INTRODUCTION TO FORMWORK

6th Nov, 2012

FORMWORK - Definitions

• “Forms or moulds or shutters are the receptacles in which concrete is placed, so that it will have desired shape or outline when hardend. Once concrete develops the adequate strength to support its own weight they can be taken out”.

• “Formwork is the term given to either temporary or permanent moulds into which concrete or similar materials are poured”...

• “Concrete formwork is a term that refers to the supporting structures used to contain liquid concrete in the desired finished shape between the time it is poured and the time it has set sufficiently to retain shape with the formwork removed.”

• Basically Temporary / Enabling Structures

Superior Aesthetics with Good Forms

Sirsi Circle Flyover, Bangalore

Formwork

• Different types of concrete formwork are commonly used and nearly any shape can be created with the proper formwork and the right grades of concrete. Depending on the job, different types of formwork may be desirable, and formwork that would be sufficient for a job such as laying a concrete pavement might not be suitable for laying a reinforced pad site or supporting column.

• Terminology:
  – Shuttering, Moulds – Generally the element giving the shape to concrete
  – Staging/ Scaffolding - Generally they supporting elements
  – Formwork/ Falsework – Generally a global descriptive term

Comparison of Form systems

Typical Falsework

Traditional formwork system

- Wooden posts (ballies)
  
System formwork

- A network of wooden beams to support the sheathing
- Collapsible type props (CT props)

- A network of wooden H-beams to support the sheathing.
General Requirements for Formwork

- Quality of formwork has a bearing on quality and soundness of the concrete it produces
- Strength & Stability: Formwork to be strong enough to take the dead, live and wind loads arising during construction. Good supporting ground conditions
- Rigidity & Joints: Joints in formwork should be rigid so that bulging, twisting, or sagging due to loads are as small as possible. Excessive deformation will disfigure the surface of concrete.
- Lines: Construction lines in formwork should be true and surfaces plane so that the cost for finishing the concrete surface on removing the shuttering is the least.
- Ease of use: Formwork should be easily erectable & removable without damage to itself so that it could be used repeatedly

Blemishes in Concrete

Some examples of poor concrete quality due to defective formwork:
- Honeycombing
- Hollows
- Fins
- Bulges
- Irregular dimensions/ inaccuracy in geometry
- Unevenness requiring more plastering
- Visible tie holes
- Poor joints with water seepage possibilities
General Loads on Forms

• Weight of reinforcing steel and concrete
• Self weight of forms
• Various live loads imposed during the construction process
• Equipment Loads from Vibrators, concrete pumps, concreting bucket, starting and stopping of heavy equipment on structure; movement of heavy equipment nearby
• Bracings and props to be designed for horizontal loads: due to winds, inclined supports, dumping of concrete. Equipment (pumps, transport pipes, braking)
• Staging to be designed for lateral loads also; very important; bracings in all three directions need to be designed and installed
• Decentering scheme is important

Concrete Pressures on Forms

• Various formulae are available to estimate the pressures from green concrete on the forms.

Some important issues

• Form release agents – impact on concrete finishes
• Formwork stripping/Decentering – Age, Procedure
• Access to Forms & staging
• Staging – Stability with cross Bracings

Table: Period of removal of formwork

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description of structural member</th>
<th>Period of time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Walls, columns and vertical sides of beams</td>
<td>1 to 2 days</td>
</tr>
<tr>
<td>2</td>
<td>Slabs (props left under)</td>
<td>3 days</td>
</tr>
<tr>
<td>3</td>
<td>Beam soffits (props left under)</td>
<td>7 days</td>
</tr>
<tr>
<td>4</td>
<td>Removal of props to slabs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) For slabs spanning up to 4.5 m</td>
<td>7 days</td>
</tr>
<tr>
<td></td>
<td>(b) For slabs spanning over 4.5 m</td>
<td>14 days</td>
</tr>
<tr>
<td>5</td>
<td>Removal of props to beams and arches</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) Spanning up to 6 m</td>
<td>14 days</td>
</tr>
<tr>
<td></td>
<td>(b) spanning over 8 m</td>
<td>21 days</td>
</tr>
</tbody>
</table>

Traditional Indian Formwork

Simple systems
Formwork & Staging

- Important & Precious enabler resources for most sites!
- Good planning, usage & storage required to get max. returns
- Mechanization such as pumping of concrete necessitates use of engineered formwork and systems to ensure timely implementation with safety.
- For better overall productivity use of engineered/system formwork is necessary
- Formwork cost generally constitutes 25%–45% of the cost of concrete but involves 60% of the time.
- Formwork done using system formwork/engineered formwork is only 5% to 10%!

Common Formwork Materials

- Timber / Plywood: mainly for sheathing; good flexibility but limited reuse; less durability; no scrap value
- Steel: Good strength and reusability; heavy weight; less Flexibility; corrosion-prone
- Aluminum: Light weight; good reusability; no corrosion; high initial costs
- Plastic / fibre glass / fibre-reinforced plastic: recent developments; light weight; no corrosion; good reusability

Form liners- for superior finishes

**SYSTEM FORMWORK – AVAILABILITY IN INDIA**

- ACRW
- DOKA
- PERI
- MEVA
- PASCHAL

**FORMWORK MATERIALS**

<table>
<thead>
<tr>
<th>Type of system</th>
<th>Framework</th>
<th>Sheathing</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>All steel formwork</td>
<td>lightweight structural steel sections, bent profiles</td>
<td>Steel sheets</td>
<td>Strong, Durable, Economical if more repetitions are derived</td>
<td>Heavy, Consumes excessive labour in shifting, Can get rusted, Flexibility in geometry of forms is limited</td>
</tr>
<tr>
<td>Steel and plywood formwork</td>
<td>steel, plywood</td>
<td>Better flexibility</td>
<td>Uses heavy steel supporting flexural members making it bulkier to work on.</td>
<td></td>
</tr>
<tr>
<td>Steel , plywood and timber beams</td>
<td>timber beams, steel flexural and axial members, plywood</td>
<td>ample flexibility to suit a wide range of form geometry</td>
<td>The system is wood dominated which is getting costlier day by day.</td>
<td></td>
</tr>
<tr>
<td>All aluminium formwork</td>
<td>aluminium, aluminium</td>
<td>Light in weight, Avoid rusting</td>
<td>Higher investment cost, less strength as compared to steel formwork</td>
<td></td>
</tr>
</tbody>
</table>

**Wall / Column Formwork**
Wall / Column Formwork

Large panel wall formwork system

Vertical lifts for walls

FLEX

ADVANTAGES
1) Flexibility in spacing bw individual props.
2) Components are light enough for erecting and dismantling manually.
3) Avoids skilled labour at site.
4) Enables re-propping and frequent reuse of materials.

FLEX System

• Enables re-propping and frequent reuse of materials.

Beam Forming Support

• For beam formwork with minimum beam depth of 300mm excluding slab thickness.
• Uses standard components avoiding skilled making at site.
• Beam bottom sheathing should be of plywood of at least 19mm or of some thicker or stiffer material.
• Requires no form ties up to a total beam depth of 900mm including slab thickness, use of ties may increase the spacing of beam forming supports.
• Arrangement on sides remains independent of beam width.
• Easy assembling, aligning, fixing and dismantling.
**ADVANTAGES**

1) Arrangement of sides remains independent of beam width.
2) Easy assembling, aligning, fixing and dismantling.
3) Uses standard components avoiding skilled making at site.

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**TYPICAL ARRANGEMENT OF HDT SYSTEM**

- **H.D.TOWER SYSTEM**
- **FOOT PLATE**
- **TOWER SPINDLE**
- **H-16 BEAMS**
- **BEAM BOTTOM AND SIDES USING CONVENTIONAL SYSTEM**
- **STEEL WAVER SHORT PROPS**

**HDT: Heavy Duty Tower**

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**ADVANTAGES**

1) Tall staging heights and heavier loading, capacity of 250 kN.
2) Inclined decking is also possible using tower spindles on top.
3) Tower as a whole can be shifted (rolled) manually by attaching transport devices to the legs.

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**An elegant formwork system**

**Stairs**

**Left-in Shuttering System (Rolladec)**
OTHER BUILDING FORMS

Cuplock System

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chain fastening of rung base. Four horizontal rungs can be fastened at one time with just one wrench making the job safer.</td>
<td>Easy and quick erection and dismantling results in ease in time and labour saving.</td>
</tr>
<tr>
<td>Versatile use in construction, demolition or maintenance projects for any type of structures i.e. straight or curved.</td>
<td>Minimum use with no loose components.</td>
</tr>
<tr>
<td>Easiest erection with no loose components.</td>
<td>Lightweight but high load-carrying capacity up to 12,500 kg per vertical.</td>
</tr>
<tr>
<td>Low maintenance.</td>
<td>Safety: with proven track record.</td>
</tr>
</tbody>
</table>

Acrow Beams

DESCRIPTION:
The frame is manufactured in a modern automated plant at Pondicherry, India using high quality acrow beams, splicing them with high strength bolts. The main advantage of using Acrow Beams is that it can fully replace traditional scaffolding. The flanges are manufactured in a modern automated plant at Pondicherry under strict quality control. The flanges are made of seasoned chemically treated timber. The web is made of boiling water proof plywood and joined with the flanges by the unique finger jointing method.

Salient Features:
- Reduced scaffolding: 30%
- Minimum site maintenance
- Built in safety: New form circuit of continuous scaffolding
- Dimensional: square: 160x160: maximum 20 mm
- Ceiling height: up to 15 m
- Remote operating, easy
- Light weight: 6 kg/m

L&T/ Doka H-BEAM - THE CORE

Climbing formwork system:

Safe working platform all around.
Aluminium Formwork System

- Latest in technology
- All aluminium formwork system. All components except for some supporting members are made up of aluminium alloy.
- Used for concrete wall and slab type of construction.
- Requires not more than a hammer for assembly and removal.
- Completely self supporting and interlocking.
- Eliminates time-consuming brickwork and plastering.

Aluminium Formwork System

- High speed of construction
- Saves construction space by 8%
- Very light in weight and hence easy to handle
- Accurate dimensions for all door and window openings
- Earthquake resistant (box type arrangement) construction
- Does not need expensive machinery or skilled workmen.
- Overall cost of construction is less when used for repetitive structures like mass housing etc.
Aluminium Formwork System

Some limitations of this system:

- No changes in the formwork setup possible once it is fabricated ex. for adding conduits for services.
- Can be used only for superstructures; foundation needs to be done in the conventional way.
- Higher initial cost
- Economical only when a number of repetitions of the formwork is obtained.
Slipforming

Hyperboloid shell for Natural Draught Cooling Towers

Automatic Climbing Formwork system for Shell

Mechanised Formwork System For Tunnels

Canal Lining using paver
Conclusion

- Formwork and staging are important elements for construction
- Expertise required for competent use and to get economy in cost
- Engineers and labour to be trained in formwork systems and usage for efficient construction
- Many systems and options are available today for good and fast construction

THANK YOU

All the Best Wishes