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FORMWORK TECHNOLOGY IN HIGH-RISE BUILDING ITS COST AND QUALITY ANALYSIS

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Abstract - *This paper describes about the formwork technology used in high- rise building suitable for Indian construction. By utilizing new technologies in formwork, construction can now achieve the casting of larger elements in a single pour. This advancement not only minimizes time and labor needed but also outperforms conventional methods. Formwork technology is based on the cost, time, and quality of project delivery. The study is about advantages of aluminium formwork and tunnel formwork with conventional system in terms of cost and quality analysis. Traditional approaches can't keep up the demand of infrastructural facilities with high degree of quality control & assurance. Case studies with two different technology is done, its cost and duration are compared. This study is focusses on the two different conducted on a construction site in Chennai. Further, the real time cost duration and labor savings in the use of aluminium formwork is demonstrated in a G+21, 8 tower building.*

Key Words: *Aluminium formwork, cost, tunnel formwork, comparison of quality analysis, economy, time saving.*

1. INTRODUCTION

Formwork in construction refers to the utilization of supportive structures and molds to shape concrete into desired structures. Concrete is poured into these molds, which can be constructed from various materials such as steel, wood, aluminum, or pre-made forms. A range of material options is available for constructing the formwork. The selection of formwork material is based on various factors, including cost, project requirements, and the type of structure involved. This study is to compare conventional with aluminium and tunnel specifically related to high rise building

1.1 TYPES OF FORMWORKS:

Timber has been the prevailing choice of material for formwork thus far. Nonetheless, due to diminishing forest reserves and escalating timber costs, the adoption of alternative materials like plywood and steel has gained prominence. Moreover, plastics and fiberglass have recently emerged as viable options for prefabricating formwork. The selection of material depends on factors such as the construction's characteristics, material availability, and cost. Additionally, project constraints such as overall cost and completion time significantly influence the choice of material for formwork. Timber, Steel Aluminum, Plastics, Fabric are common materials used in formwork. The formwork used in high-rise construction are timber, aluminium formwork and tunnel formwork.

1.2 ALUMINIUM FORMWORK:

The utilization of an aluminum formwork system enhances the construction's quality while simultaneously reducing both time and costs. The cost-effectiveness of the formwork becomes evident when it is utilized for numerous construction cycles. As aluminium can be used around 250 repetations. The primary drawback of aluminum forms is that once the formwork is manufactured, no changes can be made. The system typically operates on a four-day cycle, as outlined below:

Day 1 - The initial task involves erecting vertical reinforcement bars and one side of the vertical formwork for either an entire floor or a portion of a floor.

Day 2 - The subsequent step entails erecting the second side of the vertical formwork and installing formwork for the floor.

Day 3 - Involves the placement of reinforcement bars for the floor slab and the casting of walls and the slab.

Day 4 - The vertical formwork panels are removed after 24 hours, while the support props remain in place for seven days, and the floor slabs formwork remains in place for 2.5 days.

1.3 TUNNEL FORMWORK:

A tunnel is a specially fabricated structure made of structural steel, designed in the shape of an L and resembling a half-room in size. Its primary function is to facilitate the seamless pouring of reinforced concrete (RCC) walls and floor slabs, allowing them to form a unified and uninterrupted structure. Two half tunnels are combined to create a full tunnel with dimensions equivalent to that of a room. This innovative approach ensures efficient construction with a focus on speed, quality, and precision while offering the advantages of

on-site construction, flexibility, and cost-effectiveness. The slab cycle for this system is 24 hours. However, it should be noted that each tunnel is custom-made and highly modular, limiting the possibility of design changes.

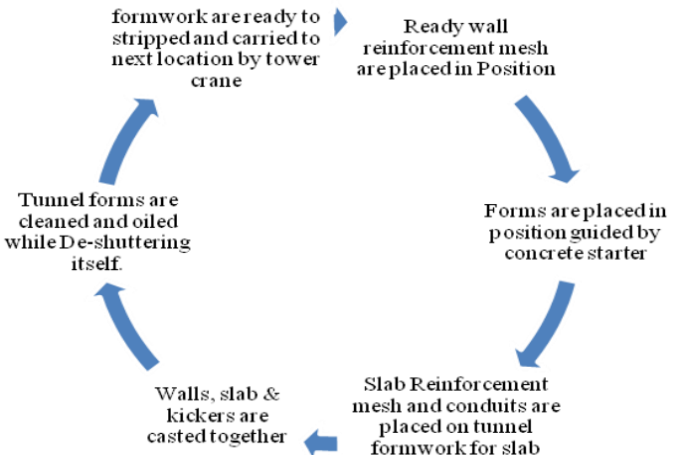

Figure 1 Tunnel Formwork Process

2. METHODOLOGY:

The study is to identify the different types of formworks used in high-rise building. The literature and net study are done to collect data about the most efficiently used formwork in high-rise. Comparative study is done between aluminium, tunnel and conventional formwork. For the proposed site aluminium formwork is implemented, its cost, quality and time schedule analysis are done and the end results are compared with conventional formwork technology.

3. LITERATURE REVIEW:

The review of journal papers involves a comparison of different types of formwork for high-rise buildings. The study suggests that, in terms of cost and availability, aluminium formwork is well-suited for construction sites in India. This is due to its design flexibility, minimal machinery usage, and the ability to utilize unskilled labor, despite having fewer repetitions compared to tunnel formwork. In contrast, tunnel formwork necessitates heavy machinery, a significant initial investment, and skilled labor. Consequently, the aluminium formwork is economically advantageous for high-rise building projects in India.

ACTIVITY	CONVENTIONAL	ALUMINIUM	TUNNEL
Capital cost	less	Cost of shuttering material is high	Cost of shuttering material and other related machinery is very high
Speed of work	slow	fast	fast
Accuracy and Quality of construction	less	Good accuracy	Good accuracy
Internal/external Plastering required	required	Not required	Not required
Cycle time of RCC work	20 days	10-15 days	1 day with proper infrastructure and other ancillary machineries
No of repetition of shuttering material	12-15	200-250	500
Cost of shuttering	Around Rs 400 to 500 / Sq.ft of shuttering floor area	Around Rs 8000 to 10000 / Sq.ft of shuttering floor area	Around Rs 12,000 to 14,000 / Sq.ft of shuttering floor area

3.1 CASE STUDY 1:

The project involves the construction of a high-rise residential building on a 3.88-acre site, consisting of 6 towers, 2 basements, stilt, and G+21 floors. The total project cost amounts to 218.72 crores, employing an aluminium formwork system.

For this project, the shear walls are 200 mm thick, while the non-shear walls are 10 mm thick. The formwork is filled with self-compacting concrete to fill the voids [4]. By utilizing thinner wall sections, the usable area is increased by approximately 5% through the adoption of shear wall systems. Additionally, maintenance costs are reduced due to improved quality and the elimination of brickwork and plaster [5]. All services are pre-planned, and the cost of construction for one floor, including the provision and laying of RCC M-30, self-compacting concrete, steel reinforcement, and aluminium formwork, amounts to 44,00,258

The construction time schedule for each floor using the aluminium formwork system is 620 days. The floor cycle is 4 days per floor, employing a box-type framework structure. The dimensional accuracy is high, and the surface finish allows for direct painting after putty application. From an economic perspective, the fund flow associated with the aluminium formwork system is favorable. The waste production when using aluminium formwork is moderate, and the formwork can be repeated up to 200 times.

3.2 CASE STUDY 2:

The project entails the construction of a high-rise residential building on a 3.88-acre site, comprising 3 towers with G+18 floors. The total project cost amounts to Rs. 117,32,17,750, employing the tunnel formwork system.

Considering the project's location in the bustling premium residential hub of Chennai metropolitan city, three distinct unconventional formwork technologies have been adopted to leverage their specific advantages [11]. While tunnel formwork allows for the construction of large, multi-story, and cellular structures [9], the project's cost increased due to the utilization of expensive equipment and skilled labor. However, tunnel formwork lacks the design flexibility necessary for incorporating basement floors in the towers, making it less preferable for efficient high-rise building construction when compared to aluminium formwork.

4. PROJECT PROPOSAL: DOSHI RISINGTON:

Figure 2 Site Map

The proposal for Phase 2 construction in DOSHI RISETON suggests the utilization of aluminium formwork, as outlined in the provided table. The conventional construction approach for Phase 2 involves approximately 10 towers, encompassing 2 basements, stilt, and G+21 floors.

By adopting the aluminium formwork system, different design phases within each tower can be efficiently executed. The estimated time duration for the conventional method is around 3 years, whereas aluminium form construction offers the advantages of high-quality construction, increased speed, and reasonable cost [5]. This technology holds significant potential for addressing India's growing population's need for affordable housing.

Moreover, the number of repetitions with aluminium formwork increases, making the initial investment more profitable [5]. Unlike the conventional method where the number of repetitions is lower, leading to an increase in cost per square meter after the 16th floor slab cycle. This includes rising costs for shuttering formwork, brickwork, and plastering. The break point for the aluminium formwork occurs after the 16th floor of the tower, and repetitions continue for the remaining part of the tower, ensuring a profitable initial investment..

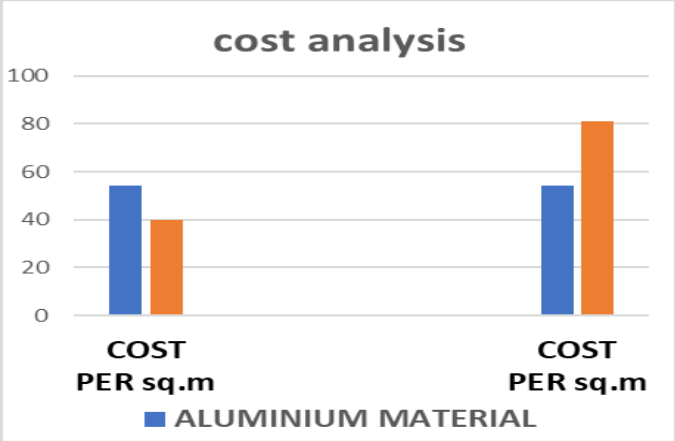

Figure 3 Cost Analysis

Time schedule for 1 floor using aluminum formwork:

INSTALLATION OF ALUMINIUM OF PRE-CONCRETE ACTIVITIES		
SI.NO	**PROCESS**	**DURATION (HOURS)**
1	level surveys	5
2	setting out data	5
3	control of deviations	5
4	enforcement wall panel	15
5	enforcement column panel	5
6	enforcement staircase panel	3
7	enforcement beam level	10
8	enforcement slab level	20
9	setting kickers	10
10	lay oil at the panel & kickers	9
ERECTION OF ALUMINIUM OF POST-CONCRETE ACTIVITIES		
11	erection wall and column panel	10
12	erection beam and slab panel	15
13	clean, transport and stack panel	10
14	erection of kickers	10
	TOTAL DURATION	132

The duration for 1 floor of 870 Sq.m is 132 hrs. using aluminium formwork. It takes about 126 days approximately to complete tower A.

Time schedule for 1 floor using conventional formwork:

INSTALLATION OF CONVENTIONAL FORMWORK OF PRE-CONCRETE ACTIVITIES		
SI.NO	**PROCESS**	**DURATION (HOURS)**
1	level surveys	15
2	setting out data	5
3	control of deviations	10
4	enforcement wall wood	150
5	enforcement column wood	80
6	enforcement staircase wood	60
7	enforcement beam wood	75
8	enforcement slab wood	75
9	setting- up other components	100
10	lay oil at the panel & kickers	25
ERECTION OF CONVENTIONAL FORMWORK OF POST-CONCRETE ACTIVITIES		
11	dismantle wood column	15
12	dismantle wood wall	50
13	dismantle wood beam	20
14	dismantle wood slab	40
15	dismantle other components	25
16	clean up leftovers	20
	TOTAL DURATION	**765**

The duration for 1 floor of 870 Sq.m is 765 hrs. using conventional formwork. It takes about 651 days approximately to complete tower

5. CONCLUSIONS

The aluminium formwork presents a favorable option for achieving timely completion of construction with maximum efficiency. Gathering information from literature and case studies will prove beneficial for selecting the appropriate formwork in future projects. Additionally, this approach helps minimize construction waste associated with formwork usage.

Although the aluminium system formwork incurs a higher initial cost, it demonstrates its cost-effectiveness when the number of repetitions falls between 150 and 200 in the construction of high-rise buildings. In contrast, employing contemporary conventional formwork, which is the least expensive type and requires more time, results in the highest total expenditure. For the proposed site, utilizing conventional formwork leads to a 25% reduction in both cost and time.

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