TVET CERTIFICATE IV in CARPENTRY

SHUTTERING

CAPSH401 Make shuttering

Competence

Credits: 6 **Learning hours: 60**

Sector: Construction and Building Services

Sub-sector: Carpentry

Module Note Issue date: November, 2020

Purpose statement

This module describes knowledge and skills required to make shuttering. It describes the skills, knowledge and attitudes required for the trainee to prepare materials, tools, equipment and workplace, perform shuttering assembling and Fix shuttering.

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General introduction

Definition of Shuttering or Formwork

It's a temporary structure erected to sustain concrete on required dimensions and shapes until it attains strength. The form work is designed as to serve live load and dead load bearing support and avoiding bulging.The shuttering serves as mould for concrete structural components unless such mould is provided by the soil, other structural components, etc. It moulds the placed fresh concrete, which in this stage normally is viscous, to the shape specified in the drawing. Types of concrete formwork construction depend on formwork material and type of structural element. It is an artificial support provided below and around the precast or cast in situ concrete work.

Concrete pours need to be contained, to hold the concrete in place until it hardens sufficiently to hold its own shape. The ways and means of containing the fresh concrete, keeping it where it needs to be until it hardens.

Formworks can also be named based on the type of structural member construction such as slab formwork for use in slab, beam formwork, column formwork for use in beams and columns respectively etc.

Figure 1: Formwork on site

Qualities of formwork

- It should be practically water proof so that it should not absorb water from concrete.
- It should be strong.
- It can be cheaper & reusable
- It should be according to the size of member.
- It should be with minimum shrinkage & swelling.

- It should be stiff enough against its deflection, buckling under load.
- Its contact surface should be uniform.
- It should be light in weight

Formwork Safe Practices Checklist during Design and Construction

A safe practice for formwork during construction at site is important for safety of workmen. Improper erection of formwork can cause damage to structural element as well as pose threat to the safety of workmen.

Formwork Safety Checklist during Design:

1. Formwork should be properly designed for the structural element considered and its working drawing should be available at site.
2. Design of formwork should consider all the loads it will experience during casting of concrete structural members.
3. Strength of materials used for formwork should be adequate to support structural load as well as other loads imposed on it.
4. Formwork design should indicate the rate of concrete pour, height of concrete pour, temperature and sequence and schedule of concrete pours.
5. Working drawing of formwork should have detailed dimensions including pouring pocket size, compaction opening and cleanouts.
6. Formwork design should consider the safe bearing capacity of soil.

FORMWORK TERMINOLOGY

1. Formwork drawing

Formwork drawing which will represent the dimensions and number of support and spacing and any other specific details are included.

2. Staging

Temporary structure is erected to support formwork for beams, slabs at raised height for supporting concrete.

3. Bracing

It is a structural member, used to stiffen the vertical members of formwork.

4. Primary runner

It is the primary wooden runner which will run along the direction of beam, on the top of stirrups.

5. Secondary runner

The secondary runners are placed perpendicular to the primary runner and placed with a suitable spacing.

6. Scaffolding

It is a temporary structure which is used in the building as plat form for workers for respective works at raised height.

Design and Estimating of Forms

"Design determines sheathing thickness, stud size, wale size, tie size"

Use of design tables

Watch for

1. Rate of pour
2. Temperature and weather
3. Proportions of mix and consistency
4. Method of placement and vibration

Common Defects in Concrete Formwork Systems

Concrete formwork systems suffer from several deficiencies such as defects due to imperfect design and construction practice, defects in foundation level of formwork systems, defects in vertical support of formwork systems and defects in horizontal support of formwork systems. These common defects are discussed below.

Common Defects in Concrete Formwork Systems

1. Formwork Defects due to Imperfect Design and Construction Practice

- Too much tolerances in construction
- Inability to control vertical rate of concrete placement
- Inability to check the tightness of bolts and wedges before loading formwork systems
- Insufficient allowance for uplift of concrete under inclined formwork systems
- Different load distribution between two or more member that supposed to support common loads
- Incorrect computation of stresses because of over simplification of design assumptions
- Lack of required provision for the vibration effect on ties, struts, braces, and wedges
- Failure to properly account for wind loads
- Insufficient allowance for the influence of stresses generated by temperature, prestressing, and moisture movements

Following inspection should be carried out before starting the concreting of structural member:

1. Inspection of entire formwork system for details from bottom to top of formwork for proper load transfer in safe manner.
2. Inspection of working scaffolds, ladders, runways, ramps and crossings.
3. Maintenance of good housekeeping around working area and passage.
4. Guarding of peripheral edges and floor openings.
5. Adequate space for safe working.
6. Safety training of workmen involved in formwork and concreting works.
7. Use of all personal protective equipment (PPEs).
8. Formwork, rigging inserts and connections checked for correct installation and periodically checked for wear and correct position.

9. Removal of all unused and hanging forms, loose materials etc. stored on exposed floors.
10. Inspection of all props and shores for adequacy to handle all the loads.
11. Removal of defective props.
12. Alignment of props such as verticality, height and spacing between props should be inspected.
13. All props should be rested on bearing plates.
14. Props should be placed on hard bearing surface.
15. Safe nailing and firm locking of clamps on adjustable props.
16. Lateral stability of formwork and complete fixity at the joint between props when one prop is placed on the top of the other.
17. Proper bearing below the stringers and joists at points of supports.
18. De-shuttering and removal of props below concrete slabs and beams after development of adequate strength in concrete.
19. Construction loads not placed on freshly cast slab or beams while removal of formwork or before concrete attaining required strength.

Formwork Safety Checklist

The following are the formwork safety checklist requirements:

1. Formwork is designed for the structural element under consideration. The working drawing of the same has to be available at the site.
2. The strength of the elements that is used as formwork must be sufficient to support the structural load as well as the load that is imposed.
3. While designing the formwork, all the loads have to be considered including the loads coming during the process of casting.
4. The rate of pour, the height of concrete pour, the sequence, the temperatures and the schedule of concrete pouring must be considered during formwork design.
5. The formwork designing must take into consideration the safe bearing capacity of soil.
6. The working drawing at site must include the detailed dimension of the compacting opening, the cleanouts.
7. All props must be checked. They must lie over bearing plates.
8. Defective props have to be removed.

Requirement of Good Formwork:

A proper idea on the basic requirements of formwork and form working procedure will help in avoiding mistakes. These include:

- ✓ Formworks must be rigid to bear the design loads without changing the desired shape of the concrete.
- ✓ The formwork has to be stable and strong.

- ✓ The design of formwork must be such that it is handled properly without affecting the dimensional stability.
- ✓ Handling of formwork has to be done properly so that it can be reused.
- ✓ Proper planning of the formwork before placement has to be performed.
- ✓ Formwork is planned based on the stripping requirements, construction joints in structure, equipment used for handling the material and sections, the weather conditions, mixing and placing of concrete.
- ✓ The formworks must lie over a base that is strong and if lying on the ground it has to be water resistant.
- ✓ Formwork material must be easily available
- ✓ The placement of the formwork has to be done in a such a way that the desired line and level of concrete surfaces are achieved.
- ✓ Joints in formwork must be tight so that leakage of cement slurry is avoided.
- ✓ Proper propping and bracing of the formwork both horizontally and vertically is another important requirement.
- ✓ Rigidity in all aspects helps to get a quality product of concrete, and i.e. line, level and safety.
- ✓ The formwork must withstand all dead and live loads.
- ✓ Use formwork material that satisfy the specifications and requirements
- ✓ Protection of the construction site will help in avoiding vandalism of formwork.
- ✓ In case of formwork removal for slabs, columns and beams, vertical faces have to be removed first. This is because the vertical face carries no loads compared to horizontal formwork.
- ✓ Improper design of formwork can result in bulging observed in columns and deep beams. If the formwork is not designed to take wet concrete pressure such issues are seen on the surface. The bulging is observed after the removal of formwork.
- ✓ The corners of the concrete have to be properly sealed to avoid leakage and bulging.
- ✓ Before concreting, adequate space must be provided for the access of workers who have to carry out placing of concrete, compacting and finishing.
- ✓ While the concreting process is carried out, the plumb, levels, the level of surface, the alignment and the camber have to be maintained throughout.
- ✓ The cover of the steel reinforcement provided must not be affected.
- ✓ If the vibration during compaction loosens the wedges and fixings, correction has to be done immediately.

Important Points to Consider in Form Working:

The formwork is subjected to:

- ✓ Stresses and loads from the placed concrete
- ✓ The forces from vibration during the compaction process
- ✓ Dead load

These factors hence will demand proper planning and design of formworks. Considering main features in the design and implementation of formwork makes the concreting process error free.

Improper execution of the work will result in formwork failures which will create huge loss and accident while concreting.

Given below are the main aspects and mistakes to be avoided during the form working process:

Design Criteria:

The design of the structure will influence the formwork. This is related to the health and safety of the people during the construction works. Basic and simple concrete design will help to have easy form working making the erection and dismantling of the formwork easy and safe.

For complicated in-situ concrete structures, formwork must not be executed without the help of a formwork designer. Such mistakes will affect the safety and quality factors in construction.

Formwork must not be executed with a vague idea or information. The designer who is in charge of form working must follow the technical design details and the engineering principles. Design of formwork includes selection of formwork materials, their size, spacing and system for de-shuttering etc.

Erection of Formwork Frames:

Always avoid hurry burry in formwork installation. The work has to be done progressively so that the safety of life and stability of formwork structure is guaranteed.

Fall Protection:

Huge formworks will require special safety provisions to avoid falls. Some of the requirements include:

- ✓ Formwork deck must have edge protection
- ✓ Containment screens around the perimeter of the formwork to avoid falling of object outside the form area.

Testing and Inspection of Formworks:

Formworks must not be put into use without proper inspection. Proper inspection will include pre-loading. Inspection of the same will help to avoid the risks during the construction of formwork.

Mistakes in Form Working:

Undesirable work procedures during the form working will result in formwork failures which will further result in accidents and building failures. Some of the mistakes to be avoided are:

- ✓ Inadequate bracing provided as support. The bracing provided must have sufficient load carrying capacity.
- ✓ Placing and pouring of the concrete not performed properly.
- ✓ Support of formwork placed in unstable soil.
- ✓ Improper stripping procedure
- ✓ Excessive vibration of the concrete
- ✓ Lack of knowledge of form working

Learning Unit 1 – Prepare materials, tools, equipment and workplace

L.O. 1.1: Use PPE for shuttering.

- **PPE used for shuttering**

What is PPE?

Simply PPE is Personal Protective Equipment

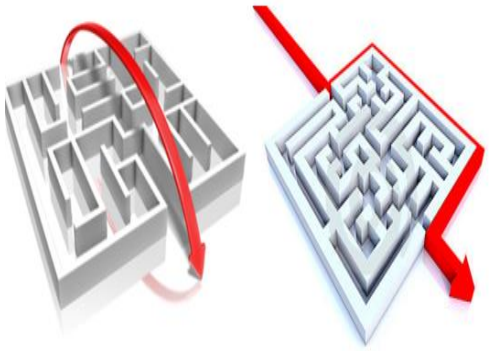
- ➢ **Helmet:** it is any of various protective head coverings usually made of a hard material to resist impact
- ➢ **Gloves:** it is a covering for the hand worn for protection against cold or dirt and typically having separate parts for each finger and the thumb.
- ➢ **Goggles:** close-fitting glasses with side shields, for protecting the eyes from glare, dust, water, etc.
- ➢ **Safety shoes (boots):** A steel-toe boot (also known as a safety boot, steel-capped boot, steel toecaps or safety shoe) is a durable boot or shoe that has a protective reinforcement in the toe which protects the foot from falling objects or compression.
- ➢ **Overall:** They are a type of garment usually used as protective clothing when working. It is a loose-fitting coat or one-piece garment worn over ordinary clothes for protection against dirt or heavy wear.
- ➢ **Safety belt:** it is a strap or belt worn as a safety precaution by a person working at great height.

Safety precaution

Shuttering can be a safe and enjoyable hobby or vocation if you follow some very basic safety rules. All of the rules are common-sense ideas, but failure to follow these rules will greatly increase the chance of injury when working with your tools. Construction site is not the place to be in a hurry or have an "it won't happen to me" attitude.

Mark Twain once said, “It is better to be careful 100 times than to get killed once.” Think about this; 90 of every 100 accidents that happen in the workplace are ultimately the fault of the person involved in the incident. What does this tell us? Workers are not taking the proper precautionary measures before working, or they are simply too lazy to be bothered with it.

Causes of Workplace Accidents



- **Shortcuts:** Humans are notoriously lazy, so taking shortcuts is a rather common practice in all walks of life, not necessarily work alone. When workers take shortcuts at work, they are exposing themselves to a potential catastrophe. Shortcuts that are taken on the job are not actually shortcuts. They are simply increasing your risk of injury, or worse, death.

- **Overconfidence:** Confidence is always a great thing to have, but there is also such a thing as too much confidence. When workers walk into work every day with the attitude that, “It will never happen to me”, they are setting an attitude that leads to incorrect procedures, methods, and tools while working. Be confident, but remember that you are not invincible.

- **Neglecting Safety Procedures:** This is probably the worst thing that any employee at any level in the organization can do. Deliberately neglecting set safety procedures in the workplace does not just endanger yourself, but it endangers the workers around you as well as the company as a whole.

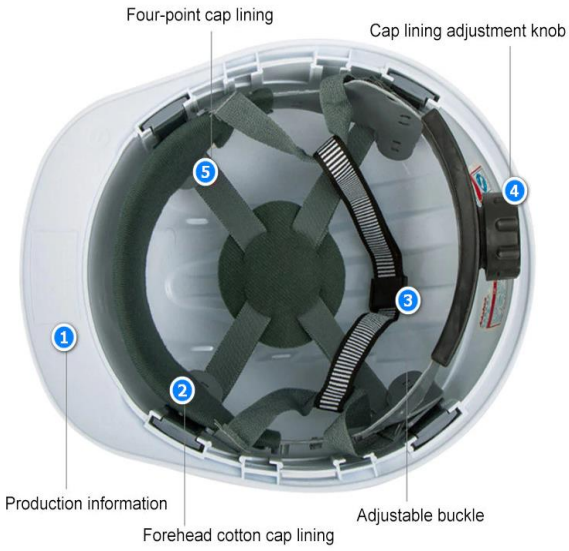
➢ **Mental Distractions:** Everyone has a life outside of the workplace, and sometimes life can take dips and turns that affect your emotions and your mood negatively. However, as harsh as it sounds, workers cannot let mental distractions from their personal lives affect their performance at work. Not only will they become less aware of their surroundings and less safe, but they will also become less productive, costing the company time and money

➢ **Lack of Preparation:** You may have heard of something called Job Hazard Analysis (JHA). JHA's are an effective method of figuring out the best way to work safely and efficiently. When workers begin a task without thinking through the process beforehand, or hastily start without any type of planning, they are setting themselves up for failure. Make sure you plan your work, and then work your plan.

Use of PPEs used in shuttering

✓ **Helmet**

Hard hat is a type of helmet predominantly used in workplace environments such as industrial or construction sites to protect the head from injury due to falling objects, impact with other objects, debris, rain, and electric shock. They must provide excellent protection for the head, including shell, headband, and harness.

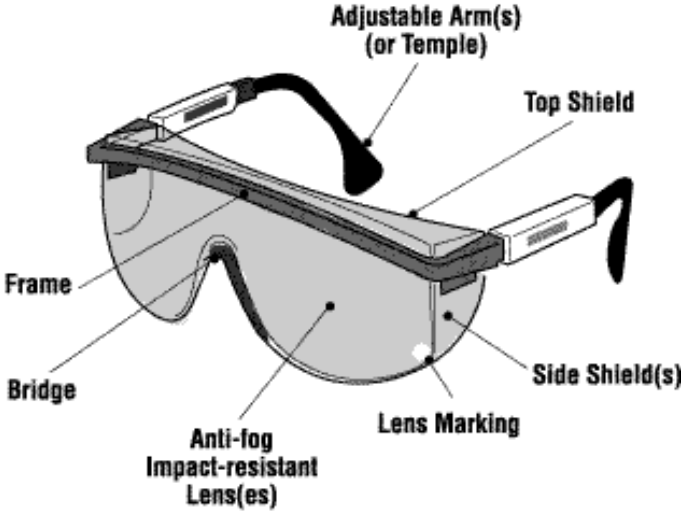


➢ **Gloves**

The Safety Gloves range is ideal for protection during a number of common engineering tasks. Cut resistant **gloves** are **gloves** designed to protect the wearer's hands from cuts while working with sharp tools. Working with metal and glass forming and hot surfaces requires **gloves** that offer the highest level of protection against the multiple hazards of a high-heat workplace.

✓ **Goggles**

Goggles, or safety glasses, are forms of protective eyewear that usually enclose or protect the area surrounding the **eye** in order to prevent particulates, **water** or chemicals from striking the eyes. They are used in chemistry laboratories and in woodworking.



➢ **Dust mask**

Dust mask is worn over the mouth and nose to protect against dust and it is used in construction, they are used in environments with dusts encountered during construction or cleaning activities, such as dusts from drywall, brick, wood, fiberglass, and silica

➢ Overall

Also called bib-and-brace overalls or dungarees are a type of garment usually used as protective clothing when working. The garments are commonly referred to as a "pair of overalls" by analogy with "pair of trousers.

- ✓ **Safety shoes (boots)**

Work in an environment where it's important to make sure we have suitable footwear. Safety shoes can make a massive difference when it comes to remaining injury free in the workplace. Often referred to as steel toe cap boots or rigger boots, **safety boots** and shoes come in a variety of **styles** and **fittings** depending on your requirements and what the needs are within your role. Not only have safety boots served a practical purpose, but they have also had their moments in fashion too,

Protection

Protection against Falling Objects, Cutting, Electrocution, Slipping, and Burns

- ✓ **Safety belt**

A safety belt is a device that is worn around a person's waist to serve as a direct connection point to a lifeline or elevated structure. It is worn to arrest a fall and protect a worker from a sudden descent and associated hazards when working at an elevated height.

LO 1.2 – Select tools, equipment for shuttering

- Classification of tools and equipment for shuttering

- Hand tools

Classification of hand Tools used for shuttering

- Marking and setting out , testing and measuring tools
- Cutting & planing tools
- Boring tools
- Hammering tools

- **Marking and setting out, testing measuring and setting out**
  - **Square :**to set right angles


  - **Sliding Bevel :**to set angles other than a right angles

Folding ruler and tape measure


CUTTING TOOLS

- **A ripsaw**

Tool used for cutting wood.

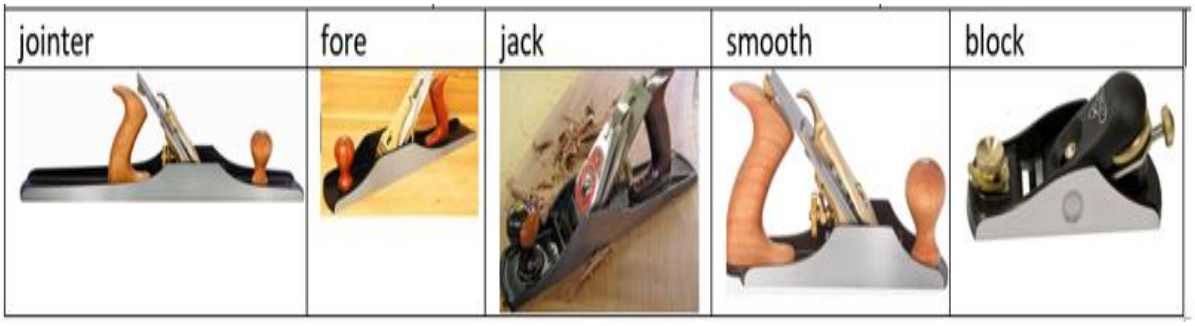
It is used to make straight cuts with the grain of the wood. The teeth of a ripsaw are chisel-shaped, 66 – 71 cm long, 3-5 teeth per 25 mm

➢ A **crosscut saw**

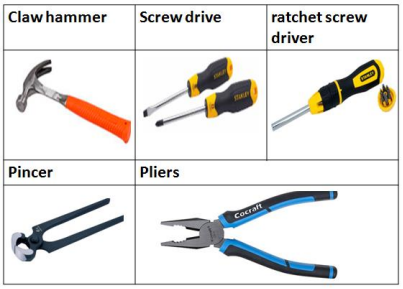
They are used to make straight cuts across the grain of the wood. They cut on both the forward and backward strokes of the blade. 51 -66 cm long, 6-11 teeth per 25 mm

➢ **PLANING TOOLS**

1. Jointer plane (22 to 28 in.)
2. Fore plane (18 in.)
3. Jack plane (11 to 15 in.)
4. Smooth plane (6 to 10 in.)
5. Block plane (4 to 6 in.).



➢ **Hammering tools**



Used for driving nails and screws and other fastenings

- Claw hammer
- Screw drive
- Ratchet screw driver
- Pincers & pliers: for taking out damaged nails

Portable power Tools

Machine operations

There are three major processes involved in manufacturing of portable wooden working machines:

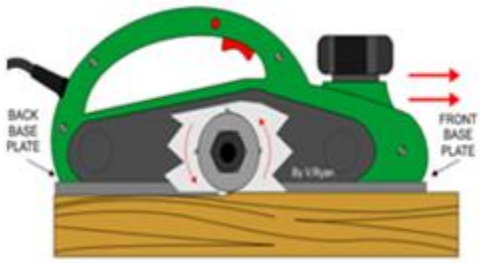
- Cutting out and planing to size
- Jointing and shaping
- Finishing

In shuttering we mainly use

- Cutting out and planing to size.
- Jointing

Portable hand planer machine

Main operations



- Chamfering
- Rebating
- Bevelling
- Planning RFS,RFE, ORFS,ORFE

Portable circular saw

Operations

- Ripping Cross cutting
- Rebating
- Housing

Portable hand jig saw

They are used to cut in curvatures, although they can also saw in a straight line just as easily.

Portable nail gun machine or nailer

It is a type of used to drive nails into wood or some other kind of material. It is usually driven by electromagnetism, compressed air (pneumatic). Nail guns have in many ways replaced hammers as tools of choice among builders.

- Heavy machines

They are precise power tools that are typically far too large and heavy to be portable, which means that they're rarely found on a job site. Instead, these tools will be most likely confined to your wood shop. Fortunately, they're so useful that you'll be quite willing to build your shuttering and carry the projects to your final destination.

Automatic Rip Saw

The main purpose of this machine is to use for solid wood cutting, they have high-precision wood processing in sawing. Excellent linear precision and sag accuracy

Circular saw machine

Main operations

Ripping, Cross cutting, Wedge cutting, Grooving

Panel Saw

Main operations

Ripping, Rebating , Chamfering , Bevelling, Tenon cutting , Mitering cutting to various angles, Cross cutting , Cutting equal pieces to size by using cross cut fence , Wedge cutting , Grooving

Surface or jointer and Thickness planer machine

OPERATIONS:

- ❑ Planing
- ❑ plane timber to desired thickness
- ❑ Planing rebates
- ❑ Planing bevels and chamfers

Band saw machine

OPERATIONS:

Ripping, Cross cutting, Round cutting, Chamfering, Bevelling, Log or Round cutting by using Templates or patens (self made)

Miter saw machine

A primary distinguishing feature of the miter saw is the miter index that allows the angle of the blade to be changed relative to the fence and cutting to various angles.

LO 1.3 – Prepare shuttering materials

The selection of the formwork material is based on the following factors:

- ✓ Price
- ✓ Quality Required
- ✓ Safety Concerns

The approval of the formwork materials is done by the engineer or the architect in charge. In projects where a clear surface for the structural element is required, pre mock-ups have to be performed with the formwork material so that any change in decision of material chosen can be made. Timber as formwork material has been used since centuries. The formwork system can use combination of two materials. Permanent forms are used in the construction of floors or the roof slabs that are constructed over the beams or the steel joists. These forms will remain even after the concrete have developed the design strength. Metal deck forms are example of such forms.

Types of materials

The material most commonly used to date is timber, but due to the depleting forest reserve the use of alternate materials such as plywood and steel has become prominent. Material such as plastics and fiberglass are also being used for pre-fabricating formwork. The type of material to be used depends on the nature of construction as well as availability and cost of material, the constraints on the project such as overall cost, time of completion also play a major role in the use of particular material for formwork.

- Types of materials

- ✓ Wood (Either all-wood or some wood components)
- ✓ Metal (Steel, Aluminium...)
- ✓ Adhesive materials
- ✓ Preservative materials
- ✓ Plywood (laminated board)
- ✓ Plastics....
  - Wood

TIMBER FORMS


Timber is required for practically all jobs of formwork. The timber being used for formwork must satisfy the following requirements:

- ➢ It should be durable and treatable
- ➢ It should have sufficient strength characteristics
- ➢ It should be light weight and well-seasoned without warping,
- ➢ Easily workable with nails without splitting, free from loose knots
- ➢ Timber used for shuttering for exposed concrete work should have smooth and even surf ace on all faces which come in contact with concrete.

Normal sizes of members for timber formwork:

Sheeting for slabs, beam, column side and beam bottom (25 mm to 40mm thick)
Joints, ledges (50 x 70 mm to 50 x 150 mm)
Posts (75 x 100mm to 100 x 100 mm)

Advantages of using timber forms:

- ➢ It is economical for small construction jobs
- ➢ It is design flexible and easy to erect
- ➢ It has good thermal insulation which makes it useful to be used in colder regions
- ➢ It can easily be made into any shape or size

Wooden formwork consists of

- ➢ Props
- ➢ Planks battens

- Ledgers
- Sheeting

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Normal sizes of members for timber formwork:

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Joints, ledges	50 x 70 mm to 50 x 150 mm
Posts	75 x 100mm to 100 x 100 mm

- Metal

Steel Formwork

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

Aluminium

- Pure aluminium chemically attacked by wet concrete
- Light weight allow larger forming units
- High reuse value

Steel

- For heavy concrete work
- With reasonable care will last indefinitely
- High initial cost and high handling cost

Steel forms compared with timber formwork:

- Steel forms are stronger, durable and have longer life than timber formwork and their reuses are more in number.
- Steel forms can be installed and dismantled with greater ease and speed.
- The quality of exposed concrete surface by using steel forms is good and such surfaces need no further treatment.
- Steel formwork does not absorb moisture from concrete.
- Steel formwork does not shrink or warp.

Steel formwork is made of

Steel sheets **Angle Iron and Tee Iron**

Sub topic 3: Adhesive materials

They are substance that is capable of holding materials together in a functional manner by surface attachment that resists separation. “Adhesive” as a general term includes cement, mucilage, glue, and paste, terms that are often used interchangeably for any organic material that forms an adhesive bond. Inorganic substances such as Portland cement also can be considered adhesives, in the sense that they hold objects such as bricks and beams together through surface attachment, but this article is limited to a discussion of organic adhesives, both natural and synthetic. Virtually all synthetic adhesives and certain natural adhesives are composed of polymers, which are giant

molecules, or macromolecules, formed by the linking of thousands of simpler molecules known as monomers.

Types of adhesive

Natural adhesives

Natural adhesives are primarily of animal or vegetable origin. Used with wood and paper products, particularly in corrugated board, envelopes, bottle labels, book bindings, cartons, furniture, and laminated film and foils. In addition, owing to various environmental regulations, natural adhesives derived from renewable resources are receiving renewed attention.

Animal glue

Animal glue traditionally has been used in wood joining, book binder, sandpaper manufacture, heavy gummed tapes, and similar applications. In spite of its advantage of high initial tack (stickiness), much animal glue has been modified or entirely replaced by synthetic adhesives.

Casein glue

This product is made by dissolving casein, a protein obtained from milk, in an aqueous alkaline solvent. In wood bonding, casein glues generally are superior to true animal glues in moisture resistance and aging characteristics. Casein also is used to improve the adhering characteristics of paints and coatings.

Blood albumen glue

Glue of this type is made from serum albumen, a blood component obtainable from either fresh animal blood or dried soluble blood powder to which water has been added. Addition of alkali to albumen-water mixtures improves adhesive properties. A considerable quantity of glue products from blood is used in the plywood industry.

Starch and dextrin

Starch and dextrin are extracted from corn, wheat, potatoes, or rice. They constitute the principal types of vegetable adhesives, which are soluble or dispersible in water and are obtained from plant sources throughout the world. Starch and dextrin glues are used in corrugated board and packaging and as a wallpaper adhesive.

Natural gums

Substances known as natural gums, which are extracted from their natural sources, also are used as adhesives. .

Synthetic adhesives

Although natural adhesives are less expensive to produce, most important adhesives are synthetic. Adhesives based on synthetic resins and rubbers excel in versatility and performance.

Contact cements

Contact adhesives or cements are usually based on solvent solutions of neoprene. They are so named because they are usually applied to both surfaces to be bonded. Following evaporation of the solvent, the two surfaces may be joined to form a strong bond with high resistance to shearing forces. Contact cements are used extensively in the assembly of automotive parts, furniture, leather goods, and decorative laminates. They are effective in the bonding of plastics.

Structural adhesives

Structural adhesives are adhesives that generally exhibit good load-carrying capability, long-term durability, and resistance to heat, solvents, and fatigue. Polyesters, polyvinyl, and phenolic resins are also used in industrial applications but have processing or performance limitations. High-temperature adhesives, such as polyimides, have a limited market.

Hot-melt adhesives

Hot-melt adhesives are employed in many non-structural applications. Based on thermoplastic resins, which melt at elevated temperatures without degrading, these adhesives are applied as hot liquids to the adherend. Hot-melts find wide application in the automotive and home-appliance fields. Their utility, however, is limited by their lack of high-temperature strength

Pressure-sensitive adhesives

Pressure-sensitive adhesives, or PSAs, represent a large industrial and commercial market in the form of adhesive tapes and films directed toward packaging, mounting and fastening, masking, and electrical and surgical applications. PSAs are capable of holding adherends together when the surfaces are mated under briefly applied pressure at room temperature.

Ultraviolet-cured adhesives

These types of adhesive normally consist of a monomer (which also can serve as the solvent) and a low-molecular-weight prepolymer combined with a photoinitiator.

- Preservative materials

Wood Preservatives

Wood preservatives are one type of pesticide. Preservatives that are not restricted by EPA (US Environment Protection Agency) us are available to the general consumer for non-pressure treatments, and the sale of others is restricted to certified pesticide applicators. These preservatives can be used only in certain applications and are referred to as "restricted use." Restricted use refers to the chemical preservative and not to the treated wood product. The general consumer may buy and use wood products treated with restricted-use pesticides; EPA does not consider treated wood a toxic substance nor is it regulated as a pesticide.

Consumer Information Sheets (EPA-approved) are available from retailers of treated-wood products. The sheets provide information about the preservative and the use and disposal of treated-wood products. Consumer information sheets are available for three major groups of wood preservatives

- Creosote pressure-treated wood
- Pentachlorophenol pressure-treated wood
- Inorganic arsenical pressure-treated wood

Wood preservatives can be divided into two general classes:

- **Oil borne preservatives,** such as creosote and petroleum solutions of pentachlorophenol
- **Waterborne** preservatives that are applied as water solutions. Many different chemicals are in each of these classes, and each has differing effectiveness in various exposure conditions.

  The three exposure categories for preservatives are:

  1. **Ground contact** (high decay hazard that needs a heavy-duty preservative),
  2. **Aboveground contact** (low decay hazard that does not usually require pressure treatment).
  3. **Marine exposure,** (high decay hazard that needs a heavy-duty preservative or possibly dual treatment). In this chapter, both oil borne and waterborne preservative chemicals are described as to their potential and uses.

- Plywood or Laminated boards shuttering

Laminated boards

In technology, the process of building up successive layers of a substance, such as wood or textiles, and bonding them with resin to form a finished product. Laminated board, for example, consists of thin layers of wood bonded together; similarly, laminated fabric consists of two or more layers of cloth joined together with an adhesive, or a layer of fabric bonded to a plastic sheet.


Resin bonded plywood sheets are attached to timber frames to make up panels of required sizes. The cost of plywood formwork compares favorably with that of timber shuttering and it may even prove cheaper in certain cases in view of the following considerations:

- It is possible to have smooth finish in which case on cost in surface finishing is there.
- By use of large size panels it is possible to effect saving in the labour cost of fixing and dismantling.
- Number of reuses is more as compared with timber shuttering. For estimation purpose, number of reuses can be taken as 20 to 25.

  Shuttering Plywood is highly densified plywood with a smooth coating on both sides. It is a general- purpose building board, but is primarily used as a temporary structure to contain concrete while it sets in place, achieving the desired shape needed. Range of shuttering plywood is available in softwood which is generally suitable for single use and phenolic which can be used multiple times.

Hardboard forms

- Hardboard is a board material manufactured of wood fibre, which is then refined or partly refined to form a panel
- The boards available in large sheets have a hard, smooth surface that produces a concret e whose surface is relatively free of blemishes and joint marks.
- The thin sheets can be bent to small radius, which is an advantage when casting concrete members with curved surfaces.

- Operations of preparing shuttering materials

Cutting the shuttering board

Resawing is simply cutting a thicker board into two or more thinner boards. The board is cut on its edge, so that the full width of the original board is retained. This kind of operation can be done on either the hand saw, band saw and table saw.

When it comes to making a length-wise rip cut in wood, a table saw is the only tool that can do it accurately while producing cuts that look like factory edges.



- **planning the shuttering board**

The transformation of raw to ready, rough to smooth.

The route to achieving pieces like these is simpler and speedier with the use of a wide planer and it leaves more time for sanding, finishing and daydreaming about the next trip to the wood yard

- **Application of lubricants**

Shuttering Oil or formwork oil is high-quality mineral oil that is applied to the inner surface of formwork before concreting. Shuttering oil is also known as a form or mould release agent

LO 1.4 – Prepare workplace for shuttering


The process of site clearance is generally undertaken as part of enabling works, carried out to prepare a site for construction. It involves the clearing the site to allow other remedial, treatment or demolition works to take place before the actual construction works can begin.

Site clearance might be carried out as part of the main construction contract, or it may be carried out in advance of the main contract, and might be part of a wider contract including other enabling works or facilitating works, such as; demolition works, soil stabilization works, services diversion, constructing access roads, and so on.

It involves clearing a site of any machinery or equipment, unwanted surplus materials, rubbish, and so on. Site clearance may also involve clearing away vegetation and surface soil, and levelling and preparing the ground for the planned construction works. Care should be taken to ensure that there are the correct approvals in place, particularly for trees which may be protected.

A site waste management plan (SWMP) may be prepared before site clearance begins. This describes how materials will be managed efficiently and disposed of legally, explaining how the re-use and recycling of materials will be maximized. All types of waste present on the site must be removed safely and efficiently. If there is any contaminated waste or potentially hazardous substances (such as asbestos), professional disposal experts must be consulted to safely handle them.

Advantages

- Shorter working times
- No damage to surfaces from hammers, scrapers or sander attachments
- The value of the shuttering is maintained
- No costly post-treatment in the case of exposed concrete
- A positive image on the construction site

- Methods of clearing workplace by machine

Mowers

You can use a mower to clear large area of land covered with undergrowth. For areas that are walkable you can choose a self-propelled model. For areas that are very large you can use a tow-behind model that is commonly known as brush hog. These machines are good at clearing saplings, tough weed and grasses. They are extremely powerful and make the job a lot easier for you.

Grubber

The grubber is effective grass removal equipment, ideal for those cases in which you just need to remove a small section of bushes or a few saplings here and there. For this you do not need equipment as powerful as the mower but something more powerful than the lawn mower and chainsaw. The grubber has spikes that can dig into a tree with a chain attached to the other end. A truck or tractor can be used to pull out the tree. This is available in different sizes and is the best way to remove one sapling at a time.

Using a digger

Now a digger can save you heaps of strain and time. Any large amount of dirt needs to be done by a digger. Hopefully, you know the exact amount of dirt you need to be removed and you have already marked everything out perfectly. In other words, you are ready for a digger to start.

Bulldozers

Bulldozers are pieces of equipment that are used in large land-clearing needs. These are one of the most pieces of equipment that are usually used. For land-clearing needs, there are many attachments that can be attached in these tools to make the job easily. Some of the attachments are a root plow to remove shrubs and bushes and a heavy-duty rake to remove small trees, rocks and stumps.

Excavators

Excavators are other pieces of equipment that are usually used for land-clearing needs. These machines are usually used in larger applications. As the bulldozers, there are some attachments that can be attached in these machines so that the machines can be used properly. Grapples are the attachments that make these machines reach, grab onto and remove small trees, brush and logs. Other attachments are stump pullers for removing stumps and heavy-duty rakes for gathering rocks before they are loaded into trucks.

These are the most common types of land-clearing tools that you might not know. By using those tools, land-clearing work will be easily done. Having problem finding the genuine company that possesses these equipment, we at **landclearance.co.uk** are completely familiar with the right companies for their adequate land clearance machinery and equipment

Level ground by hand or digger

Now you know the quantity of dirt that needs to be added or removed. For large amounts of earth-works, you need to check your local council as you might need a resource consent. To potentially avoid having to get resource consent you can look at getting earth removed with a truck rather than putting loose soil on your land that's the biggest thing local councils can have an issue with.

Methods of clearing workplace by hand tools

These tools are used by do-it-yourselves who want to clear their land. In this matter, the tools are usually used for gardening or lawn work. Some of hand tools for clearing land are loppers, pruners, hand saws, shovels, pickaxes, rakes and hoes. However, each tool has its function so that someone should choose the right tool before doing the land-clearing job.

If it's a small amount of dirt get the shovel out and start digging, Keep your height marks in place and run a string line over the ground every so often to get it right.
If you want to add drainage to stop mud after the rain read below as you want to adjust your finished ground height to suit 1 inch of drainage material.

- **A shovel**

It is a tool used to dig as well as to move loose, granular materials (like dirt, gravel, grain, or snow) from one spot to another. Spade is a tool used for digging straight-edged holes or trenches, slicing and lifting sod, and edging flower beds or lawns.

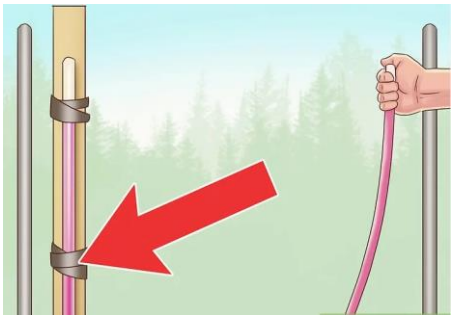
- Levelling techniques of the ground
  - Levelling techniques of the ground

BY HAND

What you will need:

A hose

A water level is a free way of transferring level marks over distances as long as your hose is. Although it can be a bit awkward to set up, it is free. It is easier to do with 2 people. Using a construction laser -level is much simpler and quicker than this water level technique, although the slow water level still works fine as an alternative. Water levels are a great way to find a level spot on items like posts or stakes, so you can build structures that are even and correct. The simple construction and easy setup make a water level a popular tool to have on-hand for a variety of projects. Making a water level is easy with a few household items like tubing and water. You can then use the water level as needed so you have a level, even structure or item every time.



How to level ground with a water level

- Bring the water level to the items you want to measure.

- Hold 1 end of the level against 1 of the posts
- Place the other end of the level against the other post.
- Slide the free end of the tube up or down until the level on both ends match
- Mark the items at the level spot.
- Get a hose the length of the distance of the ground you want to level.
- Fill the hose with water
- Have 1 person at either end of the hose, when the water level is evenly level on both sides of the hose, you have a level or “datum” point. To work from and measure down from as a level “off-set”.
- Now you have a datum point at either end of your backyard or excavation area you can simply measure down the same distance, and dig or pack up the ground to get your desired height as stated above and move on to the next steps.

BY EQUIPMENT

A cross line laser level

A line laser is a device that employs a laser and an optical lens to project the laser beam as a line rather than a point (e.g. laser pointer). This may be achieved by passing the beam through a cylindrical lens or a Powell lens. It controls the vertical laser line, horizontal laser line and cross laser line mode switching, suitable for different usage modes, and accuracy is more accurate and stable.

Level ground with a laser level

Instead of a water level, an easier option is to get a small self-levelling **outdoor laser level** , this tool is mostly used indoors but can be used outdoors if you wait until the sun goes down.

This tool is a lot cheaper than bigger pieces of construction levelling equipment, and is my recommendation for a DIY ground levelling job, as it will only take you 5 minutes in the evening to get all the level marks you will need. Just set up your steel rods in your corners at day time.

If you do want to do levelling work in the day time and you plan on getting a digger, you should get an electric sensor for the laser I talked about above this will allow you to use the laser in the day time! Just like an expensive rotary laser level, but it will be a bit cheaper. Look for one that has a full horizontal level line (not just a dot).

How to level ground professionally

On building sites, levelling jobs would normally be done with a rotary level or a dumpy level. These tools are expensive bits of measuring equipment. A dumpy has the best accuracy over long distances.

And the benefit of a rotary laser level is it shoots a line in a full 360 degrees, although the line is invisible and requires an electric sensor. A portable construction laser level shoots a visible line a line but only in one direction.

It is more practical and cheaper to get a cross-line laser level not, a rotary laser or dumpy level. And then doing levelling work in the evening, or if you want to do the work in the daytime get an electric sensor for the laser level.

Levelling ground set-out

The first thing you want to do is mark the heights you want in each corner by either digging a small square or packing up a bit of dirt to height. But first, you want to set up a method of levelling over long distances.

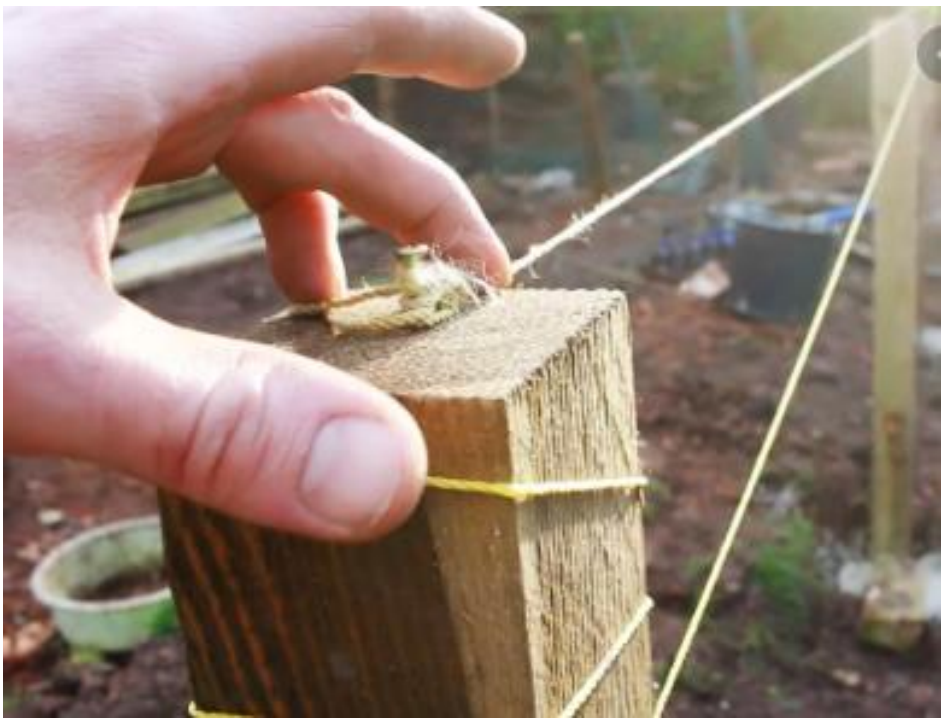
If you want to level ground perfectly, or you want a very even and perfect slop to your lawn or ground area you want to use either a water level or a laser level.

D10 = Round Steel bar of 10mm.

1. When you have a datum point at either end of your backyard or excavation area you can simply measure down the same distance, and dig or pack up the ground to get your desired height so you can visually see what you want and change it if necessary.
2. You want to tap in a small steel rod to mark your height reference point and spray it with some pink spray paint “dazzle” so it stands out and is clear.
3. Repeat these steps to get heights on every corner. You should go further back by a few meters than what you want to excavate or fill in. This means you can keep your height marks without having them get in the way of digging work done by you or a digger driver.

4. When you have all your points you can run a string line from each corner, from each D10 steel bar using the same “of-set” this will give you a height at any point you want.

- **A string line**



Learning Unit 2 – Perform shuttering assembling

LO 2.1 – Mark out shuttering elements

- Marking tools and materials and Process of marking out according to shuttering materials

Formwork installation procedure involves the following operations:

Propping and centring - Propping is a system of structural members used temporarily to support loads during construction. The forces arising from these loads must be fully resolved, using props or columns to provide all the support needed for the work under construction, such as beams, formwork but are not limited to only the above mentioned.

- ✓ **Chalk line**

How to Use A Chalk Line?

There's something almost magical in the way a simple chalk box creates a crisp, perfectly straight line in the blink of an eye. No other tool, except an expensive laser, makes a perfectly straight line over a long distance so quickly and reliably. In this article, we'll show you how to use a chalk line and provide tips that will make it easier to get good results.

The best way to load chalk into a chalk line

Fill the chalk box about half full with powdered chalk from a squeeze bottle. Tap the chalk box occasionally to settle the chalk. You'll have a choice of red, blue, white or fluorescent chalk. Fill your chalk box with blue chalk for general use

How to Snap a Basic Line

Hook the end and stretch the string tight so it crosses directly over your mark. Reach out as far as you can and grab the string between your forefingers and thumb. To chalk a line, lift the string straight up about 4 inches and release it (it'll snap to the floor).

How to Snap Angle Lines on Wood

Mark angles on plywood by tacking a small nail to your mark, hooking the end of the string on it and stretching the string to the other mark.

How to Mark Angle Lines on drywall

Cut a slit in drywall with a utility knife and slip the string into it to secure the end. Cut the slit a little above the mark so the line will hit the mark when it's extended for an angle cut.

How to Snap Lines on Shingles

Chalk a line on shingles by hooking the end of your string into a slit cut in the shingle with a utility knife or hook blade

How to Accurately Snap Long Lines

Stretch the string taut. Use a helper or another nail to hold the chalk-box end of the string. Press down on the string about midway between the ends with your thumb or finger and hold it. Lift and snap the string on one side and then the other using the technique shown. This technique is good for irregular surfaces and will help prevent unwanted double lines.

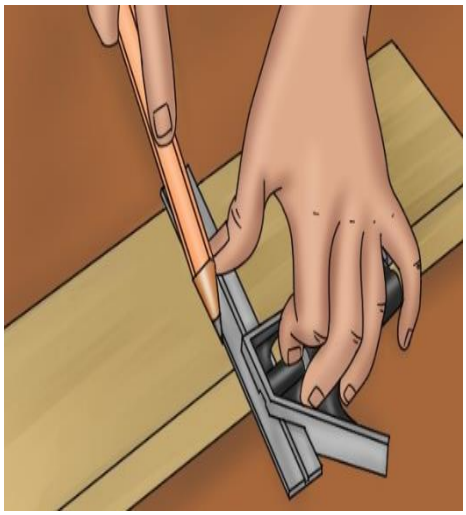
- ✓ **Nail**

Nail, in **construction** and carpentry, a slender metal shaft that is pointed at one end and flattened at the other end and is used for fastening one or more objects to each other. Nails are most commonly used to fasten pieces of **wood** together, but they are also used for marking.

- ✓ **Paint**

Marking means paying attention to the ground quality and stress and for labelling hazardous areas or obstacles, as well as being instructions. **The selection of the right marking Paint is important.** Different surfaces and stresses require appropriate products.

Pencil



A pencil is an implement for writing or drawing, constructed of a narrow, solid pigment core in a protective casing that prevents the core from being broken and/or marking the user's hand. Pencils create marks by physical abrasion, leaving a trail of solid core material that adheres to a sheet of paper or other surface include wood. They are distinct from pens, which dispense liquid or gel ink onto the marked surface.

- ✓ **Try square**

A try- square is a woodworking tool used for marking and measuring a square piece of wood. The square refers to the tool's primary use of measuring the accuracy of a right angle (90-degree angle); to try a surface is to check its straightness or correspondence to an adjoining surface

- ✓ **Tape measure**

A tape measure or measuring tape is a flexible ruler used to measure size or distance.

Learning Outcome 2.2: Assemble shuttering elements

- Techniques of assembling by using different holding tools

Formwork frames should be erected progressively to ensure the installers' safety and the stability of the overall structure.

Braces should be attached to the frames as soon as practicable and designated access ways should be indicated by using bunting or by other means. If side bracing or other edge protection is installed progressively on formwork frames other control measures to prevent a fall occurring may not be required. Many conventional formwork frames consist of diagonal braces that cross in the middle.

While these braces are not considered to be suitable edge protection for a completed formwork deck, they may provide reasonable fall protection during frame erection.

Types of holding material for shuttering:

✓ Nails

- ✓ Bolt and nut
- ✓ Wire tightening

- Techniques of levelling shuttering

Centering and shuttering / Formwork

Engineer-in-charge or supervisor must check the slope, level of slabs and beams before placing reinforcement in position. Preliminary inspection should be done even before commencing tying of reinforcement.

- ✓ Mark one level on every column as per beam depth.
- ✓ Position and level of beam bottom supports should be with respect to the depth of the beam.
- ✓ Joints of beam bottom should be properly propped so that formwork doesn't bulge during concreting.
- ✓ Before providing beam sides, level of the beam bottom should be checked.
- ✓ After levelling of beam bottom bracing should be provided.
- ✓ The plumb of beam sides at each end should be checked
- ✓ Shuttering of beam column junction should be in plumb and watertight.
- ✓ Props must be braced in both directions by tubes and fixed couplers.
- ✓ All the props must be in proper alignment, plumb and not jointed more than 20%. Props must not get staggered.

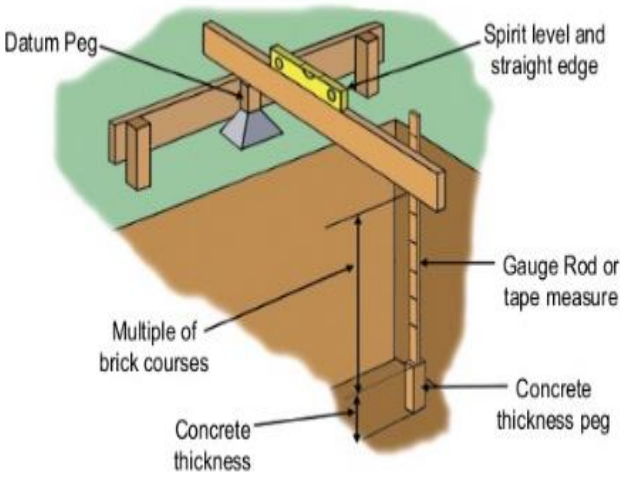
1. Props rest on wooden chunks
2. Shuttering plates as a support to props
3. Props on filled up soil and wooden chunks
4. Too height of ladder

- ✓ All the props must be kept vertical by providing wedges and cross bracings. Do not use bricks or blocks below props to adjust height.
- ✓ Individual prop must be braced both ways with continuous runners and prop system braced laterally.

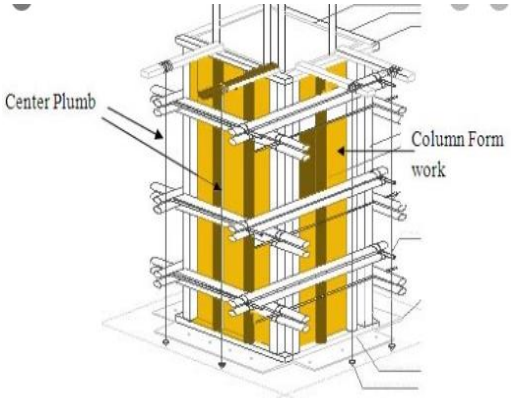
Wrong practices to support props

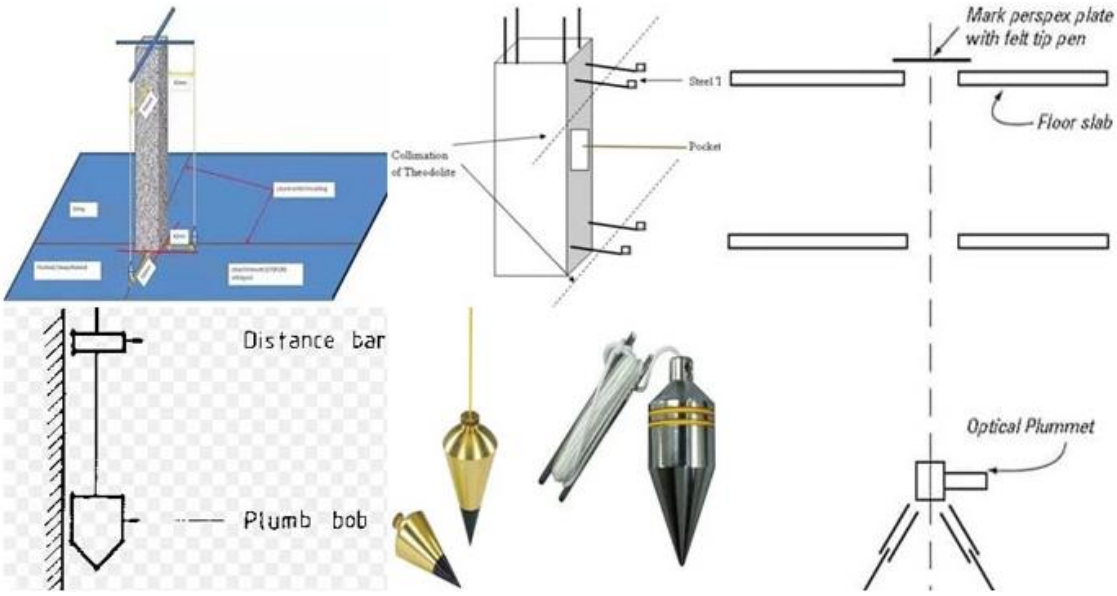
✓ **Spirit level**

This tool is appropriate for controlling verticality of small scale works for example checking formworks and door frames. If spirit level is employed for approximate checks, then it is required to check the verticality with more accurate technique.



✓ **Plumb bob**





Plumb-bob consist of a weight with pointed tip on the bottom attached to end of a string. The heavy weight will hang under gravity and offer a precise vertical line which is called plumb line. This method is applied for checking or controlling vertical line of structural elements especially indoors such as lift shaft. Added to that, it is used to control verticality of foundation, walls, and columns.

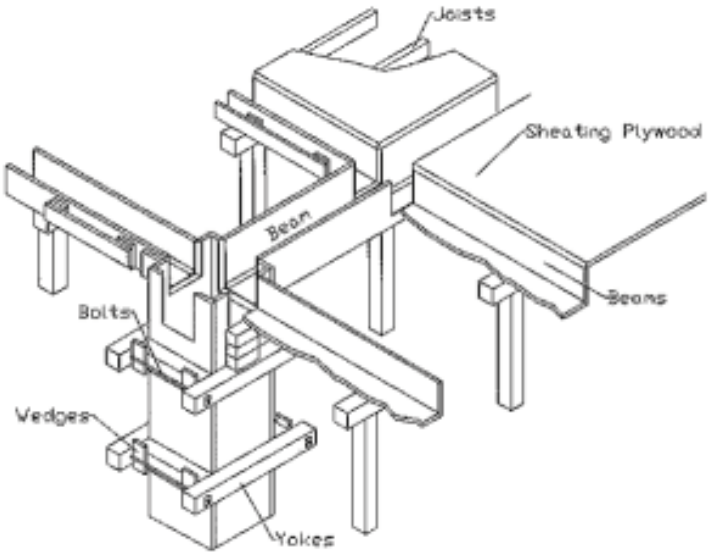
- Techniques of supporting shutter

Slab form

The erection sequence for constructing suspended floor slab includes:

1. Determining of bearer spacing
2. Erecting bearer and joists
3. Fixing the sheathing
4. Before lying concrete, the formwork should be cleaned of all rubbish particularly the sawdust savings & chippings etc.
5. Before lying concrete. The face of formwork in contact with concrete. shall be cleaned &t reated with release agent like raw linseed oil or soft soap solution as to prevent the conc. getting struck to the formwork.
6. Preparation for concrete

Column formwork



Erection sequence for a column

Prior to positioning column formwork check that steel for the column has been inspected and cl eared for casting

- Position formwork for the column from predetermined grid
- Plumb formwork both ways and securely support using wood or adjustable steel props
- The propping angle should be 450 to the floor
- Ensure the steel props are safely secured to the column formwork and the floor and that adjustment for pushing and pulling is operational
- Use nail to support the arms of column clamps while wedging
- Check the formwork at the top for square
- Using plumb bob suspended from gauge block plumb the column

Beam formwork

Erection sequence for constructing beam formwork include

- Position of sole plate
- Marking out and setting height
- Assemble and position props, adjustable head jack, bearers and spreaders
- Construct and erect side walls and beam soffit
- Position of sole

Footing Forms – Formworks for Foundation

The first step for any concrete construction starts with the construction of foundation. Foundation can be for columns or walls. So, based on type of structural member, the shape and size of footing are designed. Thus, formwork size and shape depend on the type and dimension of the footing

Components of Footing Forms:

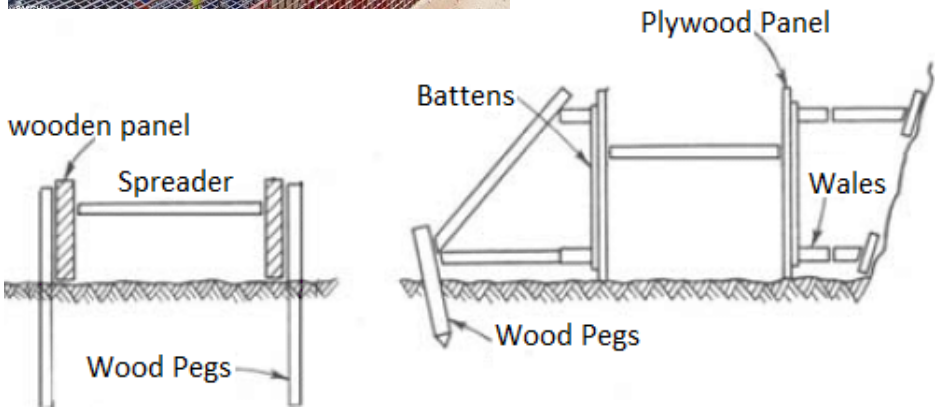


Fig: Components of Footing Formwork – For Shallow Footing – Continuous Footing Formwork

Column Forms – Formwork for Concrete Column Construction

Reinforced concrete column forms are subjected to lateral pressure because of their small cross section, large heights and relatively high rates of concrete placement. Thus, it is necessary to provide tight joints and strong tie support to the formwork. 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.

Wall Forms – Formwork for RCC Wall Construction

Formwork for wall construction is subjected to relatively lower lateral pressure than column forms due to their large cross-sectional area.

The components of wall forms are:

- **Panel sheathing** – It is used to shape the wall and retain the concrete until it sets.
- **Studs –** to support the sheathing or Wales by forming a framework to keep the forms aligned and support the studs.
- **Braces –** It is used to prevent deflection of forms under lateral pressure and keep the formwork erect.
- **Ties and spreaders –** These are used to hold the sides of the forms at the correct spacing.

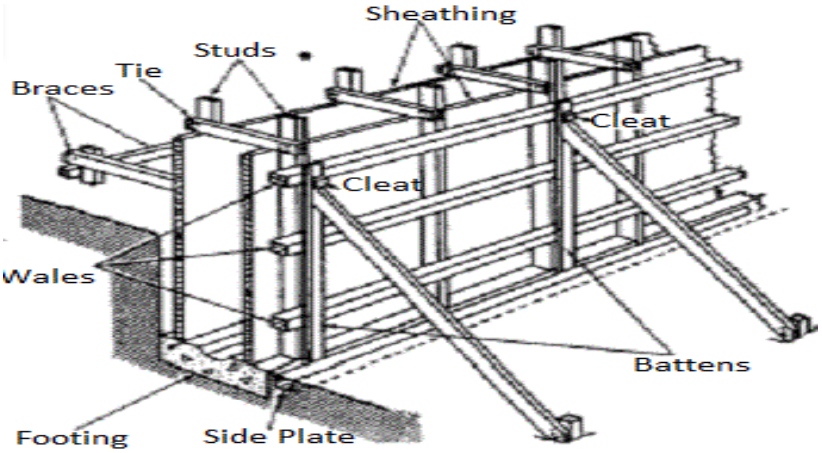


Fig: Components of a Wall Formwork

Floor Forms – Formwork for construction of RCC Slabs

Formwork for reinforced concrete slabs depends on the type of slabs to be constructed. The floor slabs can be structural slabs supported on a steel or concrete structural frame, or slab-on-grade. The design of formwork varies with the type of slab.

Structural Slab Formwork assembly is carried out as follows:

- Positioning of the girder or beam form at the bottom.
- Girder side forms overlap the bottom form and rests on the shore heads and the sides of the column form.
- Side forms are held in place by ledger strips nailed to the shore heads with double-headed nails.
- Larger girders should have the side forms vertically stiffened to prevent buckling.
- When constructing the girder and beam forms each part must be removed without disturbing the remainder of the form; strike-off formwork will commence with the beam and girder sides, followed later by the column forms, and finally by the beam and gird bottoms.

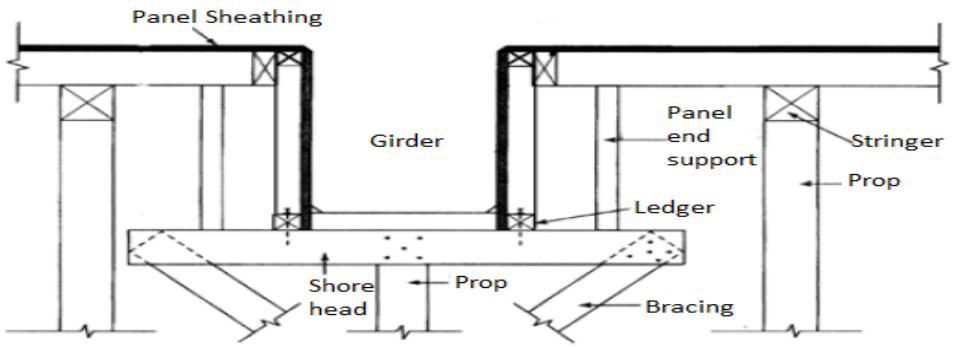


Fig: Structural Slab Formwork Components

Slab-on-Grade Forms are forms for concrete slabs placed on grade. These slab formworks are usually quite simple as concrete is placed on compacted earth or gravel leveled base. Thus no support is required for concrete at the bottom.

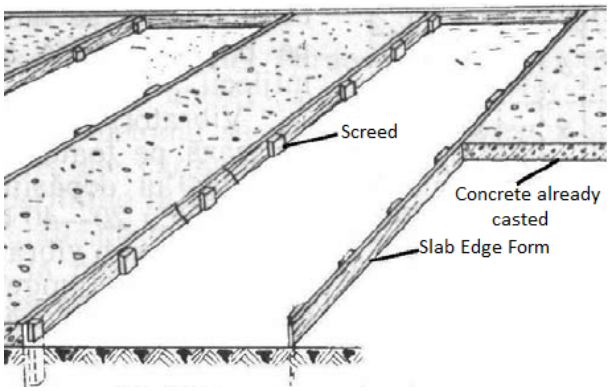


Fig: Components of a Slab-on-Grade Slab Formwork

Slab-on-Grade Formwork assembly is carried out as follows:

- Plank, plywood, or steel forms are used for forming / supporting the open edges of concrete.
- These forms are held in place by supporting with wooden pegs.
- The reinforcement in slab (if specified in the structural drawing) should be placed on its proper location according to the drawing on chairs, bolsters, and spacers made of either metal or concrete.
- If the slab is to be casted in sections, construction joints must be provided between them, which will transmit shear from one to the other. The details of construction joints should be followed as per structural drawing.

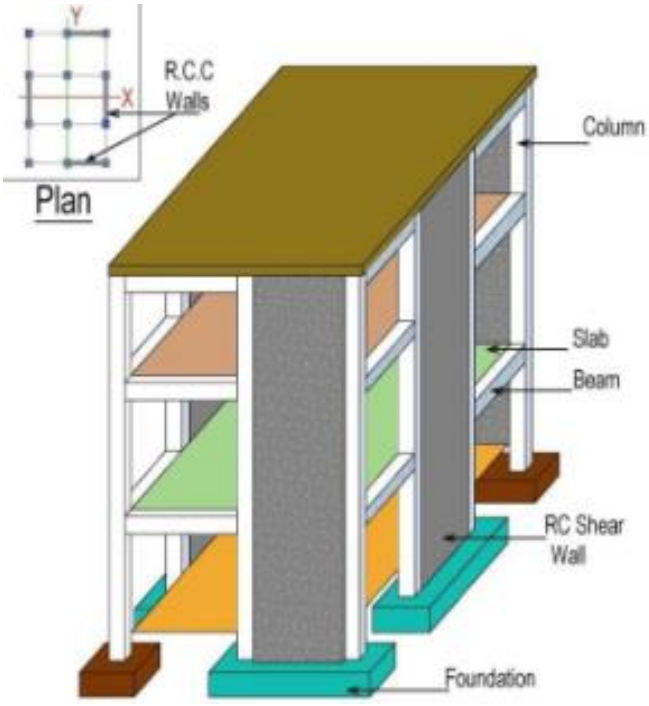
- **Footing and pedestal**

Footing marking should be completed. Reinforcement is completed and shuttering boards are placed, and are checked for verticality. Once perfectly ply boards are placed in the marked position, final verticality is adjusted using prop supports. At the edges of board c-clamps are fixed. Checked for steel cover

Column starter

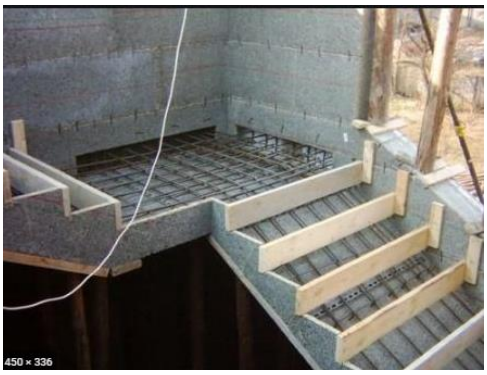
Column starter are placed perfectly after marking done and the dimension is of 1mm is less on all the sides in order to accommodate placing of foam strip. After fixing starter it is checked for distance between two adjacent starters.

Columns and reinforced concrete shear wall



Checked for the GFC (good for the construction) drawing and as per drawing shuttering is placed, and all necessary procedures are fallowed. Plumbs are checked for alignment. Foam strip is placed around the starter for avoiding loss of slurry during concreting. Shuttered are checked for grid line and setback distance. Pre-pour and post-pour checks are done for the member.

Staircase formwork



Stair case marking should be done based on that shuttering is made. Once shuttering is done leads to reinforcement. Again, after completing reinforcement raiser planks are fixed.

Formwork Safety Checklist during Construction:

Defects in Foundation Level of Formwork Systems

- Sole plates are not levelled
- Crushing of sole plate because of insufficient distribution of loads form horizontal and vertical members
- Poor load carrying capacity of the ground under sole plate
- Deterioration of load carrying capacity of the ground for instance washing out ground
- Deterioration of sole plates with time because of several factors for example weather condition

2. Defects in Vertical Support of Formwork Systems

- Lack of ties between standards at point of loading
- Supports are out of plumb
- Insufficient bracing to scaffold
- Bearing plates at the top and bottom of props are distorted
- Insufficient lateral ties, vertical and plan bracing
- Lack of rigidity of screw connection because of lack of bracing or over extension
- Utilizing adjustable steel props with nails, mild steel bolts and reinforcing bars instead of correct pins

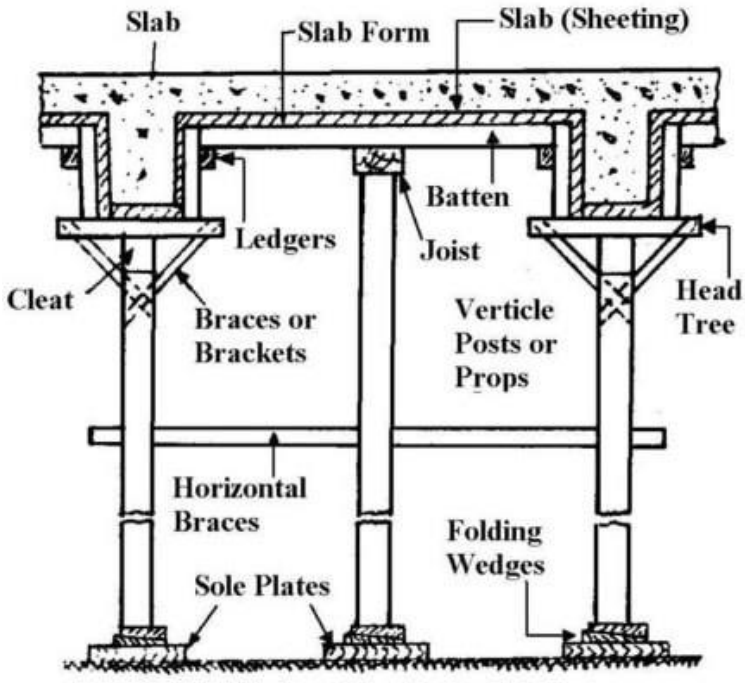


Fig.: Formwork for Beams and Slabs with Vertical Supports

Defects in Horizontal Support of Formwork Systems

- ✓ Horizontal members are not centrally placed in fork heads
- ✓ Lack of staggering in timber bolted connection which may lead to split out of the timber bolted connection

- ✓ Insufficient lateral and tensional bracing
- ✓ Inadequate support to prevent overturning of deep principal elements since fork heads are frequently omitted
- ✓ Insufficient support to cantilevers
- ✓ Inadequate bearing area to vertical supports and underside of main members lead to crushing

Methodology of quality inspection

- ✓ Check the verticality of prop.
- ✓ Checked for Shuttering work for cleanliness and water tightness.
- ✓ Check the level with respect to 1m marking.
- ✓ The dimensions of slabs and beams should be checked as per GFC drawing
- ✓ The standard dimensions are checked
- ✓ Cantering should be placed on the hard surface.
- ✓ Cavities underneath base plates are checked.
- ✓ Dislocation of base plate and cracked runner are checked.
- ✓ Shuttering should not come in contact with reinforcement.
- ✓ Machine oil, used oil, grease, diesel are totally unacceptable for formwork, due to possibility of chemical reaction between concrete and leads to stain in the concrete surface and also peeling of plastering will happen.
- ✓ Materials used for shuttering are free from rust.
- ✓ While checking the shuttering 2 things have to check, 1-line 2-level. Meanwhile good shuttering practice will result in the good finishing works, hence finishing cost are reduced.

LO 2.3 – Perform finishing

- Techniques of oiling the shuttering and covering gaps

APPLICATION OF OIL

Oil is applied onto a substrate surface which has been previously treated by the methods of Enhancement of adhesion (surface preparation): Cleaning, Surface roughening, Primers, Adhesion promoters, Plasma treatment.

The following techniques are used for application of paints:

- ➢ Brush
- ➢ Roller
- ➢ Air spray
- ➢ Airless spray
- ➢ Electrostatic spray

- ➢ **Rotating disc or bell Brush** application is used for decorative coating of relatively small and complex areas. Brush painting is a slow application method but it provides good penetration of the paint. Brush application prevents paint losses associated with the spray application method.

- **Roller technique** is applied for coating large flat surfaces. The method is faster than brush application. In contrast to the brush method roller painting is not suitable for applying high film build.
- **Air spray** In the air spray application method the paint in form of atomized droplets is delivered by a stream of compressed air. The paint is pumped from the tank into the gun where it is atomized (broken into small droplets) by the flowing compressed air. The typical air pressure in the air spray is 40-50 psi (0.28-0.34 MPa). Spray application is a simple and inexpensive method which is capable to coat objects of various shapes and dimensions. High quality coatings are achieved if the paint composition (the content of Solvents) provides the required levels of viscosity and the drying rate.

  The disadvantage of the air spray application is unavoidable overspray: losses of the paint and expensive organic solvents and thinners. Besides the costly losses the method requires additional investment in safety equipment in order to protect the workers exposed to the hazardous solvent vapors.
- **Airless spray** In the airless spray (in contrast to the air spray) the paint is not mixed with air. The liquid paint is delivered to the gun by a hydraulic pump producing a high pressure 300-7000 psi (2-48 MPa). The pressurized paint is atomized in the gun nozzle. The nozzle is commonly made of tungsten carbide. It has an orifice, diameter of which (together with the paint viscosity and the pump pressure) determines the delivery rate and controls the coating thickness. Using high pressure pumps and preheated paints allows to apply high viscosity paints having a decreased amount of solvents and thinners (e.g. High-solids paints). Lower solvent content in the paints for airless application results in a reduced overspray. A combination of the airless and the airless application methods is used in the air assisted airless spray application technique. The paint is supplied to the gun and atomized like in the airless method. However the paint is additionally atomized by low pressure compressed air which also controls the fan pattern.
- **Electrostatic spray** Electrostatic spray application is based on the electrostatic attraction of electrically charged atomized particles (either dry powder or liquid paint droplets) to the grounded (having earth potential) workpiece. The charged particles coming out from the gun hit the whole surface of the object including the back surface therefore the electrostatic spray technique is mainly used for inside coating of tubular objects where the back surface painting (wraparound effect) is negligible. Due to electrostatic effects the coating is thicker on the surfaces of protruding corners and thinner on inside corners and holes. Electrostatic spray is characterized by very low overspray. The method utilizes at least 95% of the paint.
- **Rotating disc or bell** In the rotating disc/bell application technique the liquid paint is pumped to the center of the disc/bell rotating at high speed (at least 10,000 RPM). The centrifugal force drives the liquid to the edge where it is atomized and spun off. The rotating disc commonly has an electrical potential which provides an electrical charge to the paint. The paint particles propelled by the centrifugal force are attracted by the grounded work pieces located around the rotating disc. Rotating disc or bell method is used for automatic application of high viscosity paints (e.g. High-solids paints) in conveyor lines.

Applications of shuttering oil

- Shuttering oil prevents sticking of formwork to concrete, allowing easy stripping of formwork after hardening of concrete.
- Shuttering grease protects steel formwork from corrosion.
- Reducing leakage of water during the curing process.
- For wooden formworks, shuttering oil prevents water absorption from concrete
- It ensures that a superior finishing surface is obtained with minimal defects.
- Shuttering oil also protects formwork, so that it can be reused a number of times.

Uses of Formwork Oil

Shuttering Oil is used for the following reasons:

1. Application of shuttering oil prevents sticking of formwork to the concrete surface thereby permitting easy stripping of formwork after the concrete has hardened.
2. Shuttering oil protects the formwork and hence the formwork can be reused several times.
3. Shuttering oil helps provide good finishing surface of the concrete with minimum defects.
4. In the case of wooden formwork, shuttering oil prevents water absorption from concrete by the wooden formwork.
5. Shuttering oil reduces leakage of water during the curing process.
6. Shuttering oil prevents steel formwork from corrosion.

The performance of shuttering oil is largely dependent on the type of formwork that is being used. For wooden formwork, straight refined, pale, paraffin-based mineral oil and oil-phase emulsion have been successfully used. The oil that is chosen should be capable of penetrating the wood to some extent while leaving the surface slightly greasy to touch.

There should not be any free oil on the wood surface. The form release agents that are good for wooden formwork are not always suitable for steel formwork.

And hence the shuttering oil or form release agents should be chosen based on the type of formwork that is to be used for construction.

The shuttering oil for steel formwork should be free of water and should contain rust inhibitor.

Types of shuttering oil:

1. De-Shuttering Oil (DSO)

This is a water-based mould releasing agent which gives clean and stain free high-quality concrete. It is available in a sprayable form and ready to use as a direct application on required places. It should be applied in light film either by brush or mould oil sprayer. If it is over applied, excess oil should be drained before it dries. Pools of DSO cannot be allowed to dry as it causes surface retardation of concrete.

Advantages of De-Shuttering Oil are as follows:

- DSO is economical to use.
- It is non-toxic and non-hazardous.
- It can be used for all types of concrete formworks.
- It helps reduce the cleaning efforts before reusing of the formwork.

- DSO provides a damp proof interface that protects the formwork and ensures even texture and color of concrete.

2. De-Shuttering Oil Emulsion (DSOE)

This oil does not require any dilution and can be used instantly.

3. De-Shuttering Oil Concentrate (DSOC)

This is dilutable and used as a mould release agent.

Before the application of shuttering oil on the formwork, it is important to make sure that the surface of the formwork is clean of previous impurities. The shuttering oil is applied by spraying guns, rollers or by brushes. It is important to remove any excess oil on the surface of the formwork. The use of barrier paints extends the life of the formwork by producing a hard-wearing surface on the formwork. If barrier paints are not used, it is advised to use three coats of shuttering oil before the shuttering is used for the first time.

To avoid contamination of the reinforcement, it is advised that the shuttering oil is applied on the formwork before it is erected.

De-shuttering

It is the process of removal of formwork after concreting. The duration with which formwork can be de-shuttered is known as stripping time. For slab de-shuttering first has to remove in the center and counter back prop support are given back, then at support De-shuttering is done and same props are given.

DURATION TAKEN FOR REMOVAL OF FORMWORK

During stripping of formwork, following points must be remembered:

- Formwork should not be removed until the concrete has developed sufficiently strength to support all loads placed upon it.
- The time required before formwork removal depends on the structural function of the me mber and the rate of strength gain of the concrete.
- The grade of concrete, type of cement, water/cement ratio, temperature during curing etc. influence the rate of strength gain of concrete.
- The formwork parts and connections should be arranged in a way that makes formwork rem oval easy and simple, prevents damage to concrete and formwork panels so that it can be re-used without extensive repair.
- The formwork removal procedure should be supervised by the engineer to ensure that qua lity of hardened concrete in structural member
- The separation of forms should not be done by forcing crowbars against the concrete. It may damage the hardened concrete. This should be achieved by using wooden wedges.
- Beam and joist bottoms should remain in place until final removal of all shoring under them are done.
- Joist forms should be designed and removed so that the shores may be removed temporarily to permit removal of joist forms but must be replaced at once. The shores and joists will be dismantled beginning from the middle of the member's span, continuing symmetrically up the supports.

Structure element	**Duration**
walls columns & vertical sides of beams	1-2 day
slab spanninig upto 4.5m	7 days
slab spanninig from 4.5m upto 6m	14 days
spanning over 6 m	21 days

External effects for the concrete other than formwork striking times:

- **Grade of concrete:** higher the grade of concrete, the rate of development of strength is hi gher and thus concrete achieves the strength in shorter time.
- **Grade of cement:** Higher cement grade makes the concrete achieve higher strength in sho rter time.
- **Type of cement:** type of cement affects the strength development of concrete. For example, rapid hardening cement have higher strength gain in short period than the ordinary Portland cement. Low heat cement takes more time to gin sufficient strength than OPC
- **Temperature:** the higher temperature of concrete during placement makes it achieve higher strength in shorter times. During winter, the concrete strength gain time gets prolonged. A high ambient temperature makes the concrete gain strength faster.
- Formwork helps the concrete to insulate it from surrounding, so longer the formwork remains with concrete, the less is the loss of heat of hydration and rate and rate of strength gain is high

- **Size** of the concrete member also affects the gain of concrete strength. Larger concrete the section members gain strength in shorter time than smaller sections.
- **Accelerated** curing is also a method to increase the strength gain rate with the application of heat.
- It is important to note that the time for formwork removal shown above is only when ordinary Portland cement is used. In normal construction process Portland Pozzolana cement is used. So, the time shown should be modified.
- For cements other than ordinary Portland cement, the time required for formwork removal should be as:

Portland Pozzolana Cement: stripping time will be 10/7 of the time stated above

Low heat cement: stripping time will be 10/7 of the time stated above

Rapid Hardening Cement: stripping time of 3/7 of the time stated above will be sufficient in all c ases

Except for vertical sides of slabs, beams and columns which should be retained at least for 24 ho urs.

Removal of Formwork: Know the Correct Time and The Precautions

Formwork is temporary moulds into which concrete is poured, and compacted to cast concrete according to the design. Formwork is erected in the correct position to cast concrete structural members. The formwork is kept in its position until the concrete hardens and start gaining strength.

Removal of formwork is recommended only when the concrete has gained strength to take up its dead weight without the further help of formwork or any props. Before dealing with the precautionary measures which are to be taken during the removal of formwork or props, it is always necessary to know the correct time of removal of formwork. The formwork must be removed after the desired strength is attained by the concrete structural elements that are supported within the formwork. Here we have given brief information on the correct time of removal of formwork and the precautions which must be taken.

Correct Time of Removal of Formwork

The time from which the concrete is placed in formwork till the time the formwork is removed is called as supporting period. This time period will vary, based on different factors like:

- ✓ Type and grade of concrete

- ✓ Admixtures used in concrete mix
- ✓ The formwork designs
- ✓ Temperature
- ✓ The type of structural element (Columns/beams/slabs)
- ✓ Material quality
- ✓ Curing conditions

The formwork removal process is after the concrete is casted and gained sufficient strength is called striking of formwork. This will result in stresses in the structural element as due to loss of supports either on sides or below due to loss of support, it now becomes the responsibility of structure to support itself. A properly hardened concrete element will be able to resist these external stresses during the removal of formwork. Formwork is left for longer period in order to assist the curing procedure of concrete elements.

Period for Removal of Formwork

The conditions mentioned above are applicable for normal circumstances; the normal temperature not less than 15 degrees Celsius and the cement used is ordinary Portland cement. For lower temperatures and other types of cement, the time recommended can be changed suitably. In such cases, one should strictly follow the instructions of the structural engineer.

Formwork Removal Requirements and Precautions

The removal of formwork must be carried out in such a way that minimum shock or vibration transfers to the concrete. The striking of formwork must not cause any damage to the structure

Some Precautions taken during Removal of Formwork are:

- ✓ Always start removing the formwork when the element has reached the formwork removal time, which is determined by the test results performed in the laboratory. For normal small and ordinary structures when tests are not possible, follow instructions in drawings or instructions of the structural engineer.
- ✓ The compressive strength is followed as per IS method. The test is carried out in standard cubes and/or cylinder of same sample mix.
- ✓ The developed strength of concrete can be determined at the site by means of non-destructive tests (NDT) before the removal of formwork.

- ✓ The formwork props for soffits are not removed until it is ensured that it can take its own weight and the stresses acting externally.
- ✓ The quality engineers have to inspect the site before starting the formwork removal process.
- ✓ The workers must have a safe access before removing the formwork.
- ✓ Special considerations must be given to freeze-thaw damages and crack formation in concrete due to any sort of thermal contractions while formwork removal.

  If this risk exists, the formwork removal time can be delayed. The removal of formwork at correct timing can be carried out if we had planned and insulated the structure so that they are not subjected to such damages. This is mainly encountered in cold weather concreting.
- ✓ The striking time of a structure is determined by the strength gained or through non-destructive testing.
- ✓ The formwork parts and related units have to be arranged such a way that the removal is made easy. This will help in reducing the damage to the concrete.
- ✓ Only careful removal of the formwork panels will help them to be reused.
- ✓ The procedure of formwork removal has to be properly supervised by an engineer. Good quality concrete will be free from honeycombs and cracks. If any defects exist, immediate repair works can be carried out.
- ✓ The removal of formwork has to be done sequentially and in a pattern with the approval of the site in-charge.
- ✓ Wooden wedges must be used to separate the forms and not the crowbars.
- ✓ Until the final removal of all the shoring units, the beam and joist bottoms should remain as such.
- ✓ Removal of formwork must not result in damage to concrete surfaces, mainly corners and edges. Once the removal process is complete, the exposed surfaces must be covered with polythene bags or wet bags so that the concrete is fully cured.
- ✓ Sometimes for increasing the speed of construction, the slabs are cast one above other keeping the formwork of one more slab below. i.e. In such cases, the slab whose props are removed has not only to support its self-load but also has to support the load due to one slab above which has yet not hardened and attained its full strength. In such cases always follow instructions of the structural engineer.

What would happen if Formwork is removed early?

Early Removal of Side Supports:

In case of columns and beams if you remove formwork immediately, the sides may bulge if the concrete has not hardened. The sides may go out of line or plumb. Again due to loss of sides evaporation of water will start immediately and one has to start curing immediately.

Early Removal of Supports:

The structure may deflect or even may collapse if it has not gained sufficient strength. Please, note that if deflections at such times occur it will remain permanently and difficult to repair. Hence be careful.

Striking of formwork must be done at the correct time to avoid poor quality of construction. While casting concrete, the above precautions of removal of formwork must be followed. Otherwise, the concrete structural members may break or collapse or do not gain the required strength.

Big Mistakes that must be Avoided in Formwork while Concreting

The surface that is used to contain the concrete, by means of a framework of a particular shape is called as formwork. This process is called as form working of concrete. The formwork will be removed once the concrete has completely set.

1.6: Formwork Maintenance

- Check-up and assessment of every part of the formwork equipment
- Mechanical cleaning of every part
- Safety check on all small parts. Every clamp is checked individually for complete aligning and joining safety
- Intensive cleaning of severe residues on the concrete-facing panel with 1000 bar high pressure washers

- Standard cleaning of the facing with high pressure and rotation cleaners
- Industrial cleaning of all formwork panels
- Cleaning of all small parts (clamps, crane hooks, flange nuts)
- Cleaning of all accessory parts (props, corners, push-pull props)
- Repair of damaged steel and aluminium frames and parts

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