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Evaluation of Different Kinds of Formwork Systems in Indian Construction Industry

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ABSTRACT

In the construction industry, formwork plays a critical role in the construction of cast in situ reinforced concrete structures. Due to the rapid growth of the Indian economy, population growth, urbanization, and industrialization, the demand for housing and other built structures is increasing. To meet these requirements, quick construction is needed with less project completion time. The conventional system of formwork comprises nearly 50% of the total project completion time. Wastage and labour requirement is also high in conventional formwork systems. So, the use of modern formwork systems like aluminium formwork, tunnel formwork, etc., is increasing in the Indian construction industry. This paper aims to discuss and evaluate the various formwork systems available, and to show their impact on project duration, cost, quality, cycle-time, number of repetitions, labour requirements. Through literature review, data about various formwork systems available all over the world are collected. The current practices in India are known from various stakeholders through a questionnaire survey. Data analysis will be done using the data collected from the literature review and the questionnaire survey. The research will highlight the benefits and comparison of various types of formworks in terms of project duration, cost, quality, cycle-time, number of repetitions, labour requirements. This study concluded that implementing the modern formwork systems will improve the quality, safety, efficiency and minimise the cost and waste in construction.

Keywords-- Conventional Formwork, Modern Formwork Systems, Fast-Track Construction, Comparison, Indian Construction Sector

I. INTRODUCTION

The formwork system plays a vital role in construction, and choosing the right formwork system can result in sustainable construction. Formwork is used to provide temporary support for the concrete until it can stand on its own. This conforms the concrete to various types of formwork used in construction, which varies according to the needs of the project. Concrete is poured into formworks, which are commonly made of steel, wood, aluminium, prefabricated forms, etc. The key considerations influencing the choice of formwork for high-rise buildings are time, cost, and quality [1]. In the conventional formwork style, timber and steel boards, as well as the supports, are used. People are now using plywood boards instead of timber and steel probes with jacks to assist them in their construction. Small formwork units were then discovered and used in the construction. As traditional formwork systems are being replaced by advanced ones, the need for the newly emerging type of formwork systems is increasing. These formwork systems must be strong enough to support loads, retain shape, and be free of leaks, and the material used for formwork must be inexpensive, readily available, and reusable. Thus the advantages and disadvantages of formwork design selection are determined by the type of project and project specifications. Formwork construction should be a cost-effective technique for large and repetitive projects. Formwork should be a quick construction procedure that requires a lot of speed. At the lowest possible cost, formwork construction has to provide high construction efficiency with low maintenance [1]. The major goal of this research is to compareconventional and modern formwork systems in terms of cost, time, and other parameters.

1.1 Objectives

- The primary goal of this research is to identify the critical factors that influence the choice of various formwork systems.
- A survey of numerous stakeholders concerning various types of formworks is undertaken, with a focus on important variables such as quality, cost, repetition, cycle time, and other criteria.

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II. METHODOLOGY

Data on various formwork systems from various recent literature sources are collected and reviewed. This study involves an evaluation of the conventional formwork and modern formwork techniques to find out the suitability of various formworks in the RCC construction of mass projects. The entire procedure is made up of a series of steps that must be completed in order. It begins with a review of the literature to determine the many elements to be addressed before the selection of formwork and the preparation of questions for the questionnaire survey. In addition, the questionnaire will deliver to several stakeholders in construction in various regions throughout India. Identifying the weight assigned to various elements during the formwork selection process, such as cost, quality, safety, cycle time, etc., Data analysis is done using the literature review and questionnaire survey. Conclusion and recommendations are drawn from the analysis, thereby the suitability of different types of formwork systems in RCC construction of mass projects is found.

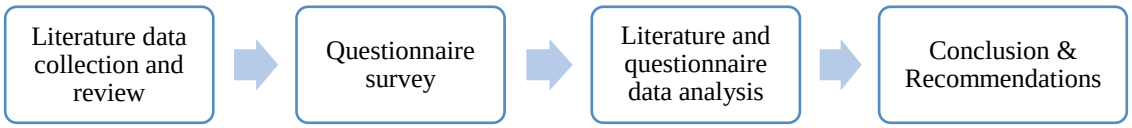

Figure 1: Methodology flow diagram

III. LITERATURE REVIEW

An effective formwork system should meet certain requirements. The formwork must be able to withstand all acting loads, ramming and vibrating forces, and other unintended loads during and after the concrete casting process [2]. Before or during concrete placement, proper precautions should be taken to avoid any formwork breakdown. To prevent cement slurry leakage, formwork should be sufficiently resistant to minimise unnecessary deflection and joints should be tightly butted. Formwork must be built in such a way that the finished concrete product is in the proper position and has the proper shape and dimensions. To obtain good concrete quality and surface polish, the formwork surface should be treated with suitable mould oil. Formwork panels should be built in such a way that their size is not increased thereby handling them manually or mechanically would be easy [3]. Furthermore, all formwork should be erected for easing, minor changes and hitting without harming the concrete. Ascertain that there is an adequate supply of formwork for the size of the workforce, the stated time schedule, and the flow of materials.

3.1 Conventional Formworks

3.1.1 Timber Formwork

It is the construction industry's earliest formwork system. Wood and plywood are used to construct this sort of formwork. The advantages of this formwork type include a low initial cost, a low experience factor, and a lightweight, while the cons include a high floor cycle, a bad finish, and a high labour need. This style of formwork has a simple manufacturing procedure, but it takes longer to install and has a short lifespan. This method is cost-effective for small-scale projects with limited reusability. Good for tight site settings where storage space is limited and crane use is problematic. This formwork is ideally suited for two or three storey structures, and it has been used for similar constructions today. This type is not suitable for major projects or high-rise constructions. The main problem of this formwork is that it loses its shape when severe loads are applied, and it absorbs concrete water, reducing concrete strength. With traditional formwork, the cycle time for one level is at least 3-4 weeks [4]. In order to achieve the finished surface, block or brickwork, as well as plastering, are required. This necessitates more time and specialized labour. This, in turn, lengthens the time it takes to complete the project.

3.1.2 Steel Formwork

Typically employed in large construction projects or where the same shuttering may be reused in huge quantities. It is utilised for buildings such as drainage tunnels and wall retention and is ideal for round tanks, columns, chimneys, and so on. This product is strong, long-lasting, and has a longer lifespan [5]. Labour costs can be reduced if steel is installed and removed with greater ease and speed. By not absorbing concrete water and eliminating honeycombing, there is no danger of formwork. Panels constructed of flat steel plates with simple metal angles strengthening the corners make up this system. The panel units can be held together using suitable clips or fasteners. In large quantities, the panels can be manufactured in any modular size or shape. Steel forms are frequently used in major projects or in instances where the shuttering can be reused. This type of shuttering is best suited to structures that are circular or curved.

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3.2 Modern Formworks

3.2.1 Need for Modern Formwork Systems

Wooden scantlings and timber runners were used in the first formwork systems because they allowed for easy forming and building on site. These wooden scantlings and timber runners, on the other hand, lose their dimensional and structural properties over time and with repeated use, posing a safety risk. Because of poor formwork and scaffolding, many accidents occur in the Reinforced Cement Concrete (RCC) building industry. Modern formwork systems are created with speed and efficiency in mind. They're meant to maximise accuracy and save waste in buildings, and most come with built-in health and safety precautions.

3.2.2 Aluminium Formwork System

In India, the Aluminium Formwork System, a relatively new technique, saves time, money, and improves building efficiency. The aluminium formwork system is very cost-effective for repetitive building designs. It is one of the techniques that has been deemed especially well suited to the circumstances of mass construction in India, where good quality and speed are needed. This system is faster to construct than most other construction techniques. Labour efficiently employs this method to ramp up construction while still assuring quality control and longevity. Any form of building condition or component, such as large windows, staircases, balconies, and other architectural elements, can be constructed with aluminium Formwork panels [6]. There is no need for brickwork. It creates a solid finish, eliminates the necessity of external and internal plastering, and enables immediate painting with a minimal skimming coat, which all result in long-term cost savings.

Figure 2: Aluminium formwork system

3.2.3 Tunnel Formwork System

The tunnel formwork is a space metal formwork that is used to pour monolithic buildings in a continuous pour, such as RCC sidewalls and slabs. Thermal curing is a technique for speeding up the curing of concrete in tunnel forms that are heated by hot air blows [7]. Only vast numbers of similar modules and tall structures, such as skyscrapers, make this approach cost-effective. The placement of reinforcement is followed by the installation of electrical and sanitary conduit fittings, as well as tunnel forms. After the concrete is poured, gas heaters are installed inside the shutters, and the open face of the shuttering is covered with heat-resistant curtains. Using tower cranes, the forms are then removed and repositioned on the next storey or next side, as needed. Tunnel form can be used to its full potential in very tall structures with identical floor layouts or massive projects with identical units to be built.

Tunnel form systems are not only simple to reuse and cleanse, but they also enable high quality surface finishes. Engineers can also rest confident that buildings will be dimensionally accurate. Another advantage of this sort of formwork system is the repeated nature of the building work, which adds to the other advantage of just requiring a small workforce on site. Room widths ranging from 2.4 to 6.6 metres can be accommodated using the tunnel form. A mid-span table is incorporated between the tunnels when the room is wider (up to 11m). The half tunnel is the system's most important component. The half tunnel is made entirely of steel, including the form's face, and provides the stiffness and flat surface required to consistently produce a high-quality concrete finish.

Figure 3: Tunnel formwork system

3.2.4 Table Formwork System

A table form, sometimes known as a flying form, is a large preassembled formwork and falsework unit that can often be used to form a whole bay of suspended floor slab. The machine needs enough room to float the table unit beyond the building perimeter on a daily basis during the new development. The supporting slab at bearing locations must be able to handle heavy loads. It is appropriate for the flat slab, beam, and slab patterns because of its versatility and easy installation in building projects with proper layouts or long repetitive structures. Residential apartment units and commercial buildings are two examples of application areas. Apart from the high-quality surface finish, the constructed parts may be transported easily, ensuring quick construction. Furthermore, when compared to the traditional formwork technologies that were previously employed, the waste generated is insignificant. Another important thing to consider is that the table formwork technique saves time, which translates to cost savings, especially in the case of constructions with flat slabs. Furthermore, because of the

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designed structure of the formwork and the repeating process, there is essentially no waste.

Figure 4: Table formwork system

3.3 Comparison of Different Formwork Systems

Table 1: Comparison of different formwork systems [1], [8]

Parameters	Timber formwork	Steel formwork	Aluminium formwork	Tunnel formwork	Table formwork
Primary investment	Less	Less	High	High	High
Repetition cycle	9	30	100	150	150
Casting cycle time for 100sq.m (days)	5	4	2	1	1
Strength (KN/sq.m)	30	30	80	70	70
Longevity	Less	Less	High	High	Medium
Surface finish	Rough	Medium smooth	Fair smooth	Medium smooth	Medium smooth
Proper planning	Not needed	Not needed	Needed	Needed	Needed
Construction accuracy	Less	Less	High	High	High
Training	Not needed	Not needed	Needed	Needed	Needed

3.4 Need for Fast Track Construction - Current Housing Scenario in India

The progress made by a country's building industry can be used as a gauge of that country's growth. Another index may be the number of pucca dwellings built in any country. While India's housing stock has continuously risen after independence, it has not kept pace with the country's rising population. Due to this, the housing crisis is worsening, and the situation in major cities has deteriorated. The country's population was 1210.98 million in 2011, with 377.10 million (31.16 percent) living in urban areas. From 2001 to 2011, India's city's population grew at a CAGR of 2.8 percent, resulting in a rise in urbanisation from 27.81 percent to 31.16 percent [9]. The increasing concentration of people in metropolitan areas has resulted in land shortage. Due to these concerns, there is currently a major imbalance between housing demand and supply in urban India. The country's housing shortage was estimated to reach 24.71 million for 66.3 million families by the end of the tenth five Year Plan, according to projections from the ministry's technical section [9]. According to the group, dwellings for Economically Weaker Sections (EWS) account for 88 percent of the shortage, 11 for lower income groups (LWS), and 0.04 million for both middle and high income groups.

3.5 Factors Influencing the Selection of Formwork

3.5.1 Safety

Formwork safety is a serious problem nowadays, particularly in high-rise construction and massive infrastructure projects such as metros, flyovers, and bridges. The fact that safety levels are so low in comparison to international standards is well recognised. Safety should not be considered a distinct entity, but rather an integrated aspect of the formwork system. Because they are utilised for rebar and concreting, formwork and scaffolding are key factors to construction site safety. The following are the several areas of safety that must be focused on and integrated with formwork: Erection and dismantling of formwork, access (both vertical and

horizontal), working platforms - lifelines and safety catch nets, Formwork storage and maintenance, simple tools and tackles, and design and engineering.

3.5.2 Cost

To complete the project on schedule and at a reasonable cost, a sophisticated formwork system is required. The modern formwork system, on the other hand, is more expensive than the traditional technique [3]. As a result, engineers must carefully calculate the cost of formwork for each project. Because of issues such as formwork efficiency being connected to subsequent and preceding activities, idle at job sites, and poor planning, the time-bound costing technique results in greater formwork expenses, particularly on materials, for no fault of the formwork.

3.5.3 Quality

Standardization of various formwork systems also has to consider. We can't afford to have many systems on the work, which produces a slew of complications in terms of both usage and accountability. Formwork systems should be standardised so that a single system can be used for a variety of structural parts and projects. Despite its limits, standardisation can be done to a degree that decreases the number of components in a system, increases the efficiency of the components involved, and increases the flexibility in how these components are used (in terms of sizing and detailing).

3.5.4 Sustainability

Rapid industrialisation, population development, and urbanisation have depleted the planet's non-renewable natural resources while simultaneously causing catastrophic global warming. Corporate Social Responsibility (CSR) is the cornerstone of the majority of the world's leading corporations and industries' existing and future corporate ethics and ideals. This facet of the Green Concept and Sustainability is now given no weight. In the future, our strategy should be "Greener Formwork Systems" in order to contribute to environmental improvement [3]. The creation of a long-term formwork system could lead to more eco-friendly buildings and improve the construction industry's ability to retain long-term viability for subsequent generations.

IV. RESULT & DISCUSSIONS

The questionnaire was sent to 150 stakeholders approx. in whom 72 people gave their responses; hence the response rate for this survey is 48%. The responses were from various experienced stakeholders like designers, contractors, clients, consultants. From few stakeholders, a telephonic survey was conducted to know about their awareness of different kinds of formwork systems in India and the factors influencing the selection of formwork systems.

Table 2: Questionnaire survey weightage results

Questions	Responses in %		
	Yes	No	May be
1. Have you heard about the following types of formworks?			
a. Timber formwork	97%	3%	-
b. Steel formwork	99%	1%	-
c. Aluminium formwork	53%	47%	-
d. Tunnel formwork	35%	65%	-
e. Table formwork	28%	72%	-
2. Have you used any of the following types of formworks in your project?			
a. Timber formwork	56%	44%	-
b. Steel formwork	70%	30%	-
c. Aluminium formwork	21%	79%	-
d. Tunnel formwork	6%	94%	-
e. Table formwork	3%	97%	-
3. What are the factors you consider during the selection of formwork for your project?			
a. Cost	42%	-	-
b. Cycle-time	7%	-	-
c. Quality	20%	-	-
d. No. of repetitions	6%	-	-
e. Safety	14%	-	-
f. Labour availability	8%	-	-
g. Hoisting technique	3%	-	-

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4. which type of formwork do you prefer for a normal residential building?			
a. Timber formwork	29%	-	-
b. Steel formwork	62%	-	-
c. Aluminium formwork	7%	-	-
d. Tunnel formwork	0%	-	-
e. Table formwork	2%	-	-
5. which type of formwork do you prefer for high rise building/ mass projects?			
a. Timber formwork	5%	-	-
b. Steel formwork	21%	-	-
c. Aluminium formwork	44%	-	-
d. Tunnel formwork	13%	-	-
e. Table formwork	17%	-	-
6. Which one will cost less for a normal residential building?			
a. Conventional formwork	71%	-	-
b. Modern formworks	29%	-	-
7. Which one will cost less for a high rise building/ mass projects with more no. of repetitions?			
a. Conventional formwork	16%	-	-
b. Modern formworks	84%	-	-
8. Do you think that use of modern formworks minimises waste in a project?	64%	29%	7%
9. Are you aware of the recycling of formworks?	43%	57%	-
a. If yes, will you use this concept in your present/near future projects?	24%	28%	48%
	Agree	Neutral	Disagree
10. What are the barriers for adopting modern formwork systems in any project?			
a. High initial investment	53%	35%	12%
b. Lack of awareness	71%	23%	6%
c. Resistance to change	48%	27%	25%
d. Lack of standards	42%	30%	28%
e. Complexity in design	35%	17%	48%
f. Need of skilled labours	41%	33%	26%
11. What are the significant enablers for adopting modern formwork systems in any project?			
a. Awareness programs	81%	17%	2%
b. Proper training for labours	67%	18%	15%
c. Best practice case studies	47%	25%	28%
d. Framing of standards & guidelines	51%	35%	14%

From the questionnaire survey, perspectives of various stakeholders about the different kinds of formwork systems are captured. One of the major issues is, most of the stakeholders not aware of the modern formwork systems. It was found that 62% of stakeholders were not aware of the modern formwork systems and 90% of stakeholders not used modern formworks in their project. Also, it was found that 42% of stakeholders considered cost as major criteria during the selection of formwork, next to the cost, quality & safety are there, whereas very few percentage of stakeholders only considered other important criteria's like labour availability, cycle-time, number of repetitions, hoisting technique during the selection of formwork. Stakeholders are clearly aware that modern formworks should be more effective for high rise buildings/ mass projects than small scale projects. Also, the stakeholders' response for barriers and enablers for adopting the modern formwork systems are mentioned in Table-2. From the literature review, comparison of different formwork systems, factors influencing the selection of formwork, current housing scenario in India and need for fast-track construction were analysed.

V. CONCLUSION

Several formwork systems provide a number of concrete construction alternatives that can be tailored to match the needs of a specific project. In the past, bespoke formwork for concrete construction was common, necessitating the expertise of skilled craftsmen. These types of formworks usually lacked safety features, resulting in slow on-site construction rates and huge waste, making them expensive and unsustainable. Modern formwork systems are designed for speed and efficiency and are essentially modular. They're made to increase accuracy and reduce waste in structures, and many have built-in safety and health features. On the basics of the result obtained, Aluminium and tunnel formwork are the two main modern techniques in use in India, in which people are well aware about Aluminium formwork and many buildings in India started using it. Despite the expense and duration, many choose conventional ways because they believe advanced methods are more expensive, however advanced methods are used in India for large construction projects. This study concluded that implementing the modern formwork systems will improve the quality, safety, efficiency and minimise the cost and waste in construction. However, due to lack of expertise and qualified workers, executing these modern formwork systems on construction sites is far from satisfactory. Enablers like awareness programs, proper training for labours, Framing of standards and guidelines will encourage the use of modern formwork systems in the Indian construction industry.

REFERENCES

[1] M. S. Gaddam & A. Achuthan. (2020). A comparative study on newly emerging type of formwork systems with conventional type of form work systems. *Mater. Today Proc.*, *33*(xxxx), 736–740. DOI: 10.1016/j.matpr.2020.06.090.

[2] S. S. Asadi & P. V. Praneeth. (2017). A comparative study for evaluation of different form work systems utilization in construction projects. *Int. J. Mech. Eng. Technol.*, *8*(11), 21–29.

[3] *Government of India Minstry of Railways Works Directorate, "Modern Formwork Systems*, pp. 1–27, 2017.

[4] R. Hangarge, A. Waghmare & S. Patil. (2017). Comparison conventional, aluminium and tunnel formwork. *Int. J. Sci. Res. Publicartions*, 7(1), 176–181. Available at: http://ijaresm.net/Pepar/VOLUME_2/ISSUE_4/3.pdf.

[5] N. Parekh, B. M. Marvadi & U. Patel. (2015). Comparative studies of construction (Conventional technique Vs Aluminium formwork techniques). *J. Information, Knowl. Res. Civ. Eng.*, 3(2), 279–287, 2015.

[6] K. Loganathan & K. E. Viswanathan. (2016). A study report on cost, duration and quality analysis of different formworks in high-rise building. *Int. J. Sci. Eng. Res.*, *7*(4), 190–195.

[7] T. D. A. (2016). Study of advanced tunnel formwork system in high rise building. *Int. J. Res. Eng. Technol.*, *05*(05), 529–533. DOI: 10.15623/ijret.2016.0505100.

[8] A. K. (2015). Comparative study and decision making for a formwork technique to be adopted on a construction site in Mumbai. *Int. J. Res. Eng. Technol.*, 04(12), 234–238. DOI: 10.15623/ijret.2015.0412045.

[9] R. Thiyagarajan, V. Panneerselvam & K. Nagamani. (2017). Aluminium formwork system using in highrise buildings construction. *Int. J. Adv. Res. Eng. Technol.*, *8*(6), 29–41.