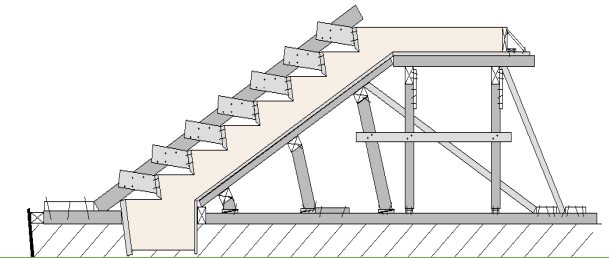


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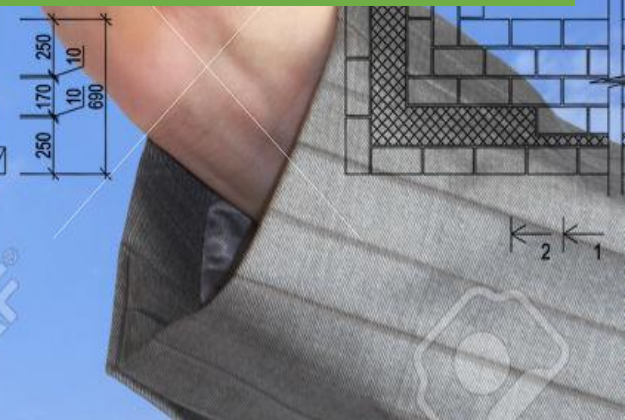
TECHNOLOGY OF CONSTRUCTIONS I



4th WEEK

FORMWORK

VARIOUS TYPES, MATERIALS AND CONSTRUCTION TECHNIQUES



INTRODUCTION

➤ *WHAT IS FORMWORK?*

1. Formwork in construction is the use of support structures and moulds to create structures out of concrete which is poured into the moulds.

Formwork can be made using moulds out of steel, wood, aluminium and/or prefabricated forms.

2. Formwork is the term given to either temporary or permanent molds into which concrete or similar materials are poured.

In the context of concrete construction, the falsework supports the shuttering moulds.

3. Formwork is an **ancillary construction, used as a mould** for a structure.

Into this mould, fresh concrete is placed only to harden subsequently.

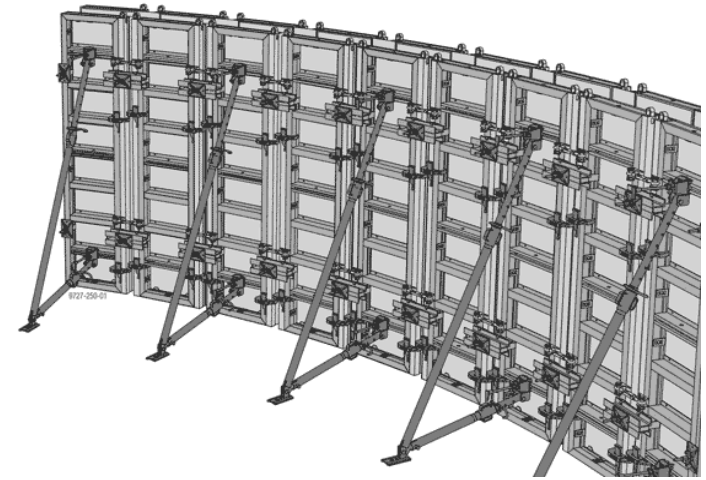
- The construction of formwork takes time and involves expenditure up to 20 to 25% of the cost of the structure or even more.
- The operation of removing the formwork is known as **stripping**.
- Stripped formwork can be reused.
- **Reusable forms are known as panel forms** and **non-usable are called stationary forms**.

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.

INTRODUCTION

- **The following points are to be kept in view to effect 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 quantity of surface finish depends on the quality of the formwork.



CATEGORIES OF FORMWORK

➤ CONVENTIONAL

- The formwork is built on site out of timber and plywood or moisture-resistant particleboard.
- 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.

CATEGORIES OF FORMWORK

➤ MODERN-DAY 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:**
 - ✓ **Table form/flying form**
 - ✓ **System column formwork**
 - ✓ **Horizontal panel**
 - ✓ **Slip form**
 - ✓ **Tunnel form**

CATEGORIES OF FORMWORK

➤ 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).

MATERIALS

➤ 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
 - Sheeting



STEEL FORMWORK



WOODEN FORMWORK

MATERIALS

➤ TIMBER FORMWORK

- Most common material used for bracing the member, hence called as the **traditional formwork**.
- Can be easily cut to size on site.
- Timber joist can be replaced with engineered wood beams and supports are replaced with metal props, which makes this method more systematic and reusable.
- **Various sizes of timber members:**

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



➤ TIMBER FORMWORK

○ **ADVANTAGES**

- + Easy handling because it is light weight.
- + Easy to disassemble.
- + Damaged parts can be replaced with new one.
- + Very flexible.
- + Easy to produce.
- + Easily available.

○ **DISADVANTAGES**

- Limited size of shape.
- Excessive loss of heat.
- A very smooth surface will be produced which would give problems for finishing process.
- Limited fixing.



➤ 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 18 mm.
- 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.

➤ STEEL FORMWORK

- Steel forms are stronger, durable and have longer life than timber formwork and they can be reused.
- 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

○ **ADVANTAGES**

- + It can be used for a no. of times.
- + It is non absorbent.
- + Smooth finish surface obtained.
- + No shrinkage of formwork occurs.
- + Easy to use.
- + Its volume is less.
- + Its strength is more.

○ **DISADVANTAGES**

- Limited size or shape.
- Excessive loss of heat.
- A very smooth surface will be produced which would give problems for finishing process.
- Limited fixing.

MATERIALS



➤ ALUMINIUM FORMWORK

○ **ADVANTAGES**

- + Quickly and accurately assembled.
- + Reduces the labour cost owing to its easy installation.
- + Light weight component provides low pressure on the lower part of the buildings.
- + Aluminium metal surface offers easy cleaning after concrete is removed.
- + Faster construction cycles.
- + Easy to handle.
- + High quality finishes.
- + Can be easily recycled.
- + Can be repeatedly used without losing quality
- + Safe work platforms.
- + High salvage cost.
- + Fewer burdens on environment.

○ **DISADVANTAGES**

- Initial high investment.
- Compares very poorly on modifications, against brick work constructions.
- Fear of theft of valuable Aluminium Extrusions & sheets & hence kit not being complete at critical stages of construction.
- Mass Housing projects are not as high for investing in large number of Aluminium Formwork.
- Sensitive to contact with concrete (alcalic material)!!!

MATERIALS

➤ PLASTIC FORMWORK



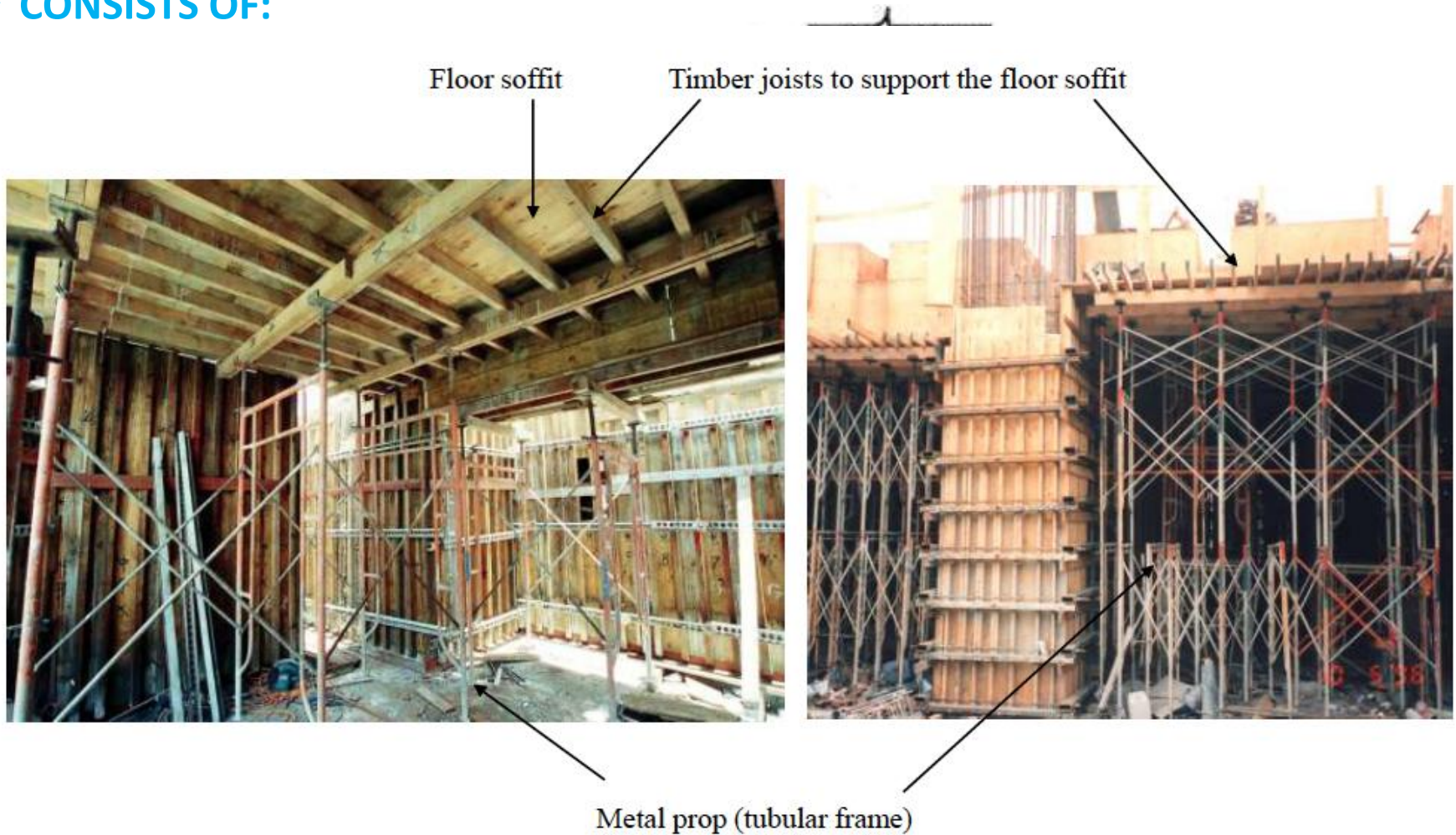
PROCESS OF FORMWORK CONSTRUCTION

➤ FORMWORK FOR VARIOUS STRUCTURAL MEMBERS

- Construction of formwork normally involves the following operations:
 1. Propping and centering
 2. Shuttering
 3. Provision of camber
 4. Cleaning and surface treatment

FORMWORK FOR WALLS

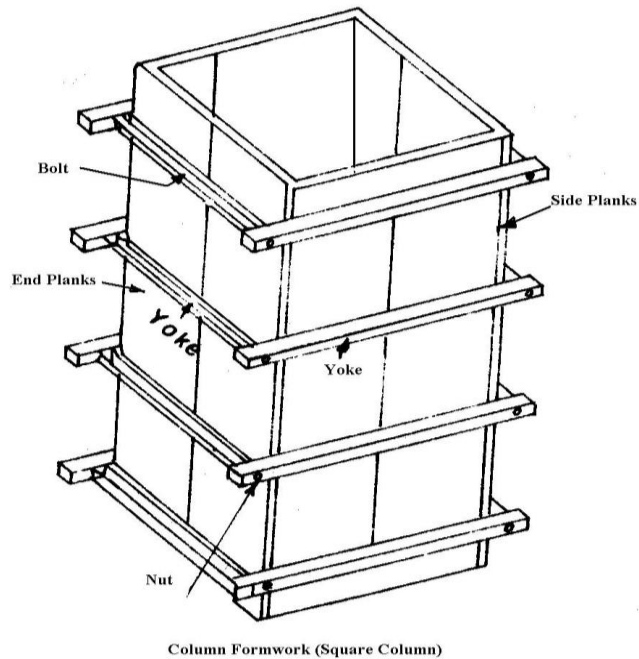
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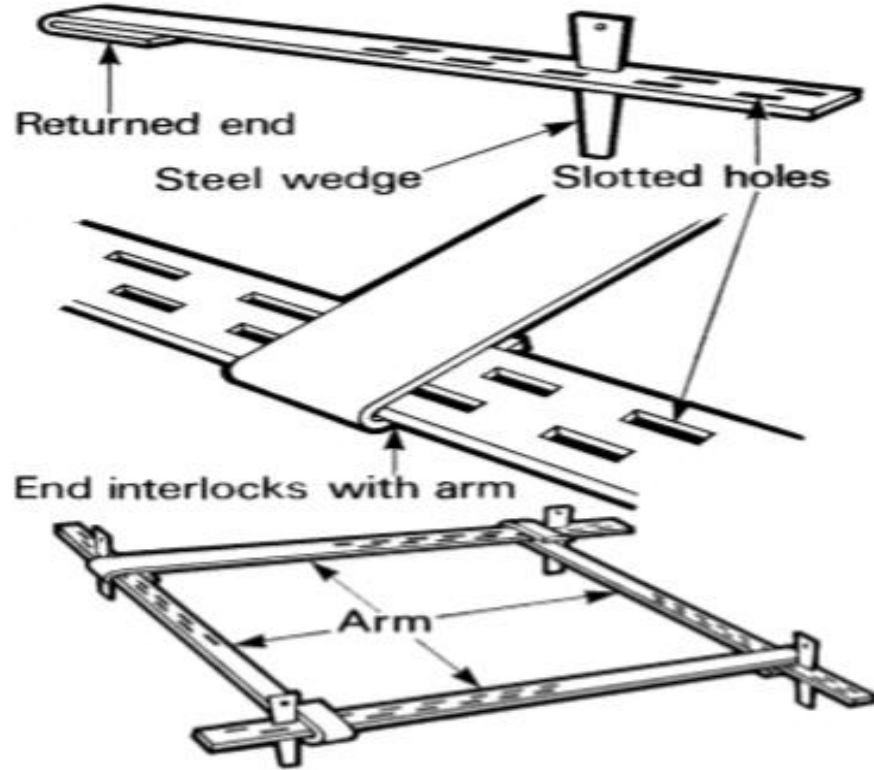
FORMWORK FOR COLUMNS

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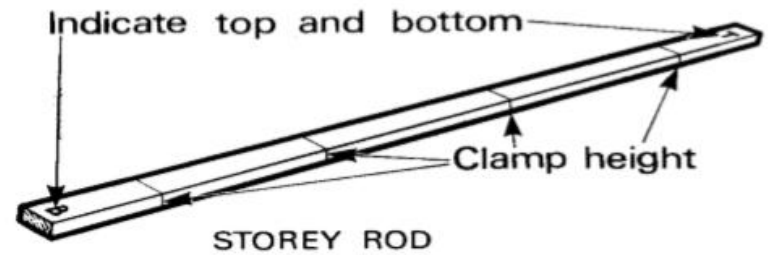
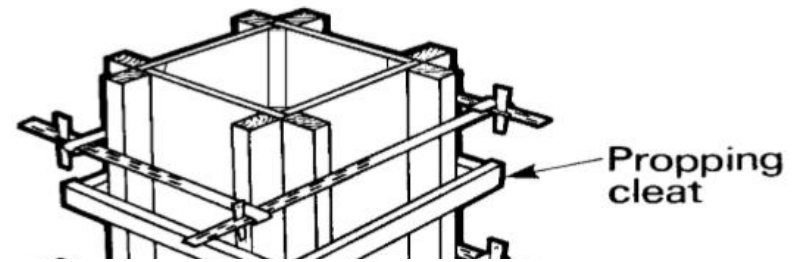
- Side & End Planks
- Yoke
- Nut & Bolts
- Two end & two side planks are joined by the yokes and bolts.



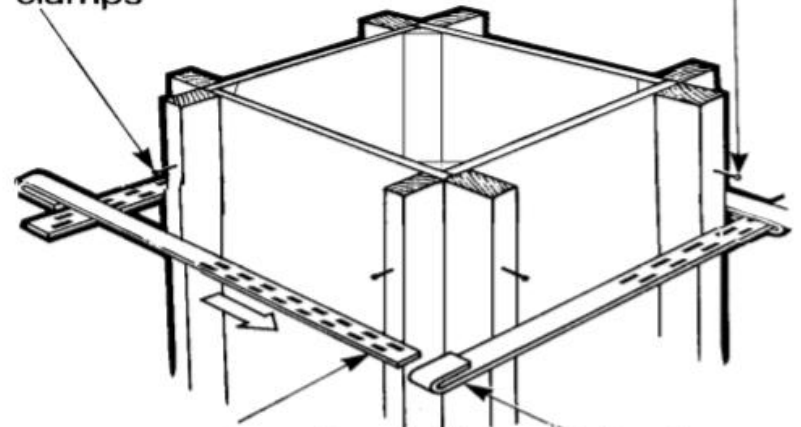
FORMWORK FOR COLUMNS



ADJUSTABLE STEEL CLAMPS



Nails to provide temporary support for clamps



TEMPORARY SUPPORT FOR COLUMN CLAMP

FORMWORK FOR COLUMNS

➤ CIRCULAR AND OCTAGONAL COLUMNS

- Cardboard tube, one-off formwork, available in a range of diameters.
- Cut to waste after concrete is poured.



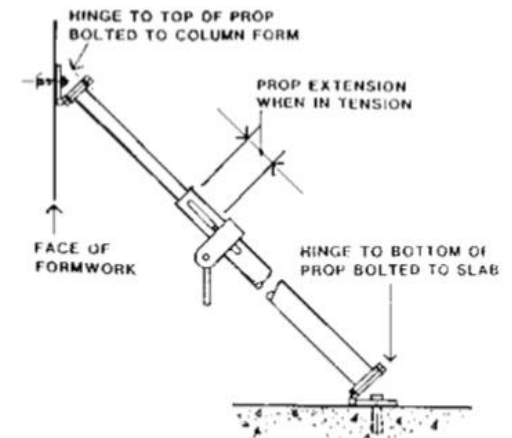
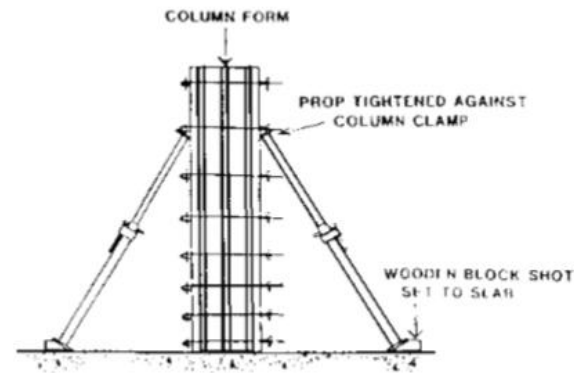
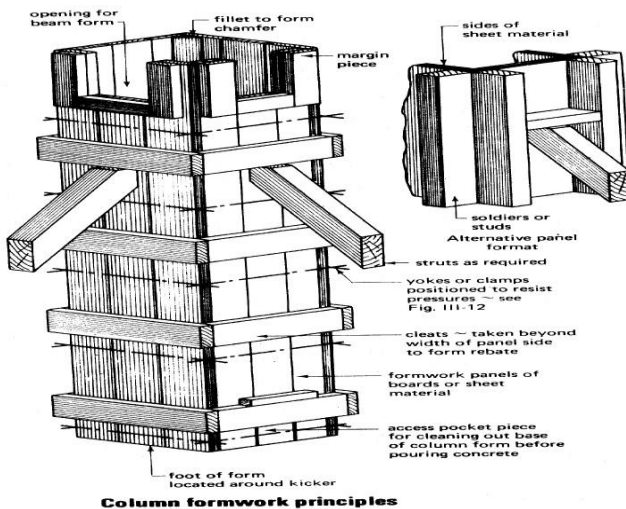
g column

FORMWORK FOR COLUMNS

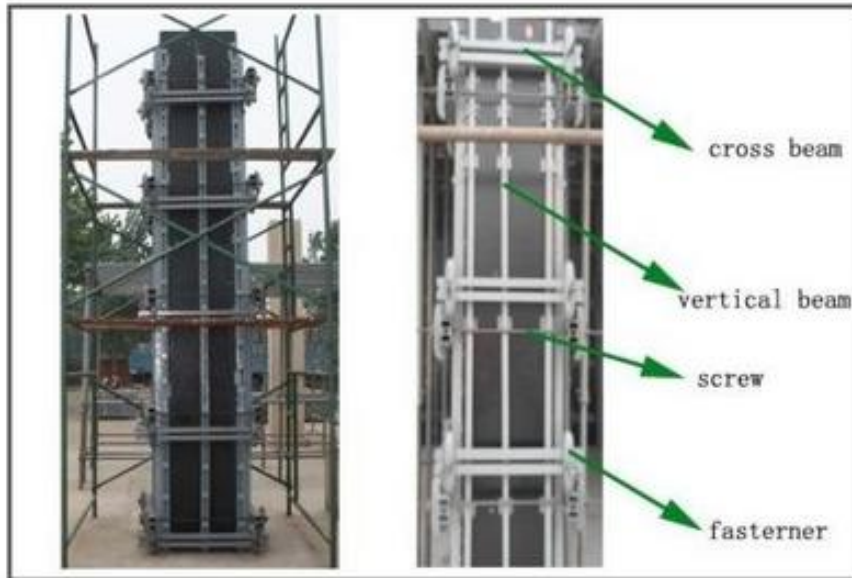
➤ COLUMN BRACING FORMWORK

○ Column formwork bracing performs two functions:

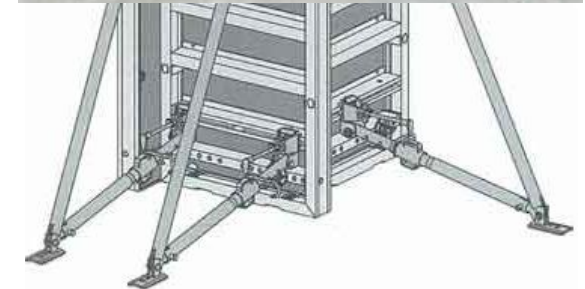
- It must maintain the accuracy of the column form position and plumb so that it is within tolerance.
 - Withstand results of forces acting on either the column formwork or the bracing.
 - The forces may be wind or impact.
 - These impact forces can occur from the collision of concrete buckets or cranes hoisting materials.
- <https://www.youtube.com/watch?v=D8MMTrXsWB0>



SYSTEM FORMWORK FOR COLUMNS



SCAFFOLD FOR COLUMN



○ Other considerations

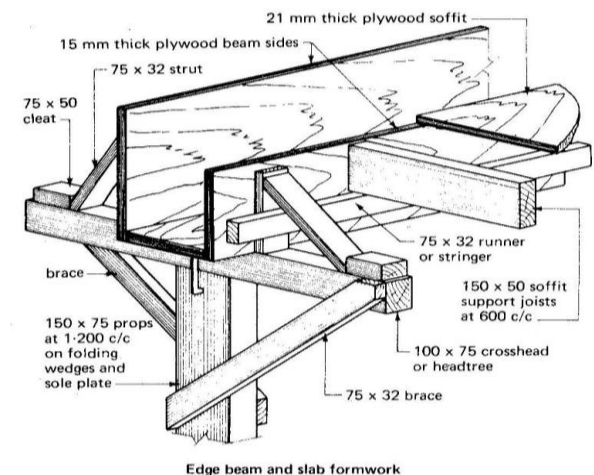
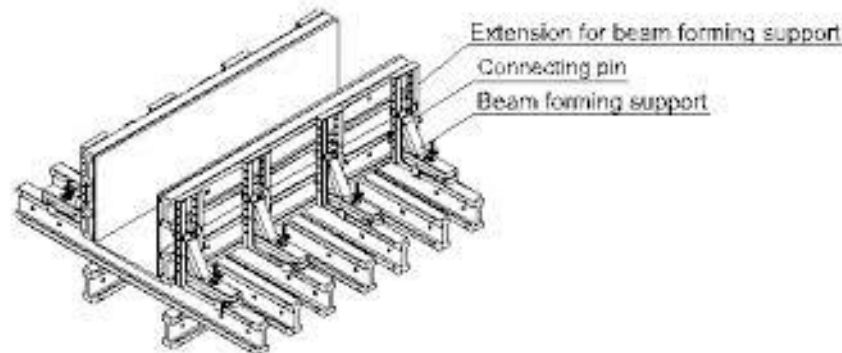
- Column forms are **designed for specific maximum concrete pressures**.
- The concrete placement rates have to be adjusted to keep the concrete pressure within the specified limits.
- The assembled formwork has to be restrained at the base properly to avoid displacement, and grout loss during concreting.

FORMWORK FOR BEAM

- Beam soffit must be thickened timber or strengthened plywood.
- Beam sides 18 mm plywood or 25 mm boards with studs (cleats) at 500 to 600 mm centres.
- Deep beams (over 600 mm) should have walkers and ties.
- Use angle fillets in the beam side to soffit joint where possible.
- Allowance must be made for height adjustment of the props or falsework.

➤ Erection sequence for constructing beam formwork includes:

- Position of sole plates;
- Marking out and setting heights for falseworks.
- Assemble and position props, adjustable head jacks, falseworks, bearers and spreaders.
- Construct and erect side walls and beam soffit.
- Position of sole plates.

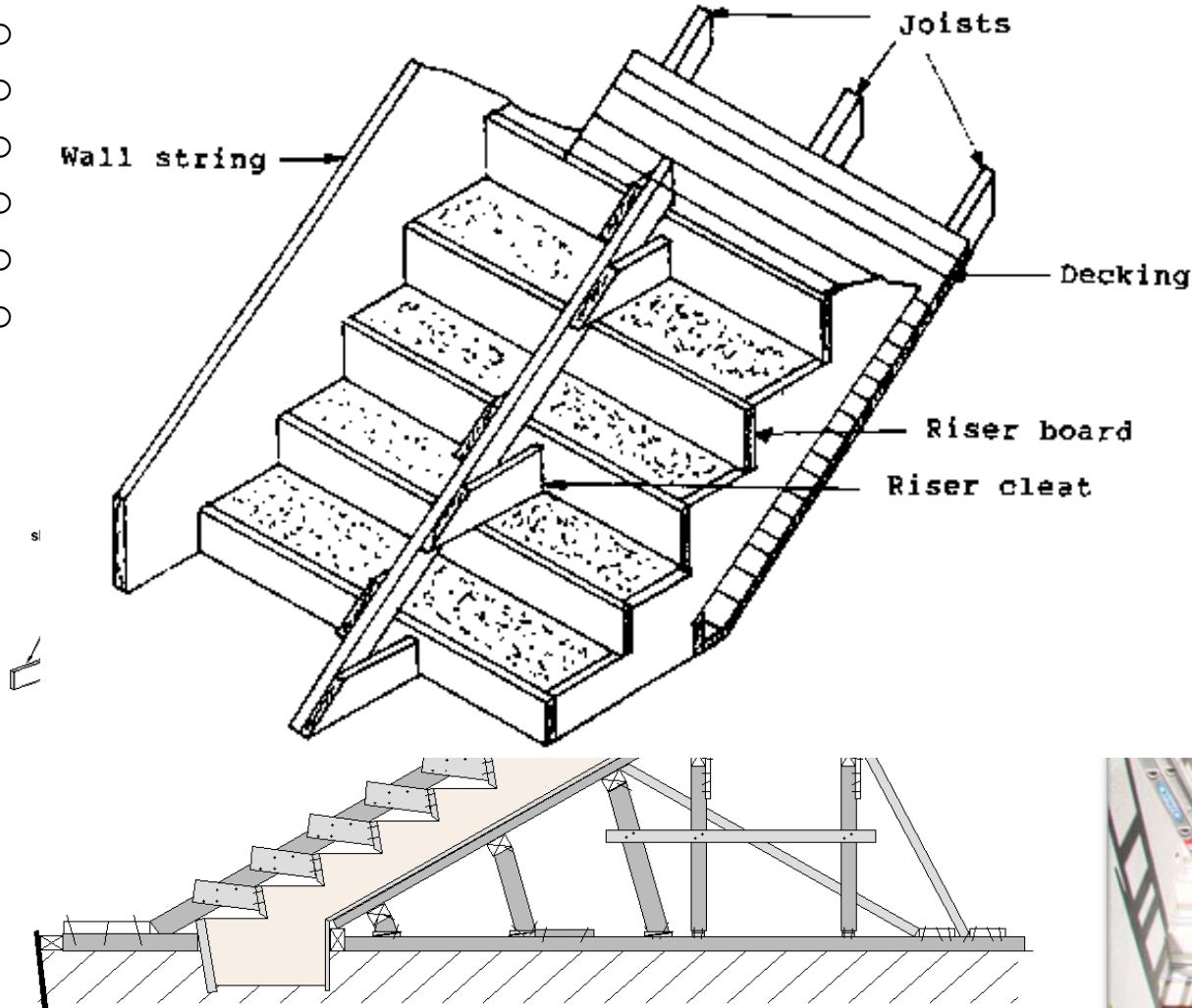


Edge beam and slab formwork
Typical beam formwork

FORMWORK FOR STAIRCASE

➤ Points to consider when designing stair formwork:

-
-
-
-
-
-



o be supported.
itted sideways.
ovement.



SLAB FORMWORK (DECK FORMWORK)

➤ HISTORY

- Some of the earliest examples of concrete slabs were built by Roman engineers.
- Because concrete is quite strong in resisting compressive loads, but has relatively poor tensile or torsional strength, these early structures consisted of arches, vaults and domes.
- To mould this structure, temporary scaffolding and formwork or falsework was built in the future shape of the structure.

➤ TIMBER SLAB FORMWORK

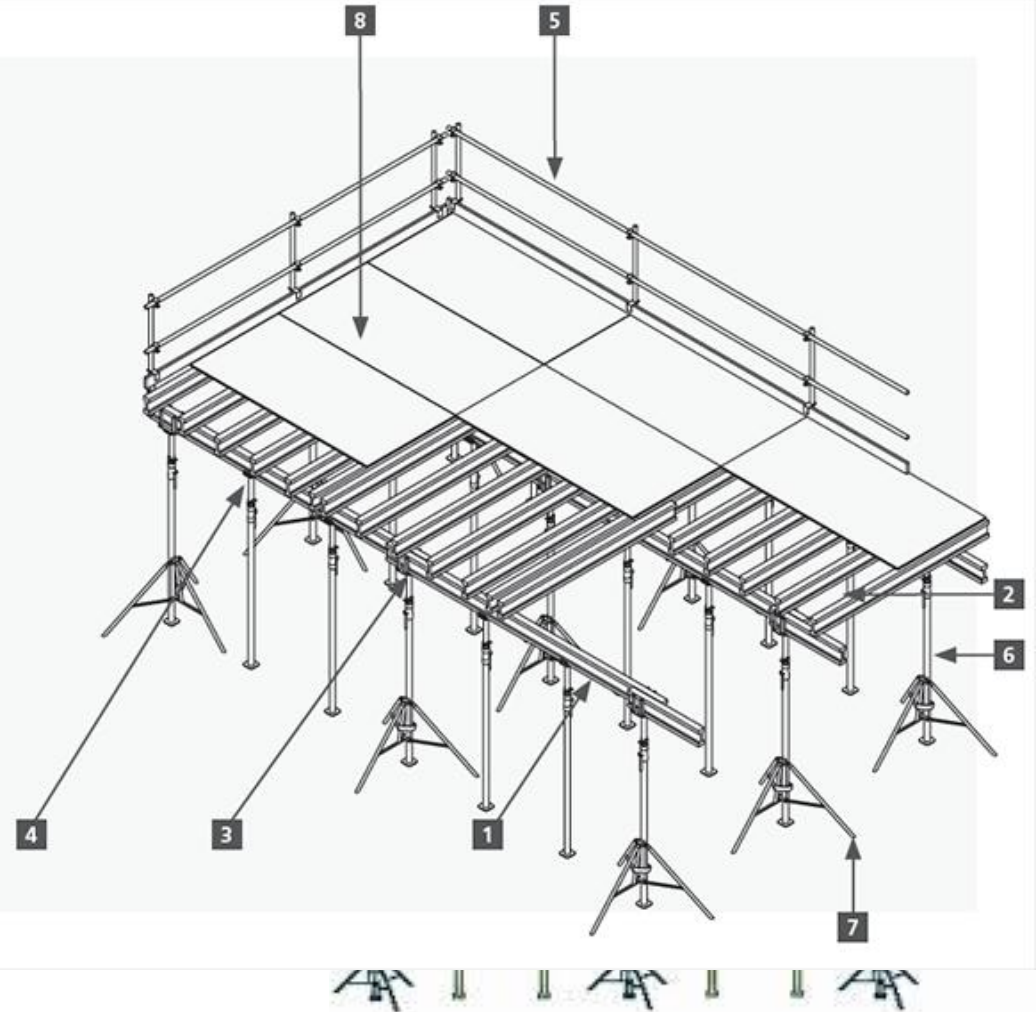
- Traditional slab formwork
- Metal slab formwork
- Table or flying form systems

SLAB FORMWORK (DECK FORMWORK)

➤ TIMBER SLAB FORMWORK

COMPONENTS

- 1** Main VM 20 beams
- 2** Secondary VM 20 beams
- 3** Double Head VR
- 4** Simple Head VR
- 5** Safety handrail
- 6** Prop
- 7** Tripod
- 8** Plywood



SLAB FORMWORK (DECK FORMWORK)

➤ METAL SLAB FORMWORK

- Similar to the traditional method, but stringers and joist are replaced with aluminium forming systems or steel beams and supports are replaced with metal props.
- This also makes this method more systematic and reusable.
- Aluminum beams are fabricated as telescoping units which allows them to span supports that are located at varying distances apart.
- Telescoping aluminium beams can be used and reused in the construction of structures of varying size.



SLAB FORMWORK (DECK FORMWORK)

➤ Table or flying form system

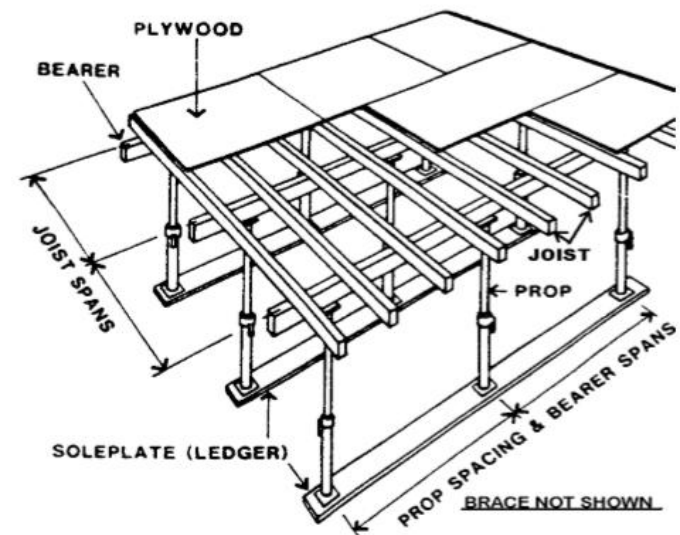


SUSPENDED SLABS

- Suspended floor slabs can be constructed using cast in-situ, precast units or a combination of both.
- Whichever method is used, it is important to support the proposed method of construction using a combination of timber or steel bearers and adjustable shoring.
- The spacing and type of support system required is determined by the load imposed during the construction process.
- Manufacturers provide tables to assist in the selection and spacing of adjustable shoring systems.

➤ **The erection sequence for constructing a suspended floor slab includes:**

- Determining the bearer spacing;
- Erecting bearers and joists;
- Fixing the sheeting;
- Preparation for concrete.



Standard slab formwork

PRE-FABRICATED FORMWORK

- Very little on-site skilled labor needed.
- The ability to reuse forms either as a large section or as individual units.
- All prefabricated systems are designed for light as well as heavy construction.
- Contractors can bid almost any type of work; straight, battered, curved or cut-up.
- Prefab forms may be set in any combination, horizontally and vertically, to any wall height.
- On high walls, one side of forms can be erected and ties placed; then the close-out side can be erected during placement, minimizing concrete drop and assuring effective vibration.



PRE-FABRICATED FORMWORK

- In a prefab system the contractor can remove and replace forms at any point.
- This simplifies erection and stripping, which can be started at any location.
- To allow for a casting pocket, a panel is simply removed and replaced maintenance of forms can be a tiresome task, but well-maintained forms mean more reuses.
- A big advance in prefab forming has been the development of ‚gang forming‘, which is simply defined as the grouping together and moving of a number of forms as a single unit.
- The success of ‚gang forming‘ is due to the development of easy-to-use hardware and ties, made especially for this forming technique.
- Since preforms are pre - engineered and precision made, they offer the best materials available and work equally well on all jobs, resulting in lower cost per use. Although prefabricated forms work well on any size job, the small job is a good way to introduce the system to the workmen.



PRE-FABRICATED FORMWORK

➤ DISADVANTAGES

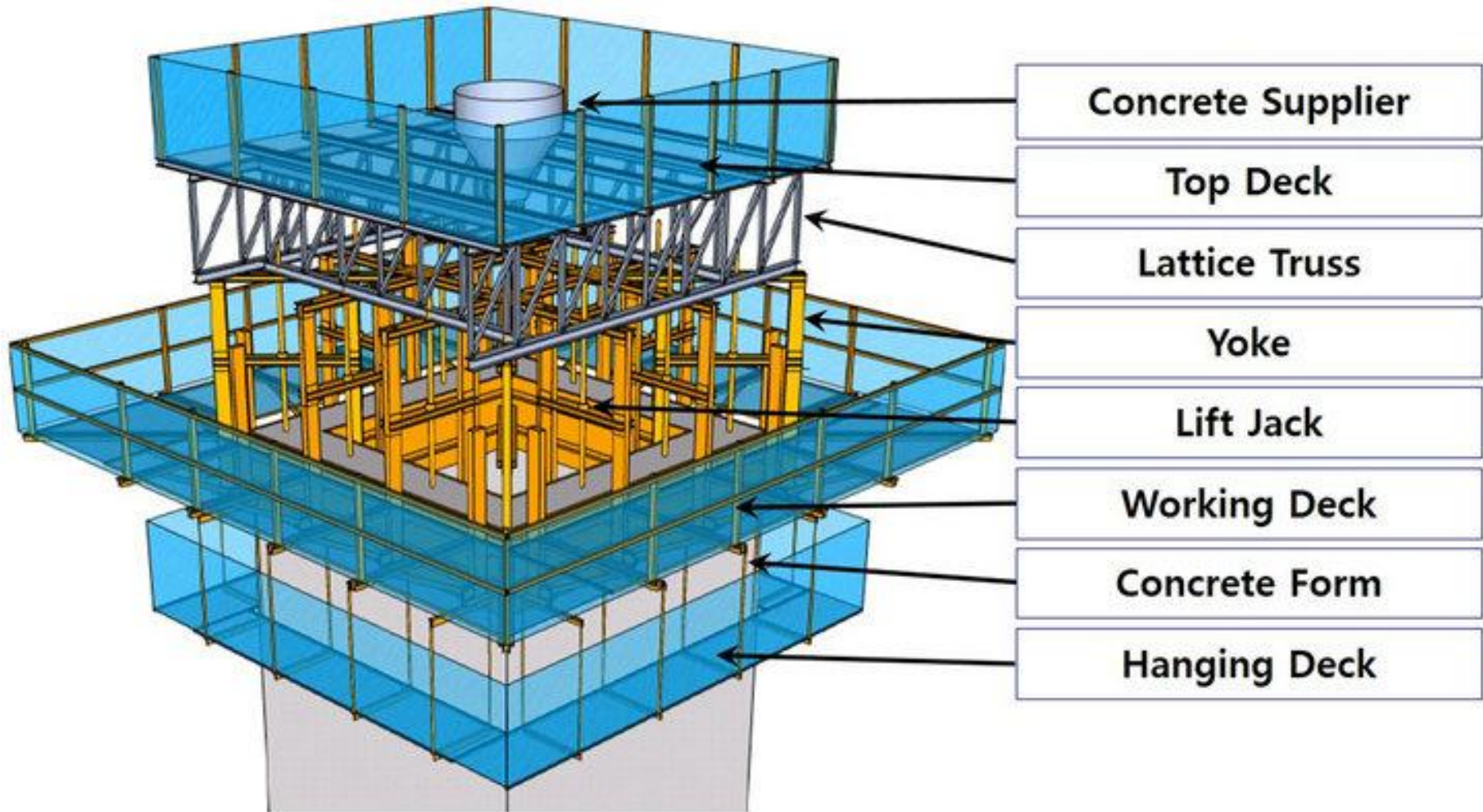
- High cost factor.
- Greater transportation cost, due to the large pieces, where as the regular formwork can be transported easily.
- Too many pieces involved in the pre fabricated formwork.
- Pre fabricated formwork, leave poor finishes at the joints of the forming members.
- The first cause of deflection is the rate of placing, which is usually too fast.
- If recommended placing rates are followed and there is good supervision of placement and vibrating, the problem of deflection can be controlled.
- With many prefab systems, panels can be removed at different locations and used as casting pockets.
- This procedure avoids dropping the concrete a great distance and helps to maintain a more constant rate of placement.

FORMWORK

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

UNTRADITIONAL FORMWORK TECHNIQUES

ERECTION OF A TOWER USING SLIPFORM



UNTRADITIONAL FORMWORK TECHNIQUES

➤ TUNNEL FORMWORK SYSTEM - ADVANTAGES

○ COST

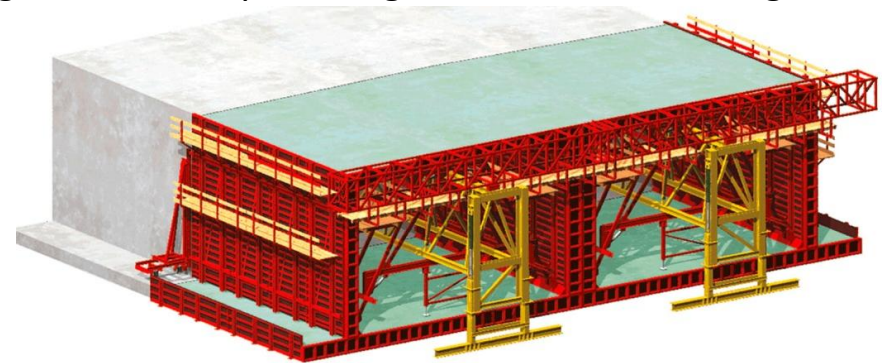
- Cost-effective, high quality construction Generating significant savings in time and costs over alternative methods without compromising on design.

○ BUILDING

- The repetitive nature of the system and the use of prefabricated forms and reinforcing mats/cages simplifies the whole construction process, producing a smooth and fast operation.

○ QUALITY

- Quality is enhanced despite the speed of construction.
- The precise, even steel face of the formwork creates a smooth, high quality finish capable of receiving direct decoration with the minimum of preparation.
- This reduces the requirement for following trades, thus providing additional cost savings and speeding the entire process.



FAILURES OF FORMWORK



FAILURES OF FORMWORK

○ Striking

- As column and beam side formwork will be removed before beam and slab soffit formwork.
- Provision must be made for easy removal and in the correct order.
- If beam and slab soffit formwork is to be removed before the concrete has achieved working strength, 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 eventuality.
- Keep forms well oiled to prevent delamination of plywood or rusting of steel and always oil the edges.

○ Storage of forms

- Any formwork with steel components should be stored in the dry.
- Avoid direct sunlight on timber forms.
- Store clear of the ground without twist or bend, and keep free of dirt.

THANK YOU FOR YOUR ATTENTION

➤ REFERENCES

<http://www.peri.com/en/products/formwork.html>

<https://www.doka.com/cz/index>

THAT'S ALL FOLKS 😊