical sheets placed very near to each other (sometimes touching each other) and keeping them in position by longitudinal rows (usually two) of wales. Struts are then provided across the wales.

   Another system of box sheeting, shown in **diagram (b)**, is adopted for very loose soils. In this system, the sheeting is provided longitudinally, and they are supported by vertical wales and horizontal struts. If the height is more, braces are also provided along with struts.

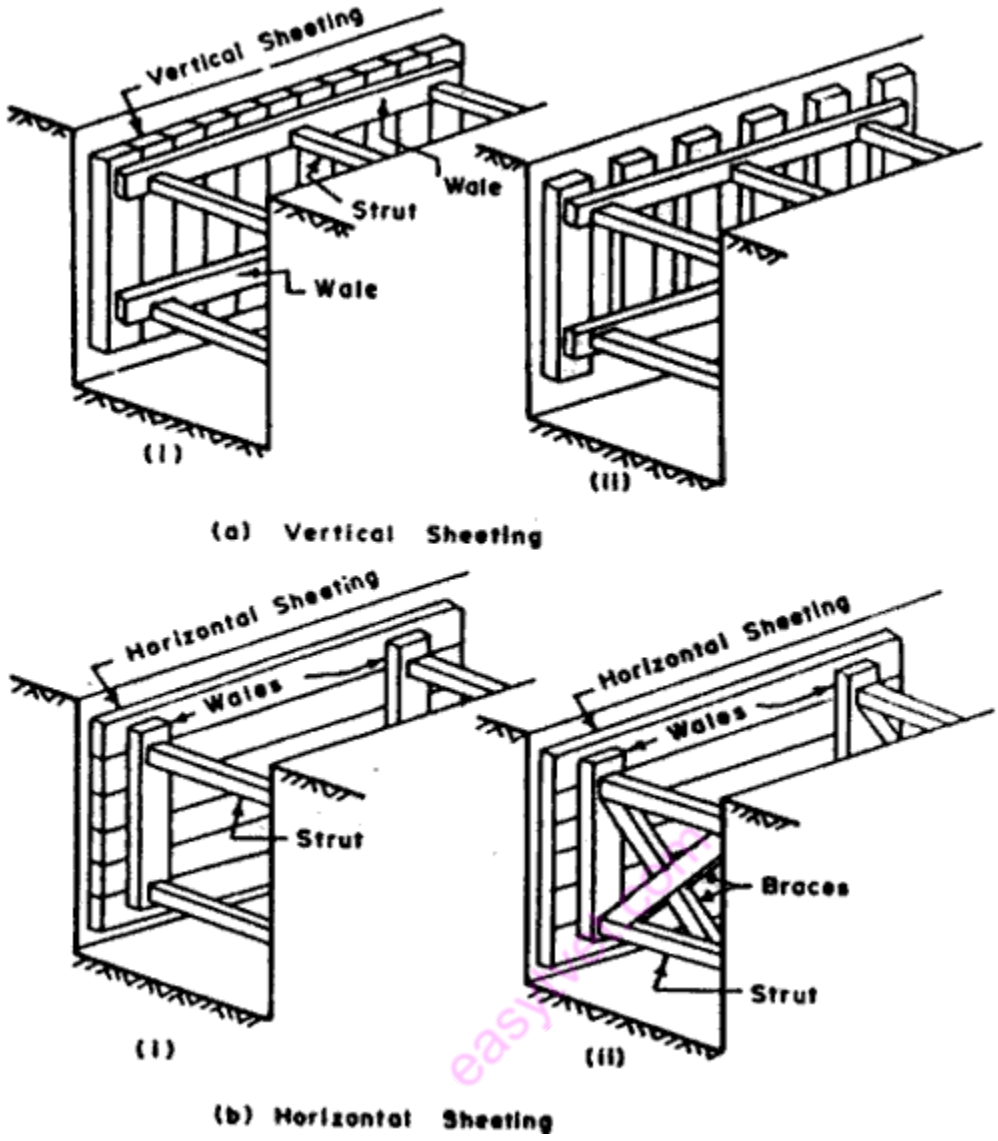


Figure 8; ***box sheeting***

Ref; http://www.abuildersengineer.com/2012/10/timbering-of-trenches-soils.html

C. **Vertical sheeting.** This system is adopted for deep trenches (up to 10 m depth) in soft ground. The method is similar to the box sheeting except that the excavation is carried out in stages and at the end of each stage, an offset is provided, so that the width of the trench goes on decreasing as the depth increases. Each stage is limited to about 3 m in height and the offset may vary from 25 to 50 cm per stage. For each stage, separate vertical sheeting, supported by horizontal wailings and struts are provided.

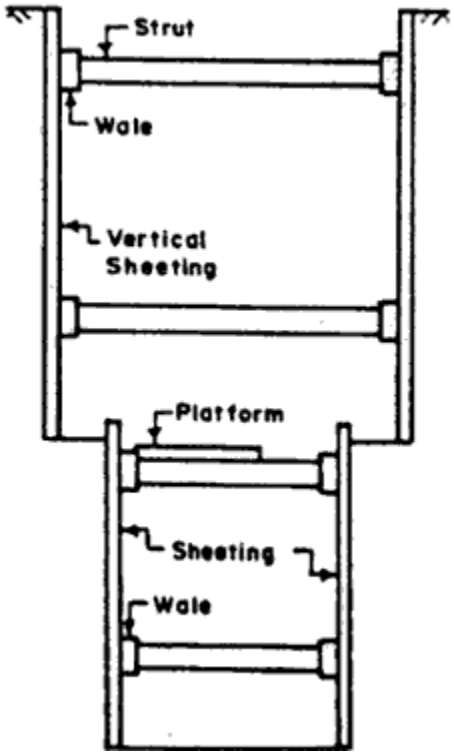


Figure 9; ***vertical sheeting***

Ref; http://www.abuildersengineer.com/2012/10/timbering-of-trenches-soils.html

D. **Runner system.** This system is used in extremely loose and soft ground, which needs immediate support as excavation progresses.
The system is similar to vertical sheeting of box system, except that in the place of vertical sheeting, runners, made of long thick wooden sheets or planks with iron shoe at the ends, are provided. Wales and struts are provided as usual. These runners are driven about 30 cm in advance of the progress of the work, by hammering.

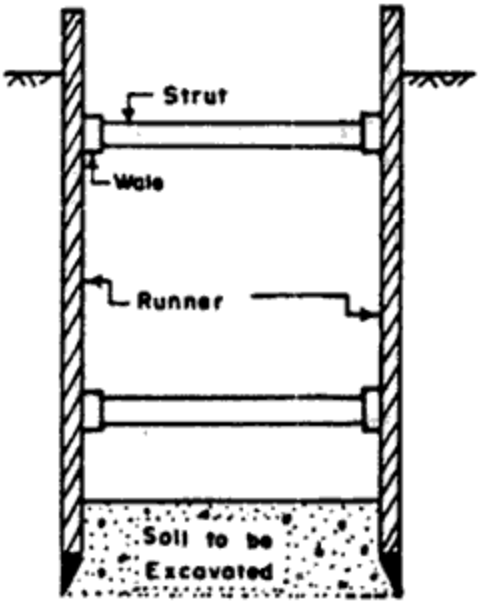


Figure 10; ***runner system***

Ref; http://www.abuildersengineer.com/2012/10/timbering-of-trenches-soils.html

E. **Sheet piling.** This method is adopted when

(i) Soil to be excavated is soft or loose
(ii) Depth of excavation is large
(iii) Width of trench is also large
(iv) There is sub-soil water.

Sheet piles are designed to resist lateral earth pressure. These are driven in the ground by mechanical means (pile driving equipment). They can be used for excavating to a very large depth.

There are two types of sheet piles:

1. Wooden sheet pile: Used to a depth of 10 m.
2. Steel sheet pile: Which is used up to a depth of 30 m. Steel sheet piles are used in different shapes and sizes.

Figure 11; **sheet pilling**

Ref; https://www.civilengineeringweb.com/2020/07/what-is-timbering.html

TRENCH LAY OUT DESIGN

Lay out of building foundation trenches is the process of laying down the excavation line and centreline on the ground based on the foundation plan. The laying out process is also called as ground tracing that is performed before commencing the excavation process.

Once the design of foundation is complete, a setting out plan or foundation layout is prepared for a suitable scale and the plan is dimensioned accordingly.

Procedure and requirements in laying out foundation trenches are given below.

1. The initial step is to mark the corners of the building. After which, the lengths of the sides are checked by diagonal measurements.
2. The axial lines (centre lines) of the trenches are marked with the help of profiles, sighting rails, strings, and pegs.
3. The trench positioning is controlled by outline profile boards. Profiles are set 2m away from the outline so that they do not interrupt the excavation process.

4. The offsets are measured from axial lines and the frontage lines are placed in their correct position relative to local requirements.
5. The cross walls positioning is performed by measuring along the main walls and squared from these walls as required. The total width of trenches must be carefully outlined during this process.

Design Considerations

a) Loading

When carrying out the design, consideration should be given to loading imposed on the open trench. The route of the trench should ideally be kept away from any traffic.
However, if this cannot be avoided, traffic load should be taken into account in the design of temporary support. The trench support should also be properly designed to take the additional load from any excavated spoil or other construction materials placed along the trench sides.

b) Drainage

Drainage measures to prevent ingress of surface runoff must be provided regardless of the excavation depth. These measures are particularly important to ensure the stability of any man-made or natural slope located below and in the vicinity of the trench excavation works and when the trench is open during any part of the wet season.
The possible flooding condition in the area, especially at depression points of roads, should be estimated and considered in the drainage design. The drainage measures are intended to minimise water runoff from the surface into the open trench, and to control infiltration of collected rainwater and runoff from the open trench into the slope; both scenarios are likely to have some adverse effects on the stability of the slope.

c) Groundwater Control

Where a high ground water table is encountered, the water may be controlled by dewatering. Dewatering may cause the lowering of groundwater in the area around the excavation, which will result in an increase in effective stress of soil and hence settlement of the ground.

d) Existing Man-Made Slope Features

Where existing man-made slope features, such as cut slopes, fill slopes or masonry retaining walls, etc. are situated at the proximity of the planned trench, the stability condition of the slope features should be examined and taken into consideration in the design. If any slope feature is suspected to be marginally stable and particularly vulnerable to ground movement, precautionary

measures should be provided to support the slope feature.

Dismantling of Timbering

Timber boards, supports, Wales, etc. Should be removed safely in stages after completion of work.

The soil filling in the trench should be done by leaving enough water in layers **of 20 cm to 30** cm thickness so that the soil layer does not settle

1.2.1.4 Learning Activities

1.2.1.4.1 Practical activities

Study the types of soils in your institution and come up with;

1. Methods of trench timbering for each type of soil.

Materials Required

- Pen
- Notebook
- Pencil
- Taping measure

1.2.1.5 Self-Assessment

1. What are the types or methods of Timbering?
2. Which type of timbering system is adopted for deep trenches up to 10m depth in the soft ground?
3. What is the main purpose of timbering of foundation trenches?
4. What is Timbering in Construction?
5. In open timbering, the poling boards are retained in position by using:
    a) Puncheons
    b) Struts
    c) Lacings
    d) Waling
6. _____ is defined as the main plank which remains in contact with sides of Trench.
    a**)** Sheeting
    b) Wale
    c) Sheathing
    d) Bracing

7. Boiling is evidenced by the upward water flow into the bottom of the excavation cut.

    a. True b. False

1.2.1.6 Tools, Equipment, Supplies and Materials

- Pen
- Notebook
- Pencil
- Calculator
- Tape measure

1.2.1.7 References

- https://www.civilengineeringweb.com/2020/07/what-is-timbering.html
- http://www.abuildersengineer.com/2012/10/timbering-of-trenches-soils.html
- Irvine & Smith (1992). Trenching Practice. (Second Edition). Construction Industry Research and Information Association CIRIA Report 97, UK, 64p.

RESPONSES

1. What are the types or methods of Timbering?
    - **Stay Bracing**
    - **Box Sheeting**
    - **Vertical Sheeting**
    - **Runners**
    - **Sheet piling**
2. Which type of timbering system is adopted for deep trenches up to 10m depth in the soft ground?

    Vertical sheeting or sheet piling type of timbering system is adopted for deep trenches up to 10m depth in soft ground.
3. What is the main purpose of timbering of foundation trenches?

    The main purpose of timbering of foundation trenches is to prevent side soil of trenches against collapse.
4. What is Timbering in Construction?

    Timbering is defined as a type of method which is used to prevent the trench side soil against collapse.
5. In open timbering, the poling boards are retained in position by using:
    e) Puncheons
    f) Struts
    g) Lacings
    h) Waling
6. _____ is defined as the main plank which remains in contact with sides of Trench.
    a) **Sheeting**
    b) Wale
    c) Sheathing
    d) Bracing

7. Boiling is evidenced by the upward water flow into the bottom of the excavation cut.

    a. True b. False

Learning Outcome 2: Construct and dismantle building formwork/shuttering

1.2.2.1 Introduction to the learning outcome

This learning outcome specifies how building technician will construct and dismantle formwork. The builder will be able differentiate structural elements of formwork, identify different materials and their properties of formwork, construct and dismantle formwork.

1.2.2.2 Performance Standard

1.1 ***Formwork material*** is identified as per structure complexity, job drawings or supervisor instructions
1.2 Formwork dimensions are determined as per the structural elements to be supported
1.3 Personal protective equipment is selected, fitted and used according to safety rules and regulations
1.4 ***Formwork type*** is erected according to the structural element to be cast
1.5 Oiling of timber formwork surface is carried out for easy dismantling after concrete setting
1.6 Formwork is fixed into position in accordance with the construction rules and regulations
1.7 Formwork is dismantled according to site procedures and critical structural safety requirements

1.2.2.3 Information Sheet

Definitions of terms

a. **Centering**- Centering is a specialized temporary vertical support used in construction of arches, shells, and space structures where the entire temporary support is lowered (struck or decentered) as a unit to avoid introduction of injurious stresses in any part of the structure.
b. **Molds-** it's a form for casting precast concrete units.
c. **Stripping** -Operation of removing form work/dismantling.
d. **Propping**- it is a system of structural members used temporarily to support loads in formwork during construction.
e. **Deshuttering**-, the process of removing the shuttering

Figure 12; ***propping***

Ref;Own picture

INTRODUCTION

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 centring.

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 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.

REQUIREMENTS OF A GOOD FORMWORK

In order to successfully carry out its function, formwork must achieve a balance of following requirements:

1. **Easy Removal**
    - Design should be such that it can be removed easily with least amount of hammering.
    - This will also prevent possible damage to concrete which has not become sufficiently hard.
    - Further, if removal is easy, it can be made fit for reuse with little expenditure.

2. **Less Leakages**
   Formwork should be so arranged that there is minimum of leakage through joints. This is achieved by providing tight joint between adjacent sections of formwork.

3. **Strength**
    - Formwork should be sufficiently strong enough to bear dead load of wet concrete as well as weight of equipment, labour etc. required for placing & compacting concrete.
    - This required careful design of formwork. Over estimation of loads result into expensive formwork & under estimation of loads result into failure of form work.
4. **Smooth Surface**

The inner surface of the formwork should be smooth so as to give pleasing appearance to the finished surface. This is achieved by

- **Applying crude oil or**
- **Soft soap solution to inside surface of form work**
  This also makes removal of formwork easy.

5. **Rigidity**
   Formwork should be rigid enough so as to retain shape without any appreciable deformation. For visible surfaces in completed work the deflection is limited to 1/300 of span & for hidden surface, to 1/15 span. It should also be noted that rigid form work will be robust & stiff enough to allow repeated use.
6. **Quality**
   Forms should be designed & built accurately so that the desired size, shape & finish of concrete is attained.
7. **Ease of handling**
    - Form panels and units should be designed so that their maximum size does not exceed that which can be easily handled by hand or mechanical means.
    - In addition all formwork must also be designed and constructed to include facilities for adjustments, leveling, easing and striking without damage to the form work or concrete.

8. Economy

- On average about 35% of the total cost of any finished concrete unit or element can be attributed to its formwork; of this just over 40% can be taken for material for formwork and 60% for labour.
- The formwork designer must therefore not only consider the maximum number of times that any form can be reused, but also produce a design that will minimize the time taken for erection and striking.

ECONOMY IN FORMWORK

A formwork system is economical only when it fulfills 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 minimize 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 minimized by keeping some good points in mind which will lead to economy in formwork.

The following are ways of economizing formwork.

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.

FORMWORK STRUCTURAL MEMBERS

a. **Forms or shutters** -It is temporary supports & casings of desired shape which supports fresh concrete till it becomes sufficiently strong to support its own weight.
b. **Props**-These are vertical post used to temporarily support formwork forms in shuttering. They are made from timber or steel.
c. **Struts and joists**
d. **Braces** – A brace is any structural member used to support another, always designed for compression loads and sometimes for tension under special load conditions..

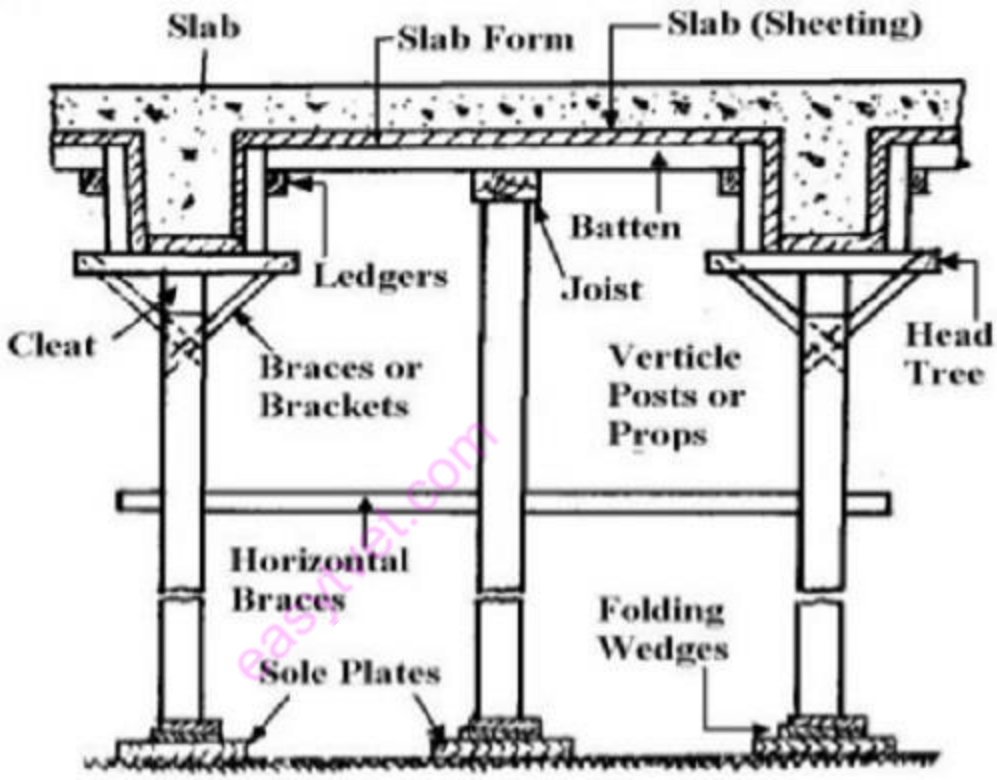


Figure 13; ***formwork members***

Ref; Building_Material_&_Construction_GC_SAHU_&_JOYGOPAL_JENA

FORMWORK TYPES

Considering shapes, formwork types can be classified as:

a. Column Formwork

The function of column formwork is to enable the construction of columns that have the specified surface quality and are acceptably accurate in shape and position with good alignment to other adjacent columns, walls and building facades.

Round column forms, more typically pre-manufactured in a range of standard diameters, are available in steel, paperboard, and fiber-reinforced plastic. Square and rectangular forms are composed of short-span bending elements contained by external ties or clamps

Columns are often constructed with the column reinforcement extending well above the form. This is done so it can lap with the reinforcement of the next column or floor to be constructed above.

As the sizes of concrete column increases, the stiffness of the formwork must be increased by either increasing thickness of sheathing or vertical stiffeners must be added to prevent sheathing deflection

It consists of the following

- **Side & End Planks**
- **Yoke**
- **Nut & Bolts**

Two end & two side planks are joined by the yokes and bolts.

*Figure 14; C**olumn formwork***

Ref; https://theconstructor.org/building/formwork-shuttering-types-walls-columns-footings-slabs/11076/

b. Beam formwork

Formwork for beams consists of a bottom and two sides (open through section) in addition to their supporting elements. The bottom is typically made of ply wood or lumber sheathing. The bottom is supported by and fastened to horizontal joists. Beam sides are also made of plywood or lumber sheathing.

The supports need to be maintained to the soffit and also provide lateral support to the sides. In timber this is done by the use of a head tree across the top of a vertical member. Metal panels are used with corner pieces, but timber head trees are needed for vertical support.

Once the bottom of the beam form is constructed and leveled, one side of the beam is erected first with holes drilled into it for installing the tie rods. Tie rods are steel rods that hold the two sides of the beam together. After the first side of the beam form is erected, the reinforcement is placed inside the beam and then the other side of the beam is erected. Tie rods are then inserted into all holes and the wales on both sides of the beam. The tie rods' function is to resist the horizontal pressure resulting from the freshly placed concrete and thus keep the sides of the beams in their proper location. Tie rods are fastened to the sides of the beam and also to vertical wales and clamps.

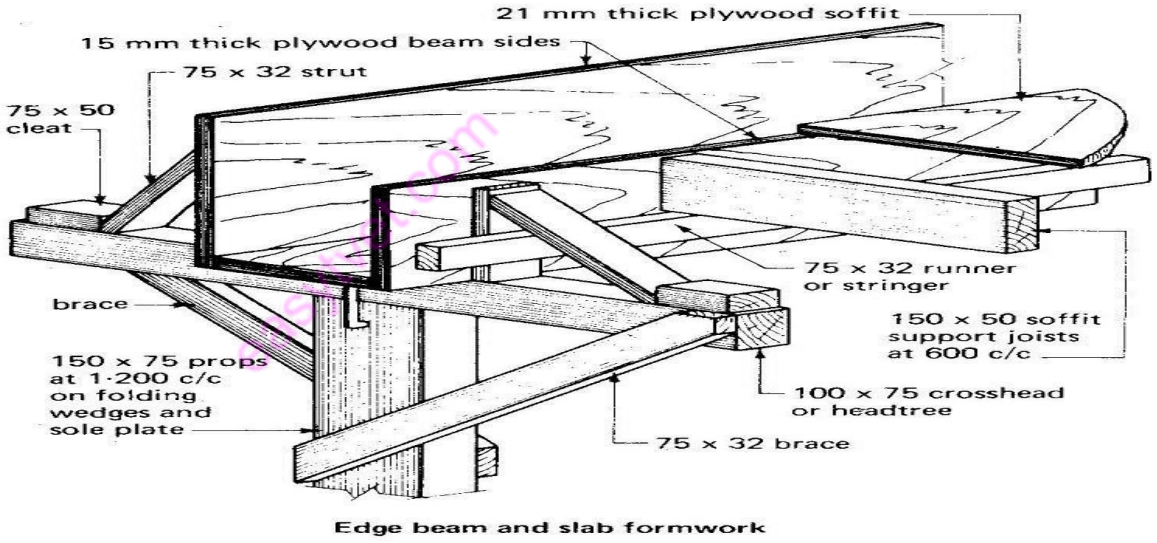


Figure 15; ***beam formwork***

Ref; Building_Material_&_Construction_GC_SAHU_&_JOYGOPAL_JENA

c. Slab Formwork

Slab formwork essentially supports the weight of the concrete during the curing process and when the concrete slab is positioned on permanent supports. Bases (also known as sills) are required that are made from wood or metal and these bases support the vertical stringers which in turn support the horizontal joists. The horizontal joists create a flat surface where timber, plywood, steel sheets, aluminum or fiberglass can be used as a base onto which the concrete is poured

Timber and metal props can be used for vertical supports.

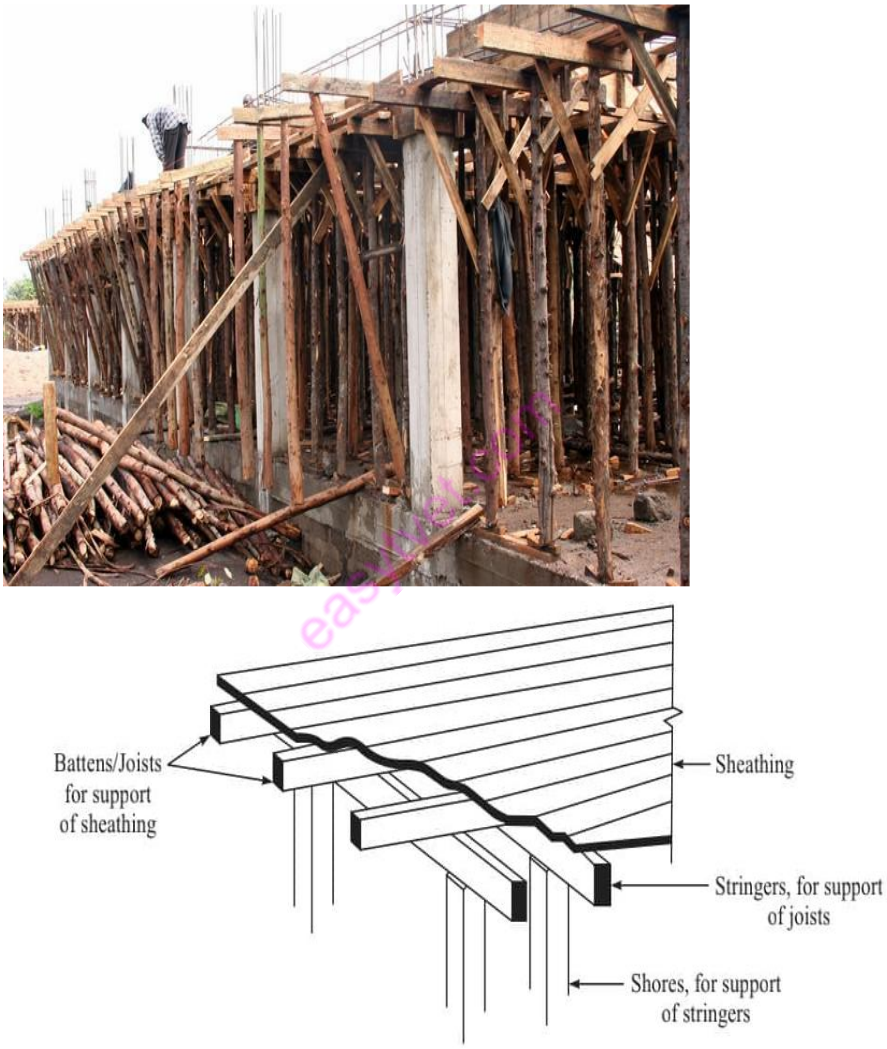


Figure 16; ***slab formwork***

d. Wall Formwork

Wall formwork consists of vertically arranged upright timbers (formwork bearers) to which sheeting boards are nailed at the concrete side. The upright timbers are diagonally braced by means of boards at both sides.

After completing one side of formwork reinforcement is provided at the place then the second side formwork is provided.

WaII support systems are usually sloping props at satisfactory intervals.

Prefabricated sheeting panels may also be used instead of sheeting boards.

Cleaning holes are to be provided at the foot of the formwork.

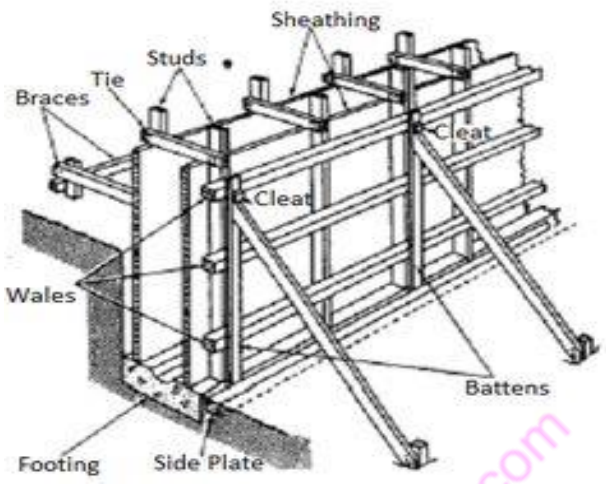


Figure 17; ***wall formwork***

Ref;Building_Material_&_Construction_GC_SAHU_&_JOYGOPAL_JENA

e. Stair form work

It consists of;

a) Vertical & inclined posts
b) Inclined members
c) Wooden Planks or sheeting
d) Stringer
e) Riser Planks

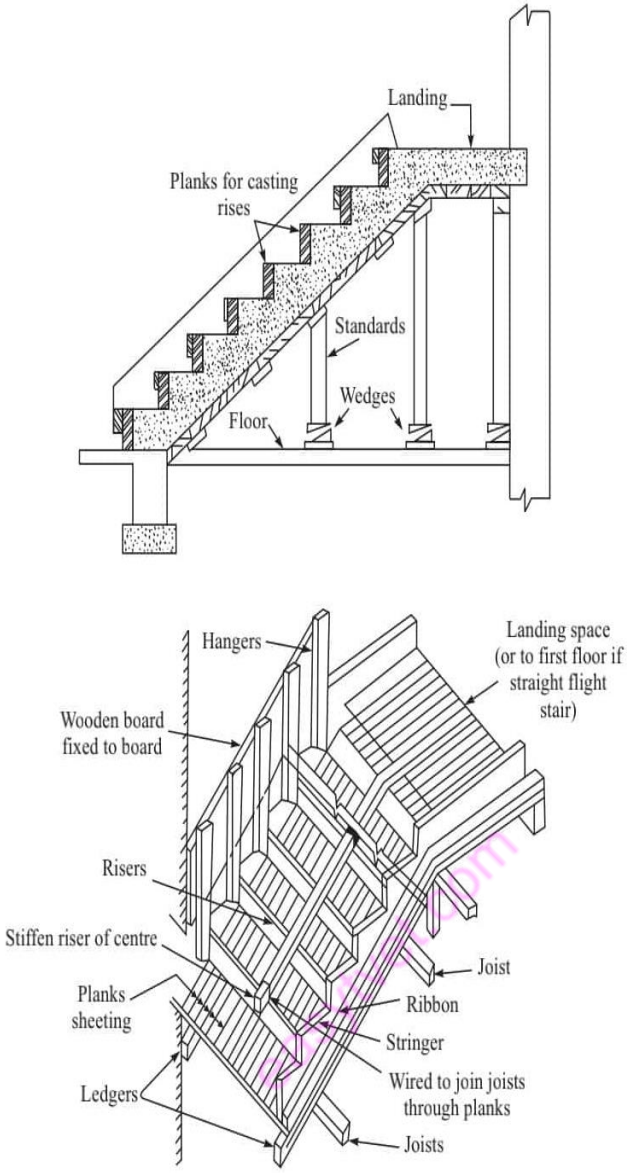


Figure 18; ***typical stair formwork***

Ref; Building_Material_&_Construction_GC_SAHU_&_JOYGOPAL_JENA

f. Permanent formwork

Permanent form or stay-in-place formwork is one in which the form is left as an integral part of the structure.

Permanent formwork can also be utilized as the facing materials of in situ reinforced concrete. They can be of two types—participating and non-participating.

The material used for these forms must be durable and of sufficient strength.

Commonly used materials include polyvinyl chloride (pvc), galvanized coiled sheet steel, fabricated steel, carbon/epoxy thin shell.

The high initial cost of design and installation, lack of familiarity for installation and maintenance and more specified form design are some of the barriers to the use of this form.

However, there are various advantages like low cost of transportation and installation, precise form design, maximum flexibility, greater durability with reduced long term maintenance and versatility.

g. Special Formwork

These are the forms that are specially designed and manufactured for a particular kind of construction.

The need for a special formwork may arise due to several factors such as

a) When the contract demands the highest class of dimensional tolerance to be followed
b) Where the form work shape required becomes uneconomical or impracticable for site fabrication
c) Where the formwork is required to be self-contained i.e. self-propelled,
d) Where rate of concreting, admixtures or types of concrete are such that concrete pressure developed within forms and stresses in the forms demand special attention where a substantial number of re-uses is envisaged.

Figure 19; ***example of special formwork***

FORMWORK MATERIALS

Materials used for the construction of concrete formwork range from traditional materials such as **Timber**, **steel, aluminum**, **and plywood** to nontraditional materials such as **fiberglass**.

The systems used can be a combination of two materials. Wood products are the most widely used material for formwork.

Timber

Timber is widely used for many construction applications including concrete formwork. Timber is harvested from trees and is classified as hardwood and softwood. Hardwood comes from trees that have broad leaves such as oaks, maples, and basswood. Softwood comes from trees that have needlelike leaves such as pines, cedars, and firs. Softwoods are most commonly used in construction of formwork.

Figure 20: timber material

Ref; own picture

Timber properties

Timber to be used as formwork should be

- Well-seasoned
- Free from loose knots
- Light in weight &
- Easily workable with nails without splitting

Plywood

Plywood is a manufactured wood product consist a number of veneer sheets, or plies Type of plywood can be grouped as exterior and interior. For formwork the exterior plywood is used. Adhesive used to bond the piles in manufacturing of exterior plywood is watertight and gives maximum number of reuses. The plywood industry manufactures special plywood called Ply form specifically for use in forming concrete structures.

Aluminum

Forms made from aluminum are in many respects similar to those made of steel. However, because of their lower density, aluminum forms are lighter than steel forms, and this is their primary advantage when compared to steel. As the strength of aluminum in handling, tension and compression is less than the strength of steel, it is necessary to use large sections.

The formwork turns out to be economical if large numbers of reuses are made in construction.

The major disadvantage of aluminum forms is that no changes can be made once the formwork is fabricated.

Steel

This consists of panels fabricated out of thin steel plates stiffened along the edges by small steel angles. The panel units can be held together through the use of suitable clamps or bolts and nuts.

The panels can be fabricated in large numbers in any desired modular shape or size. Steel forms are largely used in large projects or in a situation where large number reuses of the shuttering is possible. This type of shutter is considered most suitable for circular or curved structures

Choice of formwork materials

The selection of materials suitable for formwork should be based on the price, safety during construction, and the quality required in the finished product. Approval of formwork materials by the engineer/architect, if required by the contract documents, should be based on how the quality of materials affects the quality of finished work. Where the concrete surface appearance is critical, the engineer/architect should give special notice and make provision for preconstruction mockups

Formwork measurements and dimensions

Measurements of concrete formwork are required for payment to the contractor for the concrete work completed. The payment to contractor depends on whether the cost is included with the concrete construction per unit quantity or formwork is paid separately, as mentioned in the conditions of contract**.**

How to Measure Formworks?

The formwork is measured in terms of area that is in contact with the concrete surface.

For example, the formwork for concrete footing will be calculated as the surface area of four sides of foundation only. Bottom of the footing is resting on earth, there is no need of any formwork and top of footing is open**.**

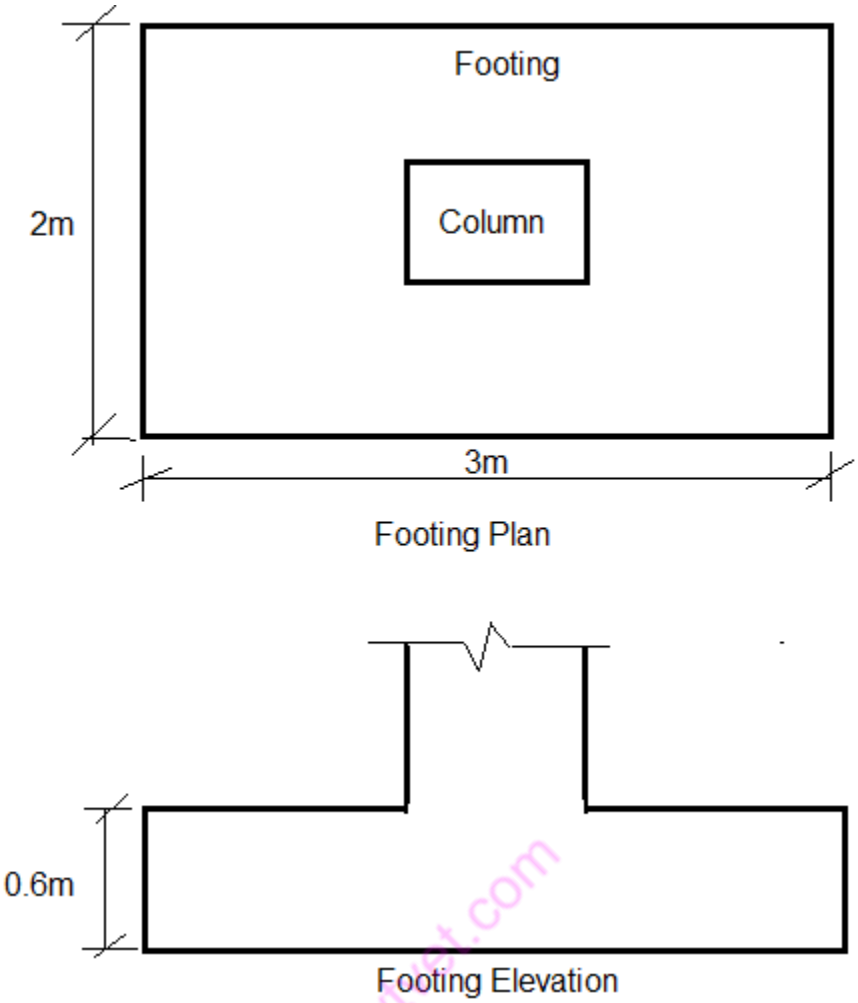


Figure 21; ***Plan and Elevation of RCC Footing***

From the above footing plan and elevation, it can be seen that formwork area required will be

2 x (2 + 3) x 0.6 = 6 m2

Similarly, for a reinforced concrete beam, the measurement of formwork will be taken as the combined surface area of two sides and bottom of the beam.

Units of Formwork Measurement

Formworks are measured in terms of area. So any unit such as square meter, square foot, square centimeter can be adopted. But generally, square meter and square foot of the contact area with concrete is taken as the unit of measurement.

Formworks are measured as just contact area, not area of formwork, as shown below:

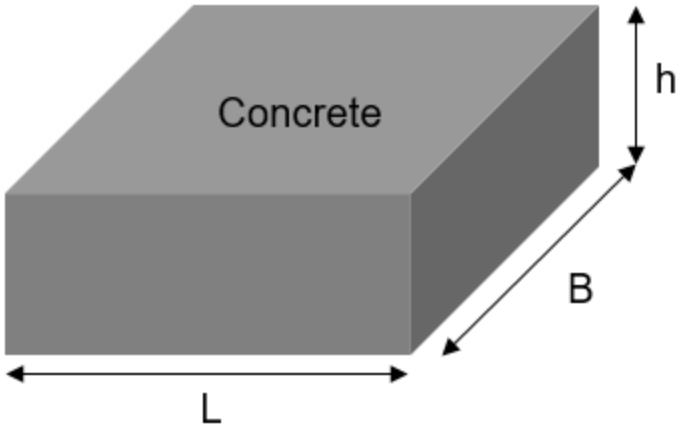


*Figure 22**: measurement of formwork***

The following measurements of formwork are carried out separately;

- Foundations, footings, bases of columns etc. and for mass concrete and precast shelves.
- Walls of any thickness including attached pilasters, buttresses, plinth and string courses etc.
- Suspended floors, roofs, landings, shelves and their supports and balconies.
- Lintels beams, girders and cantilevers
- Columns, pillars, posts and struts.
- Stairs (excluding landings) except Spiral Staircase
- Spiral staircases (including landings)
- Arches
- Domes, vaults, shells roofs, arch ribs and folded plates
- Chimneys and shafts
- Vertical and horizontal fins individually or forming box, louvers and bands
- Waffle or ribbed slabs
- Edges of slabs and breaks in floors and walls
- Cornices and mouldings

Dimensions of formworks

Sl. No.	Formwork Element	Size (mm)
1.	Sheathing	25 mm to 50 mm thick
2.	Beam and column sides	25 mm to 50 mm thick
3.	Beam bottoms	50 mm thick
4.	Joists	50 mm × 100 mm to 70 mm × 200 mm
5.	Ledger	50 mm × 100 mm to 75 mm × 200 mm
6.	Posts	75 mm × 100 mm to 150 mm × 200 mm
7.	Column yokes	50 mm × 100 mm to 100 mm × 200 mm
8.	Struts and wallings	50 mm × 100 mm to 150 mm × 200 mm

*Table 3; formwork **dimensions***

CONSTRUCTION OF FORMWORK:

This normally involves the following operations:

- **Propping and centering:**The props used for centering may be of steel, timber post or pillars made up of brick masonry in mud mortar are also sometimes used as props.
- **Shuttering**: Can be made up of timber planks or it may be in the form of panel unit made either by fixing ply wood to timber frames or by welding steel plates to angle framing.
- **Provision of camber:**Certain amount of deflection in structure is unavoidable.
  It is therefore desirable to give an upward camber in the horizontal member of conc.
- **Surface treatment:** The formwork should be cleaned of all rubbish particularly the sawdust savings & chippings etc

The face of formwork in contact with conc. shall be cleaned & treated with release agent like raw linseed oil or soft soap solution as to prevent the concrete getting stuck to the formwork.

DISMANTLING OF FORMWORK

- Operation commonly known as stripping.
- Shuttering forming vertical faces of walls, beams & column sides should be removed first.
- Shuttering forming soffit to slab should be removed next.
- Shuttering forming soffit to beams, girders or other heavily loaded member should be removed in the end.
- Formwork is to be removed when concrete has become sufficiently hard so that removal of formwork will not damage structure.

Length of time for which formwork should be kept in position depends on following factors:

a) Amount & nature of dead load
b) Character & quality of concrete
c) Shape, span & situation of structure &
d) Temperature of atmosphere

Recommended duration taken for removal of formwork

- Walls Columns & Vertical Sides of Beams 1-2 Day
- Slabs 3 Days
- Beam Soffit 7 Days
- Removal of Props To Slabs
  Slab Spanning Up to 4.5m 7 Days
  Slab Spanning Over 4.5m 14 Days
- Removal of Props to Beams and Arches
  Spanning Up to 6m 14 Days
  Spanning Over 6m 21days

1.2.2.4 Learning Activities

1.2.2.4.1 Practical activities

The diagram below shows a stair plan. Using the plan

1. Construct the stair formwork up to the first landing.
2. Dismantle the form work

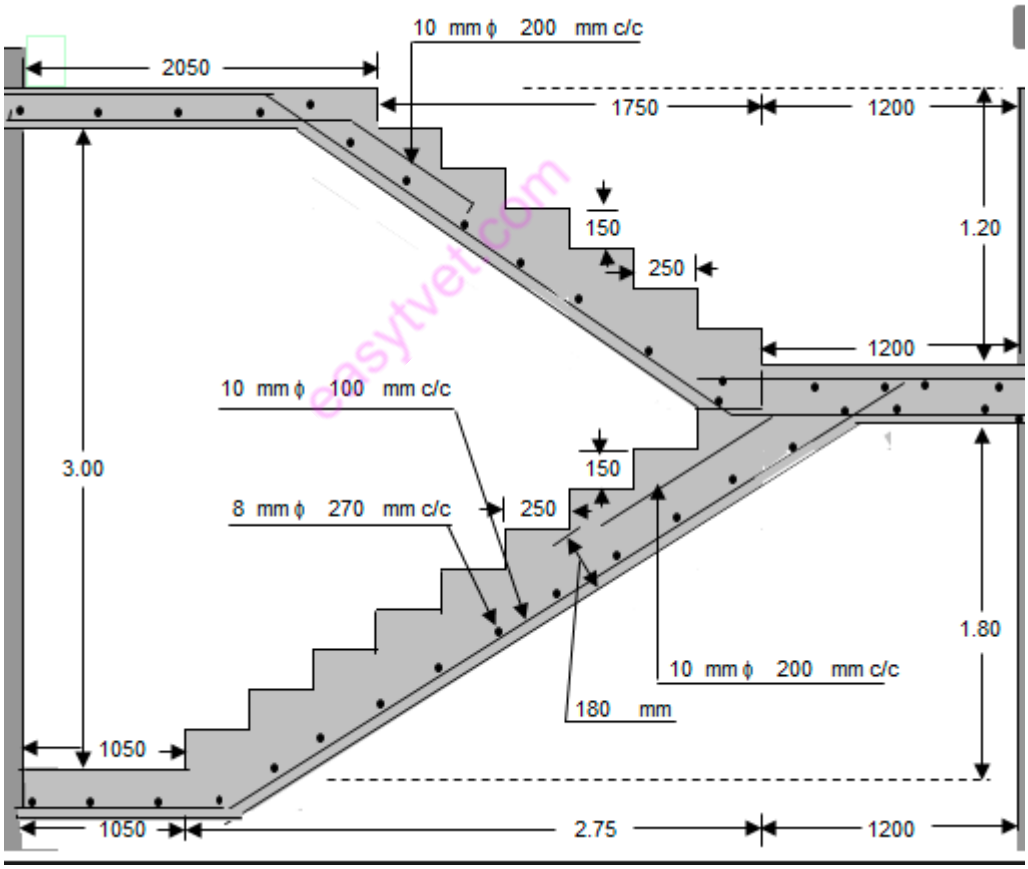


Figure 23; ***stair section***

Ref; Building Construction" authored by S.C. Rangwala, Charotar publishing house Pvt. Ltd.

1.2.2.4.2 A field Activity

Visit to the nearby construction site and identify the following:

1. Types of formworks used in the site
2. Materials used for formworks

Materials and equipments required

- Timbers
- Nails
- Plywood/block boards
- Props
- Saw
- Hummer
- Tape measure
- Plain wall
- Spirit level

1.2.2.5 Self-Assessment

1. Large leaks of concrete from the formwork causes _____
    a. bonding,
    b. honey-combing,
    c. exposing
2. For RCC columns, formwork can be removed after _____
    a. 24hours,
    b. 9-12 hours
    c. 14-20 hours
3. What is shuttering and cantering? Mention any one situation where they are applied.
4. What's stripping time?
5. The _____ is used for formwork when it is desired to reuse the formwork several times.
    a) Stone
    b) Steel
    c) Timber
    d) Bamboo
6. The column formwork consists of a box prepared from _____ separate sides.
    a) One

b) Two
c) Three
d) Four

Tools, Equipment, Supplies and Materials

- Drawing board
- Drawing papers
- Pencils
- Ruler

1.2.2.6 References

https://www.slideshare.net/khushi9922/chapter-5-formwork
https://theconstructor.org/building/formwork-shuttering/
Building_Material_&_Construction_GC_SAHU_&_JOYGOPAL_JENA
Building Construction" authored by S.C. Rangwala, Charotar publishing house Pvt. Ltd.

RESPONSES

1. Large leaks of concrete from the formwork causes _____
    a. bonding,
    b. honey-combing,
    c. exposing
2. For RCC columns, formwork can be removed after _____
    a. 24hours,
    b. 9-12 hours
    c. 14-20 hours
3. What is shuttering and cantering? Mention any one situation where they are applied.
4. What's stripping time?

    It's the time given to form before removal
5. The _____ is used for formwork when it is desired to reuse the formwork several times.
    a) Stone
    b) Steel
    c) Timber
    d) Bamboo
6. The column formwork consists of a box prepared from _____ separate sides.
    a) One
    b) Two
    c) Three
    d) Four

1.2.3 **Learning Outcome 3:** Erect and dismantle building scaffolding

1.2.3.1 Introduction to the learning outcome

This learning outcome enlightens the trainee on how to erect and dismantle scaffolding to obtain a safe working platform in building. The trainee will learn types of scaffolds, how to erect and dismantle scaffolds, and safety requirements of scaffolding.

1.2.3.2 Performance Standard

3.1 ***Scaffold system*** is determined as per complexity of the building, engineering design, job drawings or supervisor instructions
3.2 **Personal protective *equipment*** is selected, fitted and used according to safety rules and regulations and job specifications
3.3 Scaffolds are erected to plan according to safe work practices and engineers' specifications
3.4 Scaffolds are dismantled according to engineers' specifications, site procedures and critical structural safety requirements
3.5 Site cleaned and cleared of all tools, excess material and waste

1.2.3.3 Information Sheet

Introduction

A scaffold is a temporary structure erected to elevate and support workers as well as, materials during construction, repair, or surface finishing of a structure.

When the height of construction is more than 1.5m, workmen need some platform on which he can stand safely, keep necessary materials of construction and carry on the construction etc. The height of scaffolding goes on increasing as the height of construction increases.

Scaffolds can be made of timber, bamboo or metal (steel, aluminums).

The functional requirements of scaffolds include:

1. Safety and stability.
2. Ease and speed of erection, disassembly and reuse.
3. Horizontal and vertical accessibility.

FUNCTIONS OF SCAFFOLDING

- As a working platform - so that the worker can stand on the platform do the work easily and safely.
- As a platform for placing material and logistic needed by the workers to carry out their job.
- As a platform and walking passage - scaffolding support the platform that been used by the worker as their walking path to transport the material and logistic.

Definitions of terms/ Component Parts of Scaffolding

a. **Scaffolders**: are those who erect the scaffolds

b. **Standards**: These are vertical members of scaffolding, supported on the ground or drum or embedded into the ground.

c. **Ledgers**: These are horizontal members, running parallel to the wall and perpendicular to the standards.

d. **Braces**: These are diagonal members fixed on standards.

e. **Putlogs**: These members are placed on ledgers at right angles to the walls, with one end supported on ledgers and other end on the wall.

f. **Boarding or Planks**: These are the horizontal platform for supporting men, materials and appliances, these are supported on putlogs.

g. **Guard boards**: To guard against the materials, the boards are provided at the working level called guard boards.

h. **Toe boards**: These are boards placed parallel to the ledgers and used for protection at the level of working platform.

i. **Bridle**; is a feature used to bridge openings. A vertical inside tube crossing the opening is attached to the scaffold by a transom, and a horizontal crossing tube on the outside called a bridle tube. The gaps between the tubes and the structure surfaces are packed or wedged with timber sections to ensure a solid fit.

j. **Guard Rail**: A horizontal rail secured to uprights and erected along the exposed edges of scaffolds to prevent workmen from falling.

k. **Transom**: A member spanning across ledgers/ standards to tie a scaffold transversely and which may also support a working platform.

l. **Base Plate:** Base plate is used so that the standard/ poles do not get inserted into the ground due to the heavy load on the top of the scaffold boards due to the masons.

m. **Sill or Mud Sill**:A footing, usually wood, which distributes the vertical leg loads to the ground.

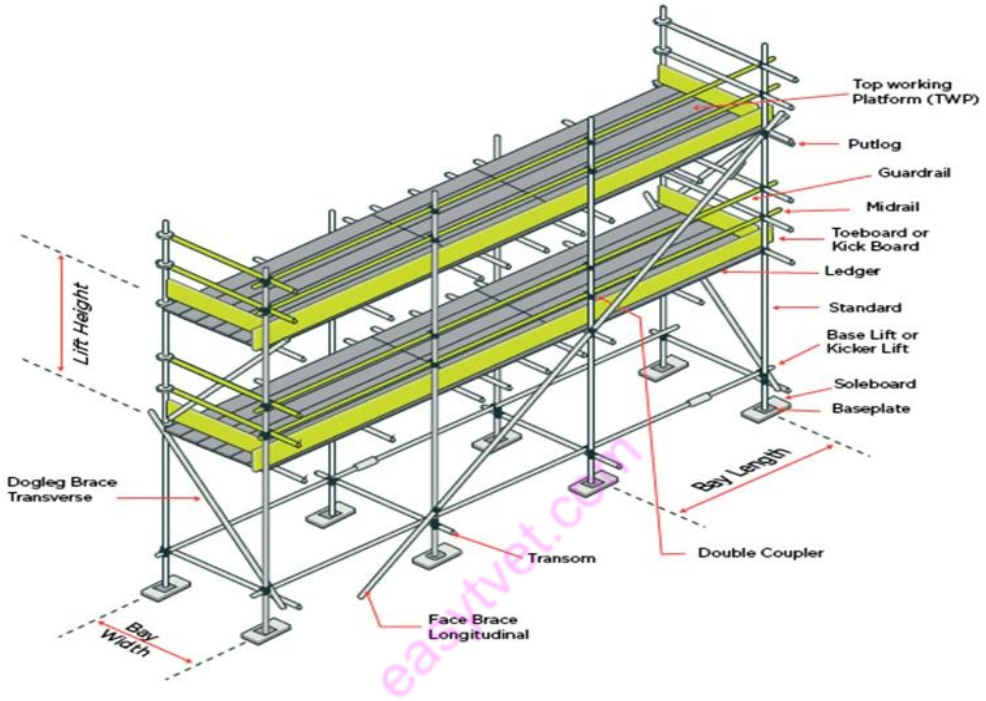
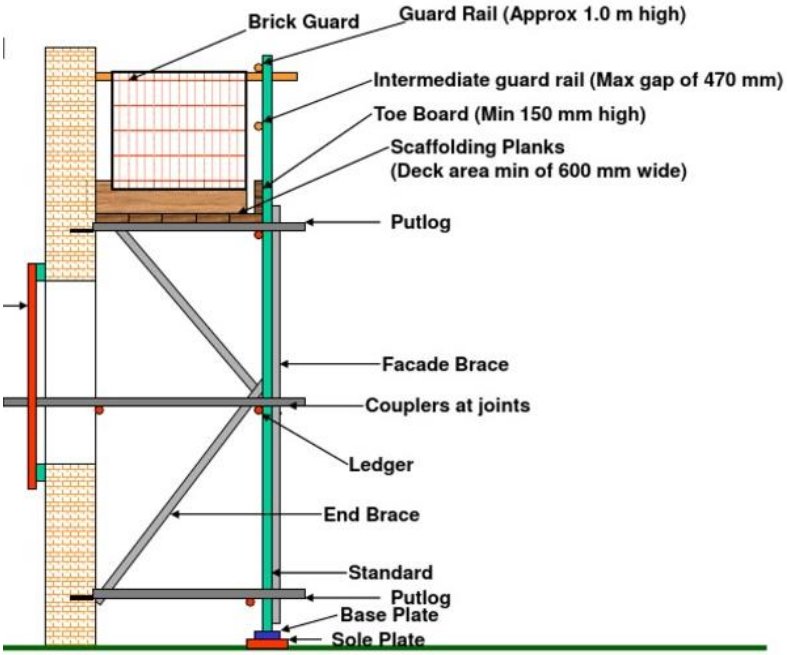


*Figure 24**: scaffolding components***

Ref; https://www.hseskyward.com/scaffolding-parts-name/

Types of scaffolds

1. **Single Scaffolding:** This consist of a single row of standards (vertical members) which are driven into the ground at a distance of about 1.5m to 2.0m apart and about 1.2m away from the wall to be constructed. Putlogs are placed with one end on the ledgers and other end in the hole left in the wall, at an interval of 1.2m to 1.5m.



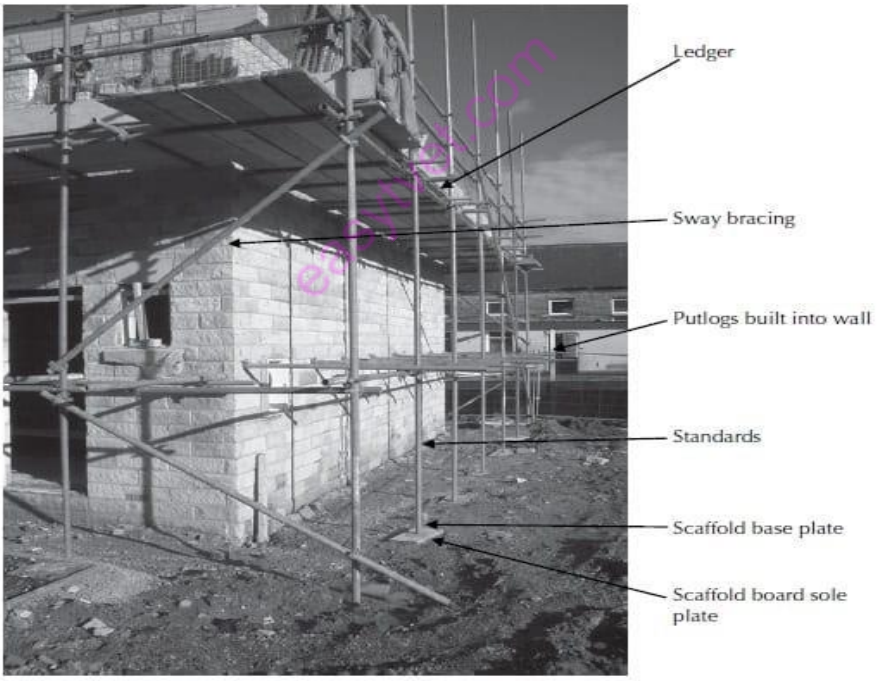


Figure 25; **putlog /single scaffold**

Ref;https://www.slideserve.com/cleopatra/putlog-scaffold

https://medium.com/@eunimien/scaffolding-a-brief-introduction-3f3fca158547

2. **Double or mason's scaffolding:** The framework is similar to the single scaffolding except two rows of standards are used, one row close to the wall within 15cm of the wall faces 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. Rakers and cross braces are provided to make the scaffolding more strong and stable. It is generally used while constructing stone masonry, as it is very difficult to provide holes in the wall to support putlogs. Such scaffolding is also called independent scaffolding.

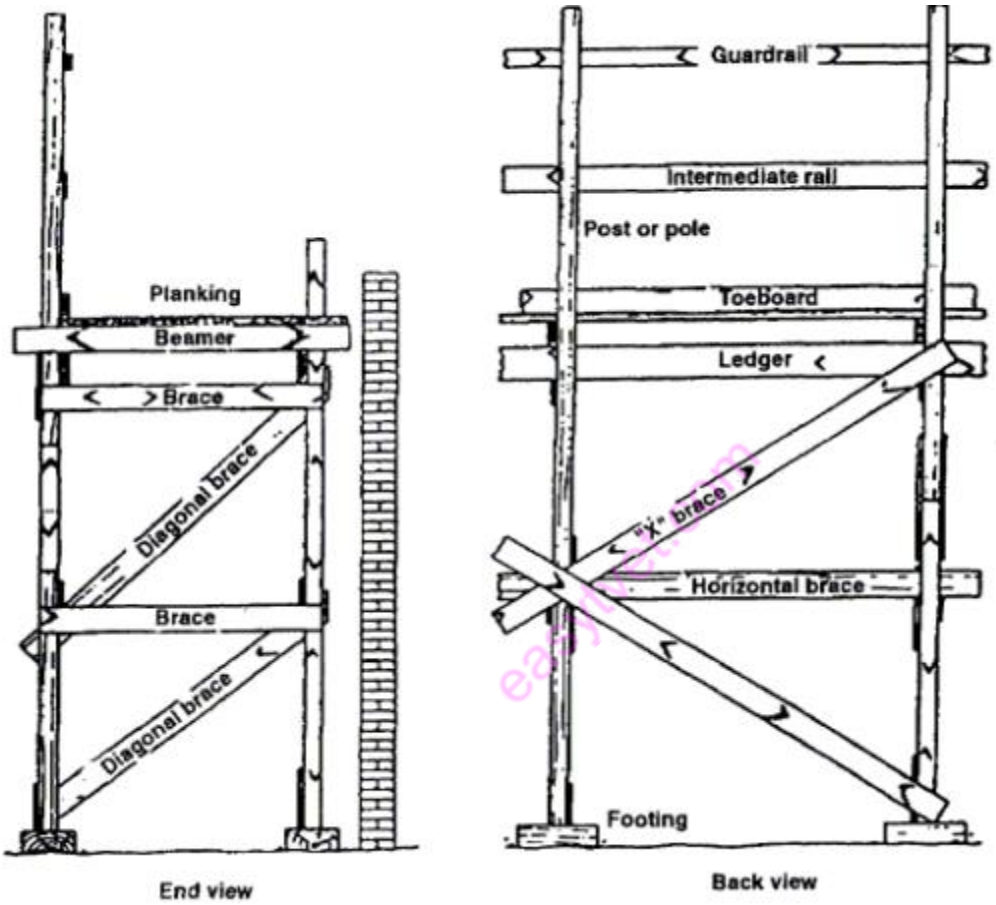


Figure 26: **double scaffolding**

Ref;Rangwala, S, C (1978), Building Construction 4th Edn, Charotor Book Stall. Anand Press, India.

3. **Cantilever Scaffolding:** Also referred to as needle scaffolding, cantilever scaffolding consists of standards that are supported on succession of needles taken out through holes in the wall.

   It can be single or double type. Single type cantilever scaffolding consists of standards supported on a series of needles. The double type cantilever scaffolding, on the other hand, has needles and projecting beams strutted into the floor through the openings.

Cantilever or needle is used under the following circumstances:

- Ground is weak to support standards.
- When construction is done on the side of a busy street
- It is required to keep the space, near the wall, free for a walk and for traffic, etc
- When construction work is carried out at very high level in case of tall building

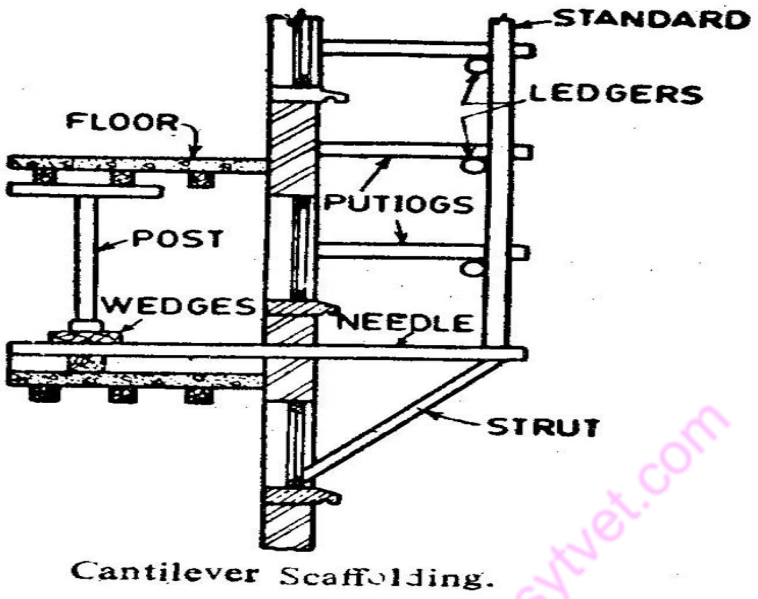


Figure 27: **cantilever scaffolds**

Ref;https://cementconcrete.org/buildings/types-of-scaffolding-used-in-construction-parts/2120/

4. **Suspended Scaffolds:** This consists of a working platform suspended from parapet walls or the roof using ropes, chains or wires that can be lowered or raised to the desired level. It's commonly used for maintenance jobs like painting.

*Figure 28**: suspended scaffolds***

Ref;https://medium.com/@eunimien/scaffolding-a-brief-introduction-3f3fca158547

Suspended scaffolds are of three types—fixed, operated by pulleys and operated by winches

i. **Fixed type suspended scaffolds.**

These are the scaffolds attached to a truss or the roof truss above the site of work using ropes, chains, tubes, etc.

ii. **Suspended scaffolds operated by pulleys, etc.**

These are like the platforms of the window cleaners and painters of buildings.

iii. **Suspended scaffolds operated by winches.**

These arc heavy platforms hung by wires from temporary outriggers and operated by external cranes.

5. **Trestle scaffolding:** It consists of working platforms supported on movable ladders and no standards or putlogs. Thus, this can be easily shifted from one point to another. Trestle scaffolding is commonly used for painting works or minor repairs inside the rooms. The usage of Trestle Scaffolding is limited to indoors as the height in this Scaffolding is up to 5 meters only.

*Figure 29**: trestle scaffolding***

Ref;https://www.indiamart.com/proddetail/scaffolding-trestle-1980109355.html

6. **Steel Scaffolding**: Steel scaffolding is constructed by steel tubes which are fixed together by steel couplers or fittings. It is very easy to construct or dismantle. It has greater strength, greater durability and higher fire resistance. It is not economical but will give more safety for workers. So, it is used extensively nowadays.

*Figure 30; **steel scaffolding***

Ref;https://theconstructor.org/building/types-of-scaffolding-in-construction/11845/

ERECTING AND DISMANTLING SCAFFOLDING

Erecting and dismantling scaffolds remains a high-risk activity, not only to those carrying out the work, but to other workers and the general public.

Erecting scaffold

I. **Select a secure foundation on which to build and set your scaffold.** Obtain mud sills or base plates to attach the scaffolding to make the footing more stable. One of the main concerns here is to have the scaffolding level and on secure ground. If you are on unleveled ground, you may need to dig down to make the dirt level in any high corner.
II. **Assemble the scaffolding frame.** Lay out the ends of the scaffolding. Lift one end piece, and attach the upper cross brace. The far end of this brace should support the end piece while you lift the second end piece and attach its upper cross brace. Secure the ends of the cross braces to the bottom of the opposite end frame.
III. **Make sure the scaffold is stable.** Move the scaffold into your desired position, and make sure it is level and secure.
IV. **Place the planks.** Lift the planks through the scaffold bars and into place.
V. **Secure access to the scaffold.** If ladders are used to access the scaffold, use ones that are designed for that specific scaffold. Stair-like ladders can be used to access the scaffold but must have handrails and treading. A concern with the access point is to make it safe to maneuver and to prevent the scaffold from tipping over.
VI. **Attach the guardrails.** Guardrails are highly recommended for all scaffolding due to the height of the equipment and the risk of falls. Also consider using tie offs and other fall protection.
VII. **Inspect the scaffolding to ensure safety.** Thoroughly examine the scaffolding setup to make sure all pieces are secure. Reinspect the scaffold system every time you leave the site and return to it to make sure it is still safe.

Dismantling of Scaffolding

The work of dismantling scaffolding should be under the supervision of an individual with proper experience and aptitude. The following should be observed while dismantling.

a. Check to see if scaffolding has been structurally altered in any way which would make it unsafe, and if so reconstruct where necessary before commencing with the dismantling procedures.
b. Dismantle scaffold from the top down. Begin by removing all accessories from that lift being dismantled at the time.

c. Always work from a minimum of two plank placed on the tier of frames below those being removed. Move the planking down as dismantling progresses.
d. Do not remove ties until dismantling has reached the tier to which they are attached.
e. Always stay within the inside of the scaffold. Do not climb on the outside for any reason when dismantling. Do not climb on ties, braces or unbraced frames.
f. Only remove fastening devices from bottom of frames being removed.
g. Lower scaffolding components in a safe manner as they are dismantled. Avoid dropping or throwing the components as this could result in damage to the equipment, or injury to personnel below.

PERSONAL PROTECTIVE EQUIPMENTS

For safety, scaffolders and scaffold users have to be on their PPE at all times, there should be a first aid kit available.

Personal protective equipment (PPE) used for scaffolding include:

- Gloves.
- Safety shoes.
- Goggles.
- Earmuffs.
- Overall and reflective jackets.
- Hard hats.
- Safety harness.

Figure 31; ***PPEs***

SITE SAFETY REQUIREMENTS

a) The uprights (standards) should not be spaced more than 1.8 m (6 ft) for heavy work such as masonry and not more than 3 m (10 ft) for light work such as painting.
b) The putlogs in single scaffolding should bear well on the wall opening. Short members nailed onto the wall should not be used as putlogs.
c) The platforms should be wide enough. It should not be less than 17 inches (425 mm) in width if the height is more than 1.8 meters.
d) The plank should not be defective. To prevent sudden failure of the planks, the grains in the wood used should not be more than 10 degrees with the length of the plank. There should be no overhanging (or cantilevering) of these planks.
e) All scaffolding should be properly strutted so that they do not fall away from the wall laterally. Similarly, it should be stable longitudinally also.
f) Workmen should not work under the scaffolding.

g) Lorries should not be allowed to come near scaffolding.
h) Safe ladders should be provided to climb on to the scaffolding.
i) If the height is more than 2 meters, guard rails should be provided for the scaffolding.

1.2.3.4 Learning Activities

1.2.3.4.1 Practical activities

The diagram below shows a scaffolding plan

1. Assemble all tools and materials required
2. Assemble and erect independent scaffolding as per plan.
3. Dismantle the scaffolding and clear the site.

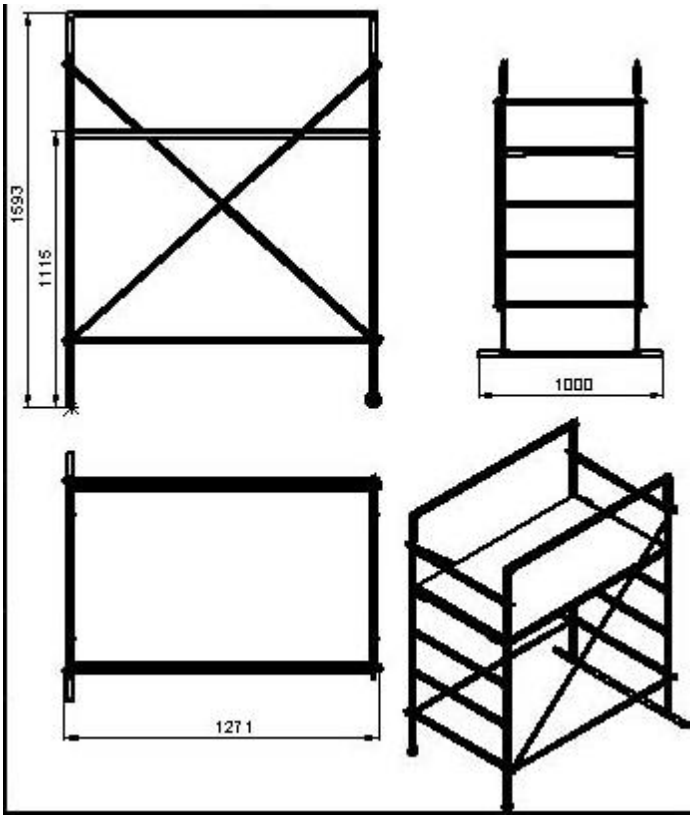


Figure 32 ***: scaffolding drawing***

1.2.3.4.2. Field study

Visit a nearby construction site

- Identify the type of scaffolding used
- Check the safety measures in the scaffolding system

Materials Required

Timber
Props
Nails
Hummer
Saw
Panga
Tape measure
PPEs
Pen
Notebook

1.2.3.5 Self-Assessment

1. What Is The Scaffolding?
2. What Is A Putlog In Scaffolding?
3. What Are the Types of Scaffolding?
4. How can a scaffold built alongside a road be protected from traffic damage?
5. Why is plan bracing needed in a mobile scaffold?

1.2.3.6 References

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https://theconstructor.org/building/types-of-scaffolding-in-construction/11845/

RESPONSES

1. What is the Scaffolding?
   Scaffolding is a temporary structure to support the original structure as well as workmen used it as a platform to carry on the construction works.
2. What Is A Putlog In Scaffolding?
   These members are placed on ledgers at right angles to the walls, with one end supported on ledgers and other end on the wall

3. What Are the Types of Scaffolding?
   - **Single scaffolding.**
   - **Double scaffolding.**
   - **Cantilever scaffolding.**
   - **Suspended scaffolding.**
   - **Trestle scaffolding.**
   - **Steel scaffolding.**
4. How can a scaffold built alongside a road be protected from traffic damage?
   - **Re-route traffic**
   - **Provide guards**
   - **Use a person to direct traffic (or flagman)**
5. Why is plan bracing needed in a mobile scaffold?
   To stop the scaffold from twisting (or distorting) when it is moved

1.2.4 **Learning Outcome 4:** Erect and dismantle building shores

1.2.4.1 Introduction to the learning outcome

This learning outcome specifies on how to erect and dismantle shoring. The trainee will learn about types of shoring, shoring materials, construction and dismantling of shoring.

1.2.4.2 Performance Standard

4.1 Type of shore is selected according to the nature of the work
4.2 Shoring materials are selected according to the construction rules and regulations
4.3 Personal protective equipment is selected, fitted and used according to safety rules and regulations
4.4 Shoring is erected as per site conditions and building construction rules and regulations
4.5 Shoring is dismantled according to site procedures and critical structural safety requirements

1.2.4.3 Information Sheet

Definitions of terms

- **Shoring-**It is the method of providing temporary support (shores) to an unsafe structure.
- **Wall plate -**wall plate is a load-bearing structural member used horizontally and part of a timber framework.
- **Cleat** - A cleat is a strip of wood or metal that is attached to one part of an object, in order to hold it in place while attaching another part
- **Raker** –it is an inclined member.

INTRODUCTION

It is essential for structures which have become unsafe due to unequal settlement of foundation or due to removal of adjacent building or due to any other reason.
For safe structures, shoring is required to prevent movements when certain additions & alterations are being carried out.
Shoring is designed to prevent collapse where shielding is only designed to protect workers when collapses occur.
Shoring is **used** under the following conditions:

- When a wall shows signs of bulging out due to bad workmanship.
- When we have to repair a crack on the wall due to unequal settlement of foundation.
- When an adjacent structure is to be dismantled.
- When openings are to be made or enlarged in the wall.

Types of Shoring

There 3 types of shoring, namely:

- Raking/ inclined shoring
- Flying/ horizontal shoring
- Dead /vertical shoring

1) Raking Shoring

Raking shores also known as inclined shoring, is used to give lateral support to the wall.In this method, inclined members known as rakers are used.

A raking shore consists of the following components:

- Rakers or inclined member
- Wall plate
- Needles
- Cleats
- Bracing
- Sole plate

Erection procedure of raking shoring

The wall plate (20 to 25 cm wide and 5 to 7.5 cm thick) is placed vertically along the face of the wall and is secured by means of needles.
These needles (10 cm x 7.5 cm) penetrate the wall by about 10 to 15 cm. In order that the needles do not get sheared off due to the thrust of the raker, the needles are further strengthened by means of cleats which are nailed directly to the wall plate.
Rakers about against the needles in such a way that the centreline of the raker and the wall meet at the floor level. Thus, there will be one raker corresponding to each floor. These rakers are inter-connected by struts, to prevent their buckling.
An inclined sole plate is embedded into the ground on which the feet of rakers are connected. The feet of rakers are further stiffened near the sole plate by means of hoop iron. The wall plate distributes the pressure to the wall uniformly.

The following points are kept in mind when using Raking shores:

- Rakers should be inclined to the ground by 45° to 75°, but 45° is more effective. The Top of raker should not be inclined steeper than 75°.
- For tall buildings, the length of raker can be reduced by introducing rider raker.
- Rakers should be properly braced at intervals.

- The size of the rakers should be decided on the basis of anticipated thrust from the wall.
- The centre line of a raker and the wall are maintained at the same level of floor.
- If longer length of the wall needs support, shoring may be spaced at 3 to 4.5 m spacing, depending upon the requirements.
- The sole plate should be properly embedded into the ground, at an inclination and should be of proper section. The sole plate should be sufficient widen so that it can easily support all the rakers, and a cleat provided along the outer edge.
- Wedges should not be used on sole plates since they are likely to give was under vibrations which are likely to occur.

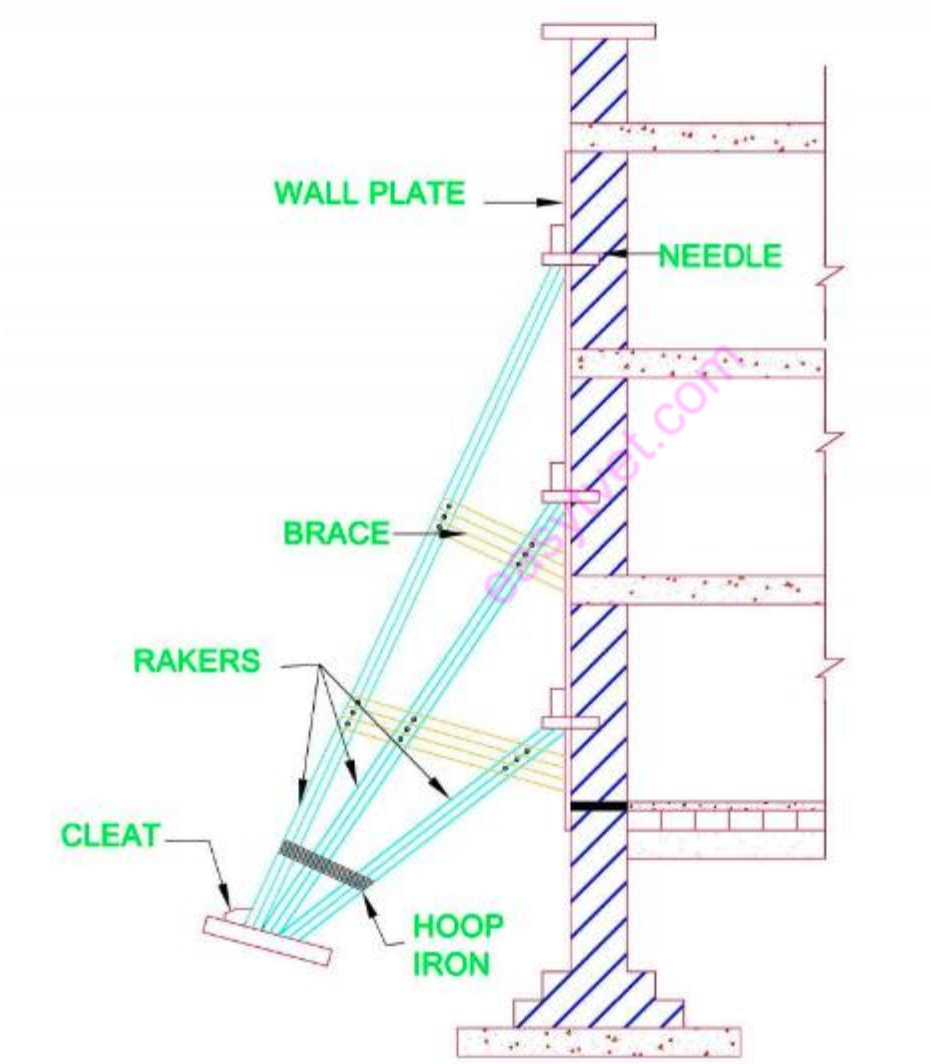

Figure 33: **Raking shoring**

Flying Shoring

Flying shores is a system of providing temporary supports to the party walls of the two buildings where the intermediate building is to be pulled down and rebuilt .All types of arrangements of supporting the unsafe structure in which the shores do not reach the ground come under this category.

The flying shore consists of

- Wall plates,
- Needles,
- Cleats,
- Horizontal struts (commonly known as horizontal shores)
- Inclined struts arranged in different forms which vary with the situation.

There are two types of flying shore: single and double flying shore

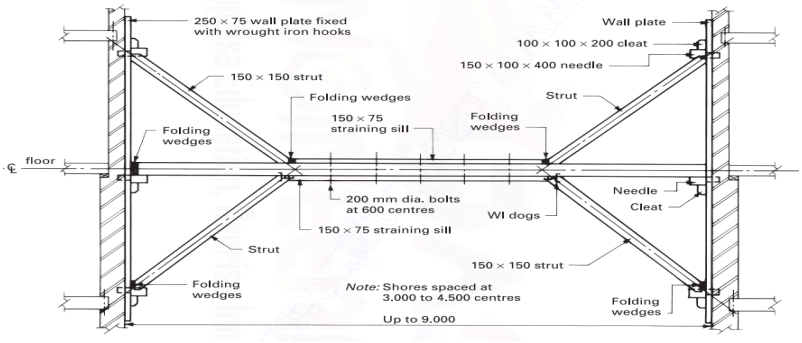

Figure 34 ***: single flying shoring***

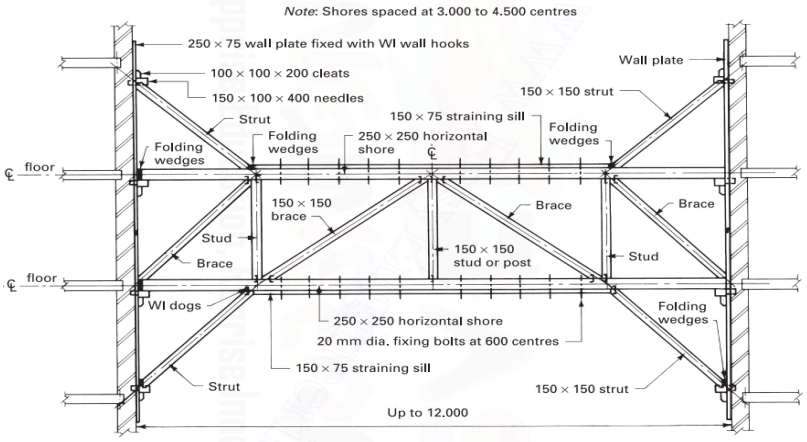

Fig 4.3: double flying shoring

Procedure of erecting frying shoring:

- In this system, first the wall plates are place against the wall and secure to it.
- A horizontal strut is place between the wall plates and is support by needles and cleats. It should be parallel to floor slab line
- Inclined struts are support by the needle at their top and by straining pieces at their feet. Folding wedges is used to prevent movement.
- The straining piece which is also known as straining sill and is spiked to the horizontal shore. The width of straining piece is the same as that of the strut.

The following ***points should be kept in mind*** while connecting the ***flying shores:***

1. The centre lines of flying shore and struts and those of the walls should meet at floor levels of the two buildings. If the floor levels are different, the horizontal shore should be placed either mid-way between the levels of the two floor of equal strength, or it should be placed at the level of weaker floor.
2. In the case of double flying shore, two horizontal flying shore is provide which is joint by brace and post.
3. Single shores should be used only up to 9 m distance between walls. For greater distance, double shores should be provided. In that case, both the horizontal shores should be symmetrically placed with respect to the floor levels.
4. Struts should preferably be inclined at 45º and should not exceed 60º
5. The flying shores should be spaced at 3 to 4.5 m centres, along the two walls; and horizontal braces should be introduced between adjacent shores.
6. In this system, various members of the shoring are determined by using large factor of safety because it is uncommon to assess the actual loads.
7. When there is a structural gap between two building due to removal of old building then, flying shore are inserted and removed after construction of new structure.

Dead Shoring

This type of shoring is used to support dead loads that act vertically downwards. It consists of dead shores, sole plate, needle and props. Needle transfer the load of the wall to the dead shores.

Dead shoring is provided to serve the following purpose:

- To rebuild the defective lower part of the wall
- rebuild or deepen the existing foundation
- To make large opening in the existing wall at lower level.

Erecting Procedure:

First of all holes are made in the wall at calculated height. Then needles made of thick wood or steel sections are inserted into the holes and are supported on vertical posts or dead shores on both sides.

Points to note

- Needles Should be spaced at 1 to 2m
- Min. 3 needles should be used for one opening
- Both needle ends are supported by vertical post
- Vertical posts are supported on folding wedges and sole plate
- Suitable bracings should be placed
- If the external wall is weak raking shore may be provided in addition to dead shore
- Shores should be removed only when the new work has gained sufficient strength but not earlier than 7 days of the completion of the new work

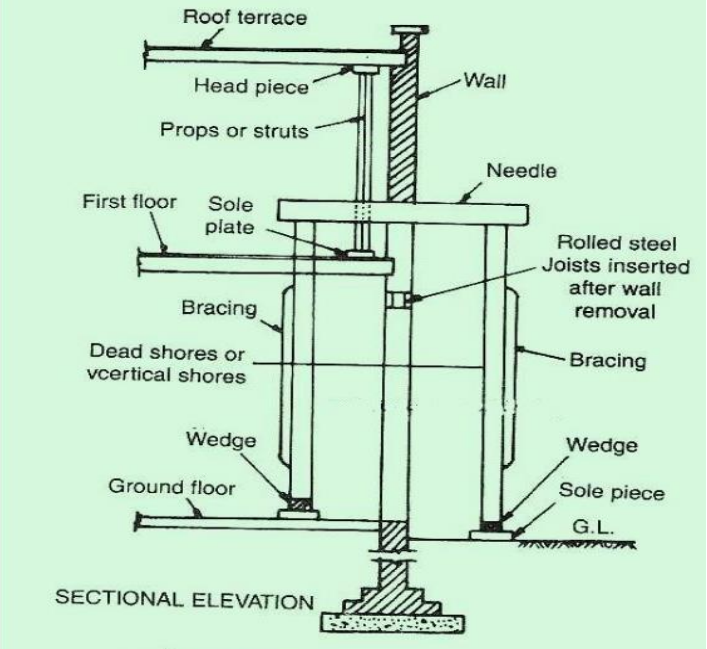

*Figure 35***4: vertical shoring**

Shoring materials

The following are commonly used materials for shoring:

- ***Timber*** **-** most commonly used material for shoring members and the system due to its construction (and dismantling) speed and cheap labor cost
- ***Steel*** – mostly used as struts and needles for dead shoring.

Shoring guidelines

- Lateral clearances must provide sufficient space for construction
- Any excavation, holes or trenches on the Railroad property shall be covered, guarded and/or protected.
- The most stringent project specifications of the Public Utilities Commission Orders, Department of Industrial Safety, and OSHA, NEEMA or other governmental agencies shall be used.
- All components of the shoring system are to be removed when the shoring is no longer needed

1.2.4.4 Learning Activities

1.2.4.4.1 Practical activities

1. Assemble all tools and materials required
2. Erect a raking shoring as shown below

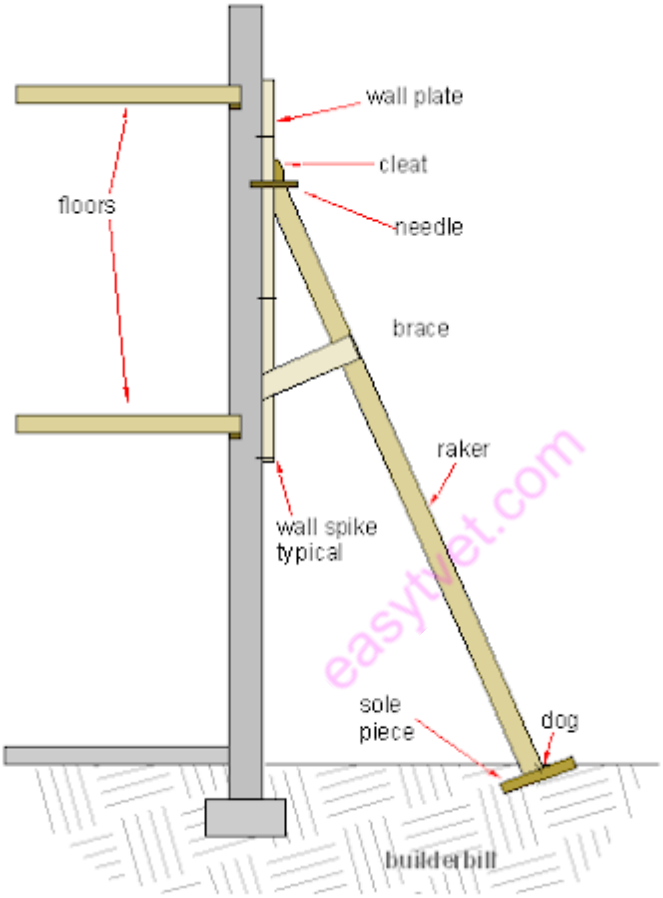

Figure 36 ***:raking shoring plan***

1.2.4.4.2. Field study

- Move around within your school and identify various situations where shoring may be needed.

Materials Required

Timbers

Nails

Hoop iron

Hummer

Binding wire

Saw

Wall platform

Pen

Notebook

1.2.4.5 Self-Assessment

1. The construction of a temporary structure required to support an unsafe structure, is called

   a. Underpinning

   b. Scaffolding

   c. Shoring

   d. Jacking

2. Which are the types of shoring?

3. In _____ shore arrangement, the inclined supports are given to the external walls from the ground.
   a. Raking shore
   b. Flying shore
   c. Dead shore
   d. Patented shore
4. What is procedure of erecting dead shoring?
5. There are two types of horizontal shoring. Which are they?

1.2.4.6 References

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Responses

1. The construction of a temporary structure required to support an unsafe structure, is called

   a. Underpinning

   b. Scaffolding

   c. Shoring

   d. Jacking

2. Which are the types of shoring?

   Raking shore

   Dead shore

   Flying shore

3. In _____ shore arrangement, the inclined supports are given to the external walls from the ground.
   a. **Raking shore**
   b. Flying shore
   c. Dead shore
   d. Patented shore

4. What is procedure of erecting dead shoring?
   - **First of all holes are made in the wall at calculated height. Then needles made of thick wood or steel sections are inserted into the holes and are supported on vertical posts or dead shores on both sides**.

5. There are two types of horizontal shoring. Which are they?

   - **Single flying shore**
   - **Double flying shore**

Prepared by Weston Chege

Tell: 0712961016

MATHENGE TTI