Arab Academy for Science, Technology & Maritime Transport
Colleague of Engineering & Technology
Construction & Building Engineering

CB 523
Methods and Equipment for Construction 1

Lecture 2:
Concrete Formworks Overview

Instructor: Dr. Ahmed Elyamany

Courtesy of Dr. Ahmed Alhady

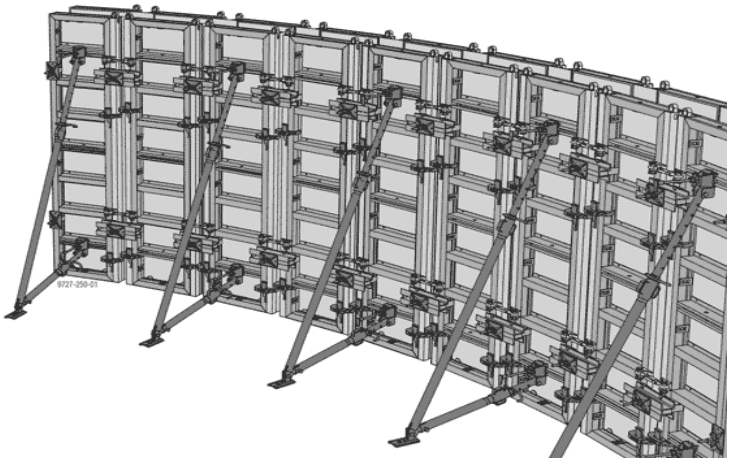
Agenda

- **Introduction to concrete Formwork**
- **Materials Used**
- **Categories of formwork**
- **Failure of formwork**
- **Safety precautions**
- **DE shuttering**
- **Construction Practices**

Concrete Formwork

Introduction

- ***What is Formwork?***
  - **Formwork in construction is the use of an ancillary support structures and molds to create structures out of concrete which is poured into the molds to harden subsequently.**
  - **The construction of formwork takes time and involves expenditure up to 20 to 25% of the cost of the structure or even more.**
  - **The operation of removing the formwork is known as stripping. Stripped formwork can be reused.**
  - **Reusable forms are known as panel forms and non-usable are called stationary forms.**
  - **Formwork is designed according to The ACI document SP-4.**



Concrete Formwork

Introduction

- **A good formwork should satisfy the following requirements:**
  - **Strong** enough to withstand all types of dead and live loads.
  - **Rigidly constructed** and efficiently propped and braced both horizontally and vertically, so as to retain its shape.
  - The **joints** in the formwork should be **tight** against leakage of cement grout.
  - Construction of formwork should permit **removal of various parts in desired sequences** without damage to the concrete
  - **Material** of the formwork should be cheap, easily available and should be suitable for reuse
  - The formwork should be set accurately to the desired line and levels should have plane surface.
  - As light as possible
  - Material of the formwork should not warp or get distorted when exposed to the elements
  - Should rest on firm base.

Concrete Formwork

Introduction

Minimizing Cost of Formwork

- Since formwork may account for 40 to 60% of the cost of concrete construction, it is essential that the formwork plan be carefully developed and thoroughly evaluated.
- A cost comparison should be made of all feasible forming systems and methods of operation.
- The formwork plan that provides the required safety, construction quality, and repetitive use of forms at the minimum overall cost should be selected for implementation.
- **Flying** forms, large sections of formwork moved by crane from one position to another, are often economical in repetitive types of concrete construction.
- Where appropriate, the use of **slip** forms can greatly reduce forming costs.

Flying Forms

Slip Forms

Concrete Formwork

Introduction

- **The following points are to be kept in view to affect economy in the cost of formwork:**
  - ❖ The plan of the building should imply minimum number of variations in the size of rooms, floor area etc. so as to permit reuse of the formwork repeatedly.
  - ❖ Design should be perfect to use slender sections only in a most economical way.
  - ❖ Minimum sawing and cutting of wooden pieces should be made to enable reuse of the material a number of times. The quality of surface finish depends on the quality of the formwork.

Concrete Formwork

Materials Used

- **Formwork are mainly of two types**
  - Steel formwork
  - Wooden formwork

- **Steel formwork is made of**
  - Steel sheets
  - Angle Iron
  - Tee Iron

- **Wooden formwork consists of**
  - Props
  - Planks battens
  - Ledgers "**horizontal timber fastened to the vertical uprights of a formwork, to support the sheeting.**"
  - Sheeting

Concrete Formwork

Materials Used (cont'd)

- **Timber :**
  - Most common material used for bracing the member, hence called as the traditional formwork.
  - can easily be cut to size on site.

Concrete Formwork

Materials Used (cont'd)

- **Plywood**
  - This is by far the most common material used for the facing panel. It is easily cut to shape on site, and if handled and stored carefully, it can be used many times.
  - A standard plywood thickness on site is 18mm. This is usually sufficient for most pours.
  - However, if the formwork is curved, a thinner plywood is used to facilitate bending.
  - Thicker plywood may be used when the weight of concrete causes a standard thickness plywood to bow out, distorting the concrete face.

Concrete Formwork

Materials Used (cont'd)

- **Steel :**
  - 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

Concrete Formwork

Materials Used (cont'd)

- **Aluminum formwork**
  - Often used as pre-fabricated formwork, that is put together on site.
  - Aluminum is strong and light, and consequently fewer supports and ties are required.
  - The lighter sections will deflect more, but this can be avoided by simply following the manufacturers recommendations.

Concrete Formwork

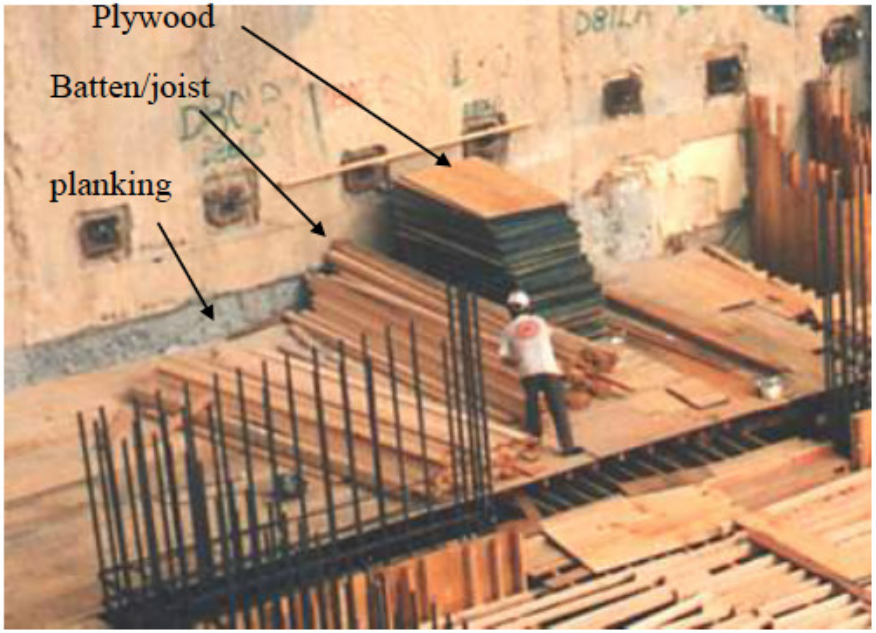
Materials Used (cont'd)

- **Plastic formwork**
  - Glass reinforced plastics (GRP) and vacuum formed plastics are used when complicated concrete shapes are required (e.g. waffle floors).
  - Although vacuum formed plastics will always need support, GRP can be fabricated with integral bearers making it self supporting.
  - Like steel, plastic formwork can be re-used many times, as long as care is taken not to scrub the surface whilst vibrating the concrete.

Concrete Formwork

Categories of Formwork (cont'd)

- **CONVENTIONAL/TRADITIONAL:**
  - The formwork is built on site out of timber and plywood.
  - It is easy to produce but time-consuming for larger structures, and the plywood facing has a relatively short lifespan.
  - It is still used extensively where the labour costs are lower than the costs for procuring reusable formwork.
  - It is also the most flexible type of formwork, so even where other systems are in use, complicated sections may use it.

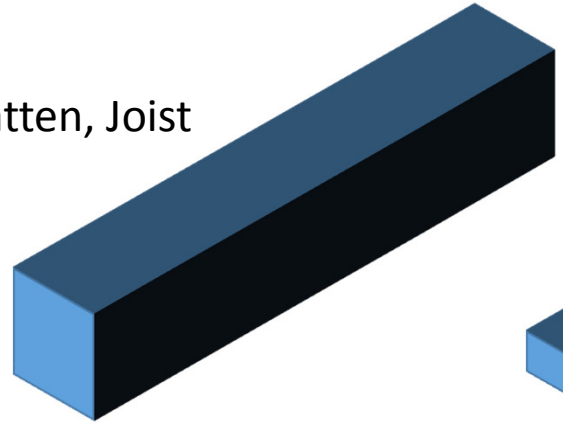


Usually timber in the form of plywood, planking, batten and joist are used as the basic material.

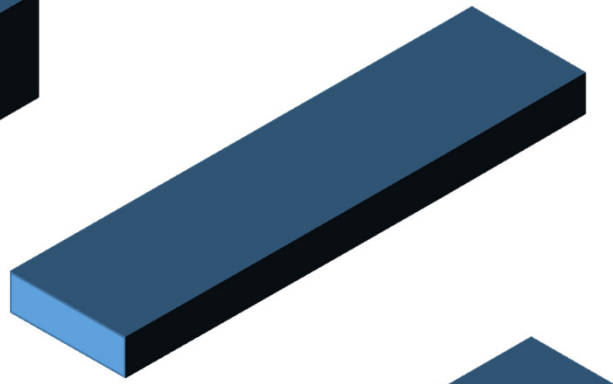
Human workers need to enter into every corner to perform the formwork installation works

CONVENTIONAL/TRADITIONAL Formwork

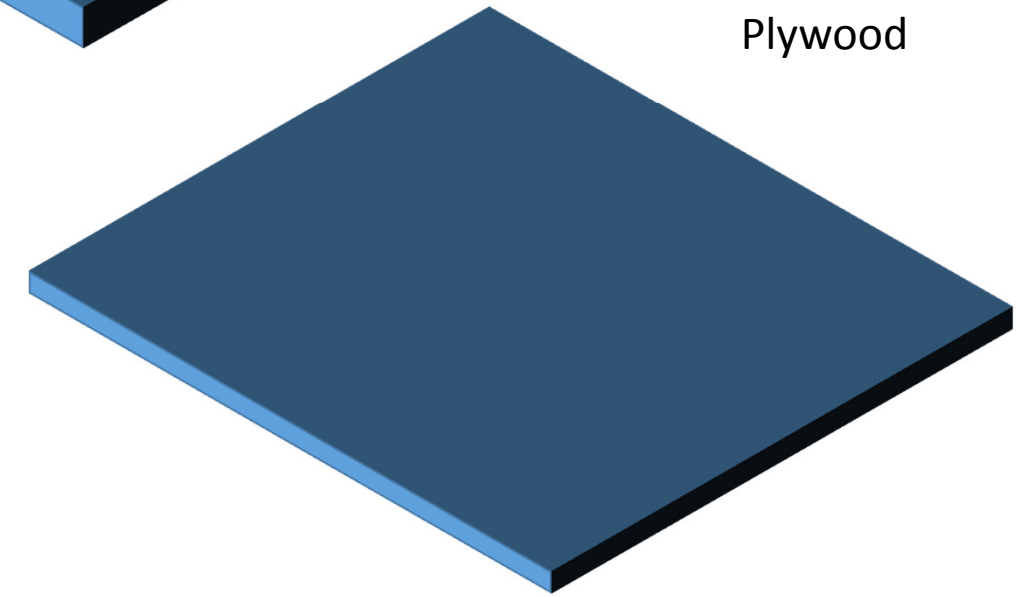
Batten, Joist

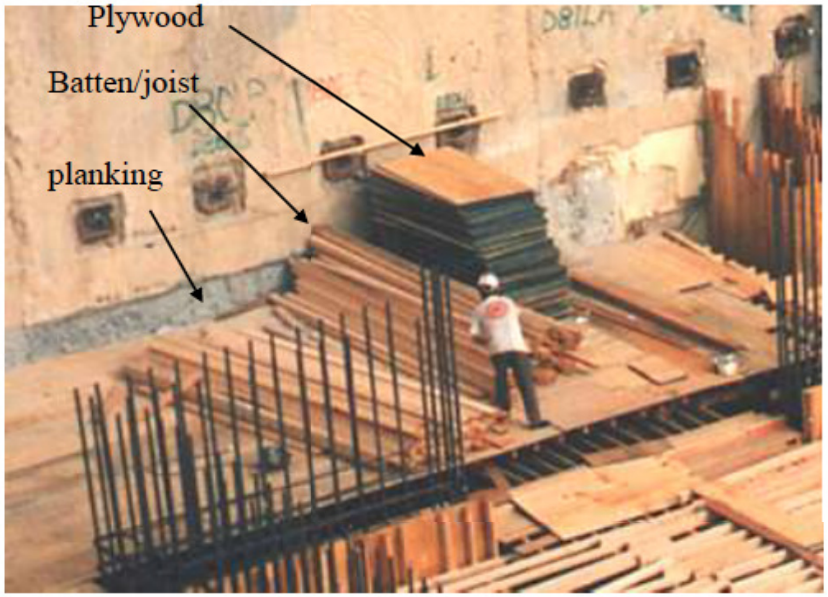


Planking



Plywood





Concrete Formwork

Categories of Formwork (cont'd)

MODERN FORMWORKS:

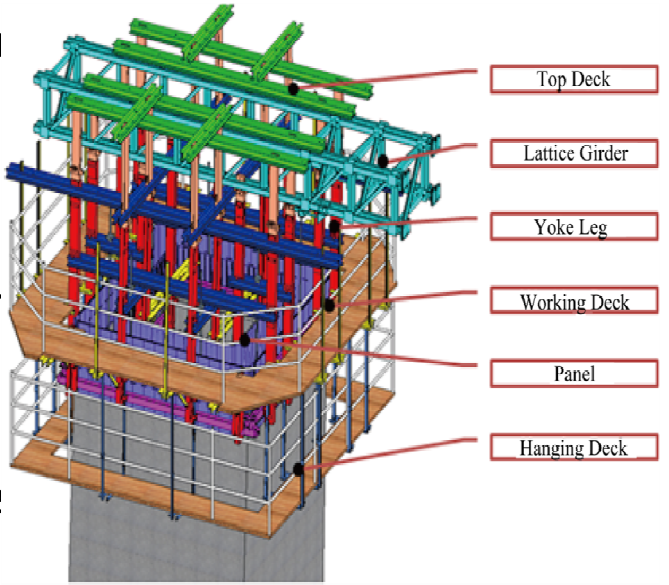
- This formwork systems are mostly modular, which are designed for speed and efficiency.
- They are designed to provide increased accuracy and minimize waste in construction and most have enhanced health and safety features built-in.
- The main types of formwork systems in use now are:
  1. Slip form
  2. Horizontal panel
  3. System column formwork
  4. Tunnel form

MODERN FORMWORKS
SLIPFORM TECHNOLOGY

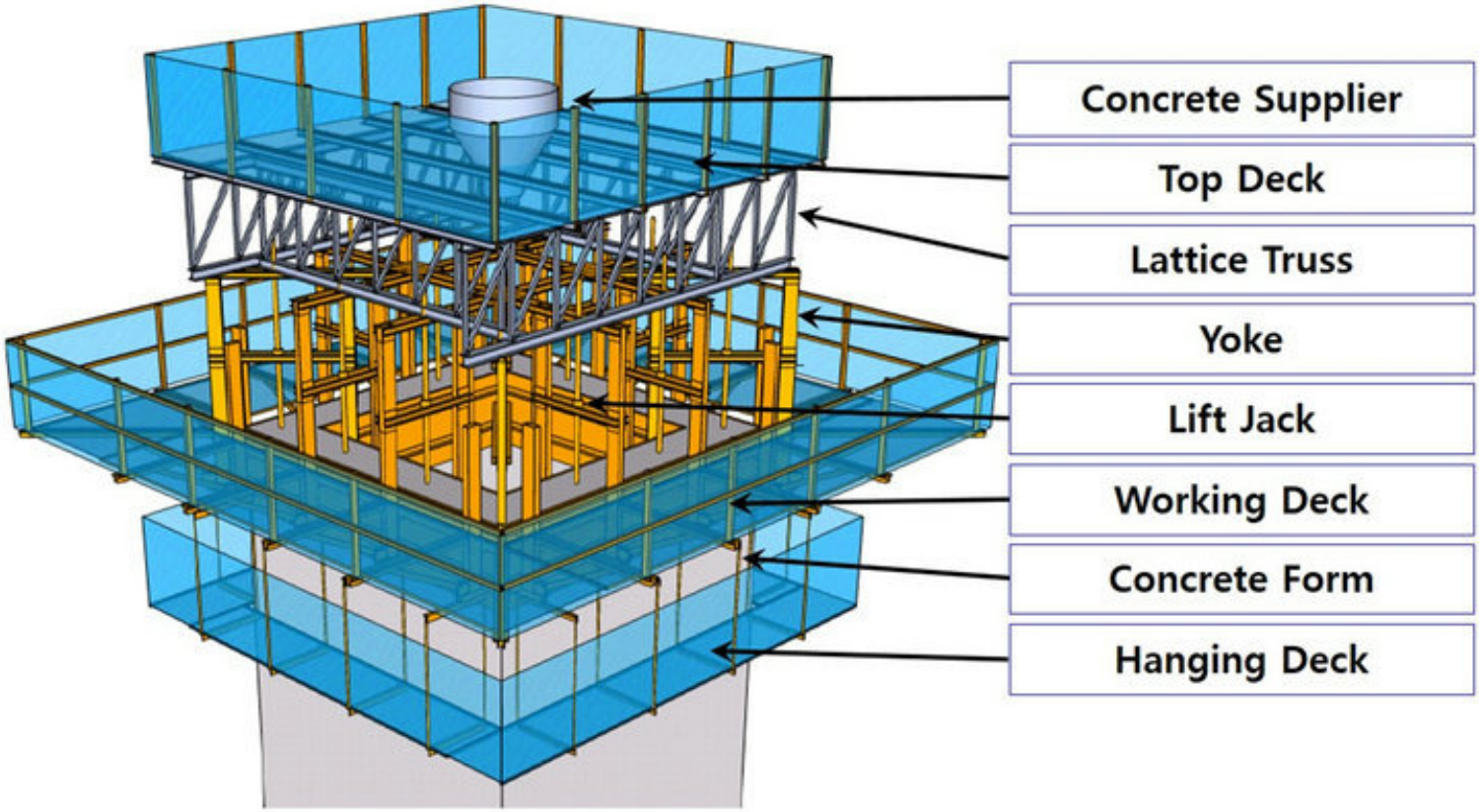
- Suitable for construction of core walls in high-rise structures and towers.
- The formwork rises continuously, at a rate of about 300 mm per hour, supporting itself on the core and not relying on support or access from other parts of the building or permanent works.
- Allows for the continuous pouring of concrete into walls of a structure and only stops when the full required height of the structure has been reached.
- The height of the formwork is designed in such a way that while the top of the formwork is being filled by concrete the lowest layer of concrete poured earlier has already gained an initial set. When the formwork is moved upwards the concrete that is then exposed remains firm.

MODERN FORMWORKS
SLIPFORM TECHNOLOGY: (PROCEDURES)

- Assembly can only start once the foundations are in place and the wall starter is in correct alignment.
- Slip form shuttering is aligned with the help of yokes.
- Horizontal crossbeams connect these yokes.
- Hydraulic jacks are attached to these crossbeams for simultaneous upward movement.
- Height of the slip form ranges from 1.1 to 1.5 meters.
- Yokes and crossbeams also used to support the working platform
- Structure should be rigid and shape maintained at all times.
- Make sure there is no lag or else it prevents the structure from free upward movement
- It is also possible to reduce wall thicknesses as the construction gains height and arrangements have to be made in the slip form structure that will enable such reduction at regular intervals.



MODERN FORMWORKS
SLIPFORM TECHNOLOGY: (PROCEDURES)



ERECTION OF A TOWER USING SLIPFORM

MODERN FORMWORKS

SLIPFORM TECHNOLOGY:

TUNNEL FORMWORK SYSTEM:

HORIZONTAL FORMWORK

- Slipform methods of construction can also be adapted to horizontal structures and are used for paving, canals, and tunneling.
- The technique is more in use for structures that have continuous walls like silos , chimneys, and piers for very tall bridges.

MODERN FORMWORKS
SLIPFORM TECHNOLOGY:
TUNNEL FORMWORK SYSTEM:

- Tunnel formwork system allows the contractor to cast walls and slabs in one operation in a daily cycle.
- It combines the speed, quality and accuracy of factory/off-site production with the flexibility and economy of in-situ construction
- Recognized as a modern method of construction (MMC).

MODERN FORMWORKS

SLIPFORM TECHNOLOGY:

TUNNEL FORMWORK SYSTEM:

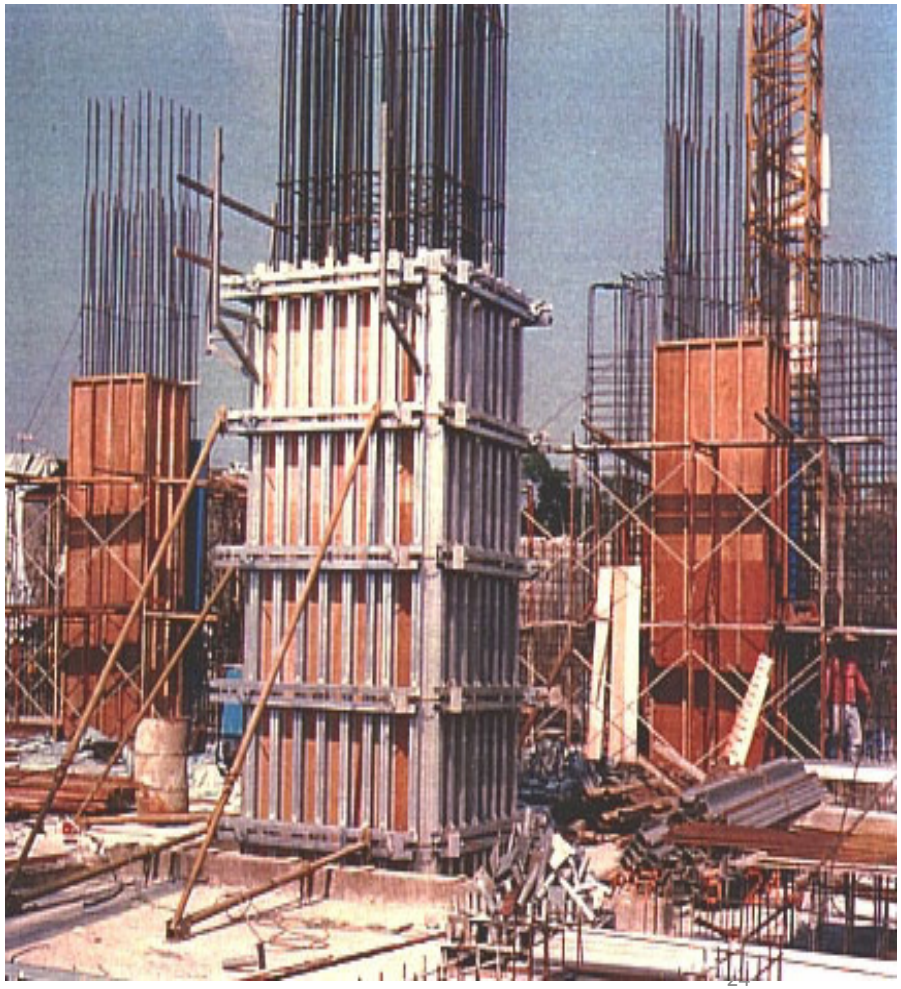
- The system creates an efficient load-bearing structure for use in a wide variety of applications.
- It is particularly effective in projects suited to repetitive cellular construction such as residential blocks, hotels, student accommodation, barracks and prisons.

MODERN FORMWORKS

COLUMN SYSTEM FORMWORK:

The column formwork systems now available are normally modular in nature and allow quick assembly and erection on-site while minimizing labor and crane time.

- They are available in steel, and aluminum and have a variety of internal face surfaces depending on the concrete finish required.
- Innovations have led to adjustable, reusable column forms which can be clamped on-site to give different column sizes.



MODERN FORMWORKS

COLUMN SYSTEM FORMWORK:

- Column forms are designed for specific maximum concrete pressures. The concrete placement rates have to be adjusted to keep the concrete pressure within the specified limits.
- The assembled formwork has to be restrained at the base properly to avoid displacement, and grout loss during concreting.

SCAFFOLD FOR COLUMN

Engineered/Pre-fabricated Formworks

- This formwork is built out of prefabricated modules with a metal frame (usually steel or aluminium) and covered on the application (concrete) side with material having the wanted surface structure (steel, aluminium, timber, etc.).
- The two major advantages of formwork systems, compared to traditional timber formwork, are speed of construction and lower life-cycle costs (barring major force, the frame is almost indestructible, while the covering if made of wood; may have to be replaced after a few – or a few dozen – uses, but if the covering is made with steel or aluminium the form can achieve up to two thousand uses depending on care and the applications).

Concrete Formwork

POINTS OF DIFFERENTIATION	CONVENTIONAL METHOD	MODERN DAY METHOD	PREFABRICATED METHOD
MATERIAL USED	TIMBER(Plywood Or moisture-resistant Particleboard).	STEEL AND ALUMINIUM.	Frame of ALUMINIUM covered with ALUMINIUM OR TIMBER
TIME CONSUMPTION	VERY TIME CONSUMING. (For large structures.)	DESIGNED FOR SPEED AND EFFICIENCY. (mostly modular)	Work happens simultaneously with construction hence saves time
LIFE SPAN	The plywood facing has a relatively SHORT LIFE SPAN.	LONGER LIFE SPAN	The frame is very durable (If made of metal n aluminium can be used for 2000 times)
USED IN	The labour costs are LOWER than the costs for procuring reusable formwork.	The labour costs are HIGHER than the costs for procuring reusable formwork.	The labour costs are HIGHER than the costs for procuring reusable formwork.
FLEXIBILITY	MOST FLEXIBLE	LESS FLEXIBLE.	There is NO FLEXIBILITY after making the formwork

Concrete Formwork
FAILURE OF FORMWORK

Concrete Formwork
FAILURE OF FORMWORK (cont'd)

- Formwork failures are the cause of many accidents and failures that occur during concrete construction which usually happen when fresh concrete is placed
- Generally some unexpected event causes one member to fail, then others become overloaded or misaligned and the entire formwork structure collapses

Concrete Formwork
FAILURE OF FORMWORK (cont'd)

- Improper stripping and shore removal
- Inadequate bracing
- Unstable soil under shoring plumb
- Inadequate control of concrete placement
- Lack of attention to formwork details
- Inadequate cross bracing and horizontal bracing of shores
- Forms sometime collapse when their shores/ jack are displaced by the vibration caused by:
  - passing traffic
  - movement of workers & equipment on the formwork
  - the effect of vibrating concrete to consolidate it

Concrete Formwork
SAFETY PRECAUTION

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

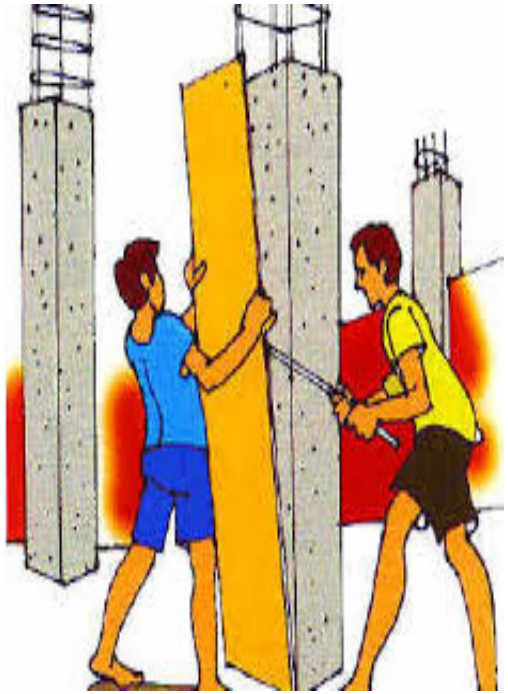
Concrete Formwork
SAFETY PRECAUTION

- Striking As column and beam side formwork will be removed befo re beam and slab soffit formwork, provision must be made for ea sy removal and in the correct order. If beam and slab soffit form work is to be removed before the concrete has achieved working s trength, permanent propping or shoring is required. Take care to avoid damage to formwork which is to be re used. Eight or more uses may be obtained from timber formwork.
- **Maintenance** Clean forms with stiff brush and clean cold water. Use scrapers only as a last resort. Keep forms well oiled to preven t delamination of plywood or rusting of steel and always oil the ed ges.
- **Storage of forms** Any formwork with steel components should be stored in the dry. Avoid direct sunlight on timber forms. Store cle ar of the ground without twist or bend, and keep free of dirt.

Concrete Formwork

DESHUTTERING

- **DESHUTTERING** simply means, the process of removing the shuttering (Formwork for Concrete).
- **Order and method of removing formwork:**
  - Shuttering forms of vertical faces of walls, beams & column sides should be removed first. Shuttering forms of soffit to slab should be removed next.
  - Shuttering forms of soffit to beams, girders or other heavily loaded members should be removed in the end.
- **Factors considered :**
  - Concreting is done under normal circumstances
  - Cement used is Ordinary Portland Cement
  - Adequate curing is done
  - Ambient temperature is not fall below 15 degree



Concrete Formwork

DESHUTTERING (cont'd)

RELEASE AGENTS FOR FORMWORK:

Formwork needs to be treated with a release agent so that it can be removed easily after the concrete has set. Failure to use a release agent can result in the formwork sticking to the concrete, which may lead to damage of the concrete surface.

A single application of release agent is all that is required when forms are then used. Care must be taken to cover all the surface that will come in contact with the surface of concrete. However, if there is an excess of release agent, it may cause staining or retardation of the concrete.

Concrete Formwork

DESHUTTERING (cont'd)

- There are different release agents depending on what material is used for the formwork.

  The three (03) most common release agents for formwork are:

  - Neat oils with surfactants: used mainly on steel surfaces, but also suitable for timber and plywood.
  - Mould cream emulsions: good general purpose release agents for use on timber and plywood.
  - Chemical release agents: recommended for high quality work, applied by spray to all types of form face.

Construction Practices

- Forms must be constructed with tight joints to prevent the loss of cement paste, which may result in honeycombing.
- Before concrete is placed, forms must be aligned both horizontally and vertically and braced to remain in alignment.
- Form alignment should be continuously monitored during concrete placement, and adjustments made if necessary. When a vertical form is wider at the bottom than at the top, an uplift force will be created as the form is filled. Such forms must be anchored against uplift.

Construction Practices

- Use drop chutes or rubber elephant trunks to avoid segregation of aggregate and paste when placing concrete into high vertical forms. Free-fall distance should be limited to 5 ft or less.
- When pumping forms from the bottom, it is important to fill the forms rapidly so that the concrete does not start to set up before filling is completed. If the pump rate is so low that setting begins, excessive pressure will be produced inside the form, resulting in bulging or rupturing of the form.

Construction Practices

- Concrete forms are removed after the concrete has developed the required strength. When removing (or stripping) concrete forms, care must be taken to minimize damage to the surface of the concrete during the removal process.

Thank You

Questions ?