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Fast Track Construction Technique–With Special Reference to Formwork System for High Rise Structure

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Abstract—*Fast tract construction technique are helping builders save time and money while cutting back waste and improving quality. A variety of Fast track construction techniques are helping home builders minimize construction waste, reduce labor, time, and cost and improve quality. One method in particular is the Advance formwork system.*

Formwork systems are one of the key factors that govern the success of a construction project in term of speed, quality, cost and safety of works.

Now a day, most projects are required by the client to complete at the shortest time possible as a means to minimize cost of capital. For building of high-rise nature, the most effective way to expedite works is to achieve a very short floor cycle, that is, to have the structure as a typical floor completed in shortest time.

Modern buildings in many occasions can be very complex, either in terms of scale or size of the building, no matter whether they are high rise or horizontally spread or to fit for sophisticated building services or other facilities requirements. The design and use of right type of formwork system is crucial to overall success of a project.

Present conventional formwork if aims at the speed then have to do it at the cost of contradicting the quality like misalignment, misplacement, defective concrete, or striking up of others causing serious interruption to activities can result.

This study highlights the basic comparison between the conventional system and advance formwork system. It also highlights why convention system fails and how we need to move our self in industrialized way of production in high-rise.

1. INTRODUCTION

The construction industry is the second largest industry of the country after Agriculture. India's construction sector has recorded phenomenal growth in last ten years and High-rise buildings are symbols of a city's identity and economic strength with its "absolute" height and high investment. High rise buildings are the mix of the most advanced architectural concept, technology and engineering. The advance progress of high rise buildings indicates the modernization of the city, it also pose a particular challenge for other related industries, just like architectural design , lifting, fire protection, structural and geotechnical engineering, new materials etc. this high speed construction demand advance technology and engineering and explore new skill to achieve the desired speed and economy in construction.

A study like "Fast track construction technique – special reference to formwork system for high rise structure" could be very useful to achieve effective and timely completion of high rise building with optimal use of resources.

The overall gist of this study is to discuss effective and timely completion of high rise building with optimal use of resources.

2. FORMWORK SYSTEM

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

Formwork is a moulds for concrete. It is also a temporary structure to support concrete and construction loads until concrete hardens and can stand its own. This formwork is important enabling work, which has to keep pace with the modernization of concrete construction.

Formwork development has paralleled the growth of concrete construction throughout this century. Unfortunately very little attention is being paid to formwork design or its usage in India.

International Standards for Formwork:

- ACI 347-2004 – guide to formwork for concrete.
- ACI SP-4 – formwork for concrete.
- OSHAS – Occupational Health and Safety Act standards
- American society of Civil Engineers Standards development.

- Construction Industry research and Information Association (CIRIA) reports on concrete pressure on formwork, striking times, recommendation etc.
- BS 5975 – British Standards for Formwork
- CAN/CSA – S269.3 Canadian standard on formwork
- SAA 1509 – 1974 – Australian standards for f/w
- DIN 4420 – German standards for f/w.

The above standards cover all topics in detail, including lateral pressure of concrete, superimposed load, impact load and environmental loads like wind loads etc.

Indian Standards:

- IS – 14687 – 1999, Indian Standard – False work for concrete structures – Guidelines
- The other code available for reference IRC 87 – 1984 – Guidelines on design and erection of formwork for road bridges is derives from British and American codes.
  The above codes do not elaborate on design factors and special applications when compared to the treatise of international codes, hence formwork not given its due importance in India. Age old methods still followed in construction.

3. DIFFERENT FORMWORK TECHNIQUES USED IN INDIA:

A number of formwork systems are particularly designed for constructing internal or external vertical shafts, columns, beams, and floor slabs. There is not much effective formwork system for stairs and staircases.

Types of formwork used in India:

- Timber formwork
- Panel formwork
- Steel formwork (TUNNEL FORMWORK)
- Aluminium formwork (MIVAN)

Timber formwork is used because of its relative low initial cost and adaptability. It is manually operated.

Panel formwork is semi-fabricated construction techniques under design and built arrangements.

Steel formwork consists of hot rolled or cold formed sections along with sheeting material for formwork

In Aluminium formwork, Aluminium as usual is not a very strong material so the basic elements of the formwork system are the panels which are a formwork of extruded aluminium sections welded to an aluminium sheet. It consists of high strength special aluminium components. This produces a light weight panel with excellent stiffness to weight ratio, yielding minimal deflections when subjected to the load of weight of concrete. The panels are manufactured in standard sizes with non-standard elements produced to the required size and size to suit the project requirements.

Before selecting and application of formwork a number of attributing factors have to be considered.

- Shape of Building: Shape of the building is important consideration while designing the formwork and its types. Therefore for awkwardly shaped building a more traditional and labour intensive formwork system are suitable.
- Design of external wall: It is imperative to understand the impact of design of external walls on the choice of the formwork due to the provision or interruption of features during the casting process. E.g. shading blades or planter boxes may limit the choice of formwork system.
- Internal layout: Complicated internal walls like features and in-built load bearing nature offsets the choice of the formwork.
- Structural forms: Another important factor deciding the type of formwork is nothing but structural forms. A comparisons of buildings with structural core vis-à-vis : Building irregularity arranged shear walls can illustrate impact on formwork
- Consistence in building dimension: nonetheless to mention, that the building dimension could create a doubtful situation challenging the very design of usage of formwork
- Headroom: A precaution has to be taken especially in the case of higher headroom while deciding about the formwork. It is so, sine higher the headroom more problems will be encountered in terms of erection, stability and safety of formwork.
- Repetitive nature: Repetitive nature of structure, more definite is the choice of formwork. Care has to be taken to curb utilization of expensive resources in case the level of repetitiveness is bound to be limited.
- Finish of surface: To get finished surfaces, the formwork needs to be of high quality in terms of surface treatment of panels, tightness of formwork joints and dimension accuracy.
- Building span: Larger the building span crucial role it plays in decision of formwork design and erection process.
- Complexity of built environment: In case of situations like counter, sloped, crowed, complex, small and very large sites with lot of physical constraints increase difficulties in working with formwork.
- Speed of work: Speed of work depends on critical path. Mere increasing formwork cannot solve problem. However a proper selection, design and arranged formwork system will for sure increase the efficiency of work for each type cycle.
- Number of possible reuse: The durability of the plywood sheeting optimizes re-use of timber form up to 2 to 14 times. In spite of re-usability of metal form, constrains are

due to the high initial cost resulting in discouraging the selection. A careful balance between cost, speed, performance and the quality of output should be properly considered when making the selection.

- Construction planning and arrangement: Arrangements for setup provision of hoisting, concrete placing facilities, planning construction phase wise can influence the consideration factor of selection and application of formwork.
- Provision of construction joints: The provision of construction joints can challenge the output and quality of the concrete there by affecting the choice of formwork; sometimes it is inevitable to introduce a large number of construction joints in a large structure to subdivide works into effectively workable sizes. Careful selection should be made to ensure a particular formwork system can satisfactorily allow such arrangements.

4. RESEARCH STUDY

The expectation of this study is not to provide a detailed comparison or explain the technical features of any individual formwork system in detail. Instead, it aims to show the conditions and constraints governing the use of suitable formwork systems under typical local circumstances. For example, generally a typical floor in high rise building may take up to 8 day or more to complete if you conventional timber formwork, whereas it would only take 3 to 5 days if system formwork is used. Multiply four extra days by say 30 floors and it is whopping four months which you could have completed earlier. Think of the cost saving over extra months: staff machinery overheads, bank interests, company reputation and savings for buyers for earlier moving in.

Apart from time factor, some formwork systems are technically more superior to others in producing structures better quality, both dimensionally and finishing as well as providing better safety features during construction.

In this research time comparisons Different projects with Conventional formwork system, L & T Doka formwork System, Tunnel form system and Aluform system

4.1 Case studies on Formwork systems:

4.1.1. Burj Dubai – Doka Formwork System

Using Doka formwork systems, one of the highest buildings all over the world is in Dubai. The architectural design of the tower demands highest adaptability of the formwork and the tough time schedule sophisticated application engineering.

Project details:

- Type of building: Hotel, Residence, Office tower
- Location: Dubai, United arab Emirates
- Start of construction: February, 2005
- Total construction time: 40 months
- Building data: Floors: 160

The unbeatably fast table form with the perfect fit. The innovative design of Dokamatic table makes for even faster formwork handling whenever large floor slabs have to be cast. Standard functional components can be installed for straightforward, speedy and safe adaptation to changing requirements on the construction site.

4.1.2 Neelkanth Green, Thane, Mumbai- Mivan (Aluminium formwork system)

Project details:

- Type of building: High rise residential tower
- Location: Thane, Mumbai
- Start of Construction: December 2006
- Building data: Total 6 towers of 27th floors
- Design: Load bearing wall and slab
- Scope: 4 numbers of blocks on each floor

Stilt and Podium are done with conventional formwork system. 2 to 3 slabs are done on monthly basis.

This formwork system used by Man Infrastructures is 9 day cycle but for this site because of inverted beam it takes 14 day which slow down the construction speed.

Panels can be used up to 250 times, one can achieve saving as compared to conventional formwork system.

Formwork system can be erected with unskilled labour.

It required uniform planning as well as uniform elevations to be cost effective.

Modifications are not possible as all members are cast in RCC (shear walls).

In MIVAN formwork system, a good quality construction possible which economical because of time cutting on repairs and modification due to poor quality work which generally delay the job and cause financial impact on the project.

4.1.3 Millennium Towers at Sanpada, Navi Mumbai- Tunnel Formwork system

Project Details:

- Client: CIDCO of Maharashtra Ltd
- Agency: B. G. Shirke Const. Tech. Pvt Ltd
- Period: 36 months
- Type of structure: G + 14 (walls and slab casted in one pour with Tunnel Form Technology)

Tunnel formwork system is advantageous than convention formwork system and even Aluminium formwork system especially enhancing safety with better management control due to equipment oriented approach and predictable work flow

allowing/ generating quicker returns on investment can be achieved.

Labour saved is about 20 to 25 % than convention formwork system (since equipment oriented)

There is eventually in long run with 750 repetitions of tunnel formwork.

Healthy solution to green building as there is no waste of natural resources, additional cost is saved, fast returns assured.

The technique has in built quality assurance control and even an unskilled trained worker can give maximum productivity.

Separate code of practice is required to be formulated, since the constructional tolerance, percentage of shear wall area in a building and many other parameters do not compare with conventional structures on which the present codes are mainly based.

5. RESULT OUTPUT

Formwork system plays a vital role in leading high-rise construction. Results based on the above study are as follows:

Table 1: Comparison between tunnel formwork, aluminium formwork and conventional formwork

	Conventional formwork	Tunnel formwork	Aluminium formwork
Material	Timber and Ply	Steel Panels	Aluminium Panels
Durability	20 times	750 times	250 times
Plastering	Needed for leveling the concrete surface	Plastering is totally eliminated.	Plastering is totally eliminated.
	Conventional Formwork	Tunnel Formwork	Aluminium Formwork
Labour	Skilled workers needed	Unskilled workers can also do efficient job with required amount of productivity	Unskilled workers can also do efficient job with required amount of productivity
Cost	Double the cost required by steel panel in long run	High initial cost but balances in long term savings	High initial cost but balances in long term savings
Quality	Subjected to workmanship of labour	High quality assured in short time period due to technique	High quality assured in short time period due to technique
Speed	8 days	1 day	4 days
Operations	Manually	Crane oriented	Crane not required
Environmental issues	Loss of natural resources	Most scarce natural resources of forest can be saved	Most scarce natural resources of forest can be saved
Application of system	Minor construction works e.g. residential buildings	For repetitive layout mass housing	For repetitive architectural layout mass housing

Due to its lighter material density compared to mild steel, aluminium system formwork panels are generally bigger pieces than hand held steel formwork panels. They are manually handled by workers during installation without needing a tower crane to transfer to the next floor level. Typical panel sizes found in the market and their respective weights are as follows:

- A standard aluminium panel for wall is 600mm width by 2050mm height weighs about 26kgfor a standard panel for slab, the size is 4550mm width by 1100mm length weighs about 10kg.
- Whereas a steel formwork wall panel of 600mm width by 2700mm height weighs about 104 kg and a 600mm by 900 mm wall panel weighs about 40kg.

Obviously working with steel panels is a lot more difficult and exhaustive for workers without using tower crane to lift them around.

Table 2: Comparisons between Tunnel form system, Aluminium formwork system and conventional system

This comparison is sufficient to conclude from direct and indirect economy

Tunnel formwork system	Aluminium formwork system	Conventional formwork system
Footings	Footings	Footings
Stem Column	Stem Column	Stem Column
Plinth beams	Plinth beams	Plinth beams
RCC Walls + Chajjas + Slabs	RCC Walls + Chajjas + Slabs	(columns + beams + slabs) Manonry, (lintel + chajjas) masonry, plaster
Stair	Stair	Stair + Plaster
RCC parapet wall	RCC parapet wall	Masonry parapet wall + plaster
Concrete door frames, cast at the time of wall/ slab concreting	Concrete door frames, cast at the time of wall/ slab concreting	Door frames required to be fixed after manonry

Table 3: Factors contributing to real time and economy by using Advance formwork technique:

Factors	
Construction Manpower	Requirement is reduced to a great extent due to reduction in construction activities
Masonry	Quantum of work is reduced substantially
Internal Plaster	Quantum of work is less, since it is required only for few internal masonry wall
Ceiling plaster	Totally eliminated since the slabs are form finished
External plaster	Totally eliminated, since the walls are form finished
Door frames	Separate door frames are not required, since the same can be constructed in RCC at the time of wall-slab casting
Shuttering	Can be used for at least 750 times for tunnel formwork system and 250 times for Aluminium formwork system
Completion	The project can be completed earlier
End Product	More stronger, stiff and hence 'SAFE' and 'STABLE'
Fixed cost	Reduces considerable due to early completion

6. CONCLUSION

From the above comparisons we can definitely conclude that aluminum and steel formwork is better for high rise structure but again there are other factors to be considered when selecting a formwork system

- The availability of local resources such as formwork materials, skilled workers, concrete.
- Does it have to be environmental friendly compliance?
- Does it have to be industrialized building system (IBS) compliance?
- Crane Dependent?
- Is the construction period specified? What minimum formwork cycle required?
- Size of building: Is there enough repetition for system to work? Is the floor plan symmetrical in design?

Type of building design will affect what formwork system is more suitable:

- Cellular with shear wall
- Shear wall with non-load bearing concrete partitions
- Column, beam and slab structure
- A lot of curvatures
- Are there many design variations on floor layout and façade?

Cost comparison of different formwork system formworks

- Compare the all-in forming cost per m² from quotations
- Comparisons should include considerations on wastage, supervision, and cost of achieving required quality, time factor, crane cost, formwork and labour, enclosure, protection, working platform, formwork accessories, consumable hardware and ease of safety compliance.

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