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Design and Analysis of Various Formwork Systems

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Abstract:- Concrete is a fundamental material in the construction industry, with formwork playing a crucial role in shaping and strengthening concrete elements. It also represents a significant cost in building projects. The history of formwork is extensive, and diverse systems have been employed across various projects. When selecting a formwork system, considerations such as safety, cost, structural requirements, construction duration, and environmental impact must be carefully weighed.

This project provides a comprehensive review of different formwork systems used in concrete construction, encompassing their materials, flexibility, fabrication methods, application in structures, and environmental implications. The advantages and limitations of these systems are analysed and compared, culminating in practical recommendations.

Formwork systems are pivotal in determining the success of construction projects in terms of efficiency, quality, cost-effectiveness, and safety. Recent innovations, particularly modular formwork systems, have revolutionized the construction industry in countries like Japan, Singapore, Malaysia, and the Middle East. These systems have proven to be cost-effective, enhance construction quality, and accelerate project timelines. Their adaptability makes them particularly suitable for mass construction projects in India, where achieving high-quality, rapid construction is crucial.

By leveraging modern formwork technologies, construction practices can achieve safer, faster, and more sustainable outcomes, aligning with advancements in concrete materials and construction methodologies.

Keywords:- *Formwork; High-Rise Building; Climbing Formwork; Constructability.*

I. INTRODUCTION

As urban areas face increasing space constraints, the construction of high-rise structures has become commonplace. Globally, many high-rises are constructed using steel, whereas in India, reinforced cement concrete (RCC) predominates. Despite advancements in construction techniques, mechanization has been limited due to the availability of abundant semi-skilled labour. While concrete manufacturing in urban areas has largely mechanized, progress in formwork technology has been comparatively slower.

Formwork is essential in construction, involving support structures and Molds that shape poured concrete into desired structures. Materials such as steel, wood, aluminium, and prefabricated forms are commonly used to create these, Molds. Once the concrete sets, the formwork is removed in a process known as stripping, with reusable forms termed panel forms and non-reusable ones referred to as stationary forms.

For high-rise projects, formwork and concreting are significant cost factors. The evolution of construction practices in urban India underscores the importance of addressing these challenges to optimize efficiency and cost-effectiveness in high-rise construction.

A. Historical Development

Traditionally, multi-story buildings used wooden formwork, but urban space constraints have led to taller structures being built. With the popularity of multi-story construction, formwork evolved to include plastic-coated or marine plywood, supported by wooden props, to handle greater repetitions. As sand shortages and cost increases emerged, the concept of form finish for RCC members gained traction. Large plywood sheets with telescopic spans and wooden or steel props became common.

However, as raw material costs rose and repetition limits became apparent, steel plates and adjustable steel props were introduced, proving effective up to G+7 floors. Yet, with taller buildings, the costs of formwork units and transportation escalated. Despite mechanization in concrete production, advancements in formwork for buildings lagged. Many areas still rely on conventional formwork systems, though modern alternatives are increasingly used for high-rise and diverse structure constructions.

It's crucial to raise awareness of these modern formwork systems among young engineers, practicing architects, and government bodies. In the following sections, we will explore various formwork systems, discussing their advantages and disadvantages.

B. Formwork Practice in India

System formworks are constructed from prefabricated modules, typically consisting of standard timber beams combined with metal frames and patented plywood sheathings. Since 1980, there has been significant improvement in system formwork due to advancements in

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forming technology and fabrication processes. Innovative materials like plastic, FRP (Fiber Reinforced Polymer), aluminium, among others, have emerged as alternatives to traditional timber components.

These advancements have enhanced the efficiency, durability, and flexibility of formwork systems, allowing for greater versatility in construction projects. The integration of new materials has also contributed to reducing costs and addressing environmental concerns associated with timber usage as shown in Fig 1(b).

Fig 1: (a) Conventional Formwork System (b) System Formwork

➢ *The Two Major Advantages of System Formwork Over Conventional Timber Formwork Systems are as Follows*

- Speed of construction (reduced time in assembly and stripping).
- Lower life-cycle costs (maximum number of re-use).

II. TYPES OF FORMWORKS

A. Conventional formwork:

On-site formwork is typically constructed using timber and plywood, or moisture-resistant particleboard. While it is easy to produce, it can be time-consuming for larger structures, and the plywood facing tends to have a relatively short lifespan. Despite these limitations, on-site formwork remains widely used in regions where labor costs are lower than the expense of procuring reusable formwork. Its flexibility also makes it suitable for complex sections, even in areas where other formwork systems are employed.


Fig 2: Conventional Formwork

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B. Modern-Day Formworks:

These formwork systems are predominantly modular, engineered for rapid deployment and efficiency. They are crafted to enhance precision, reduce construction waste, and often incorporate advanced health and safety measures. The primary types of formwork systems currently in use include:

- Table form/flying form
- System column formwork
- Horizontal panel
- Slip form.
- Tunnel form

Fig 3: Table Form/Flying Form

Fig 4: System Column Formwork

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Fig 5: Horizontal Panel

Fig 6: Slip Form

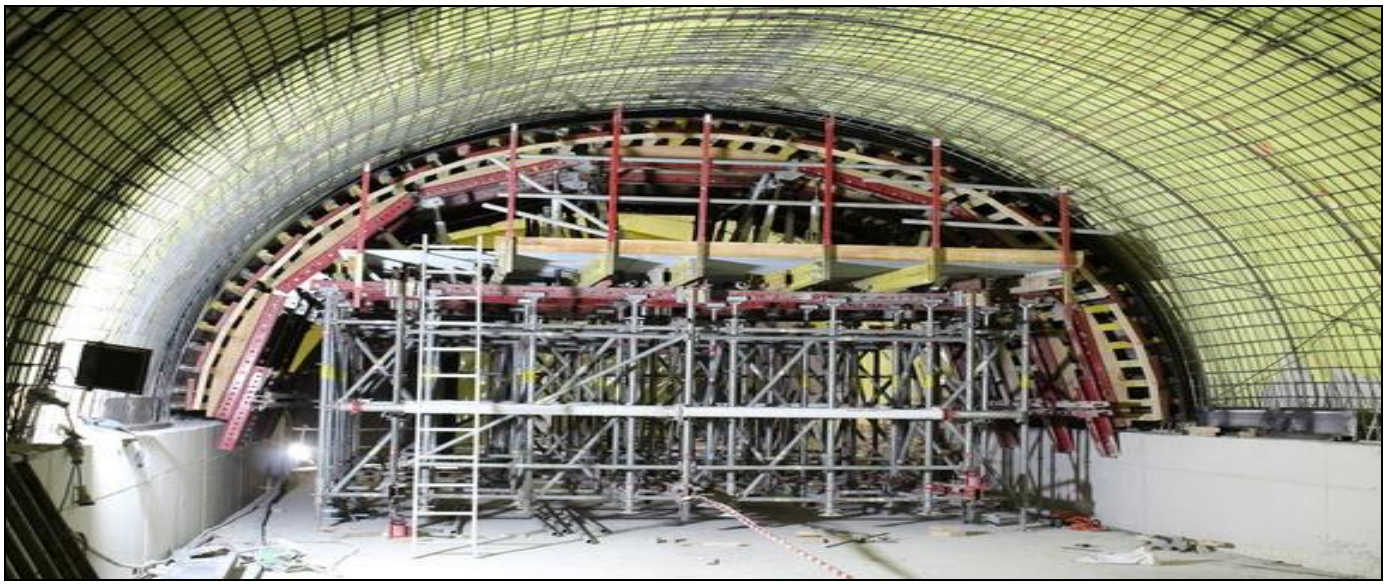

Fig 7: Tunnel Formwork

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Fig 8: Bridge Deck

C. Engineered/Prefabricated Formworks:

This formwork consists of prefabricated modules with a metal frame, typically made from steel or aluminum, and the concrete-facing side covered with materials such as steel, aluminum, or timber to achieve the desired surface structure. Compared to traditional timber formwork, formwork systems offer two significant advantages: speed of construction and lower life-cycle costs. The metal frame is highly durable and nearly indestructible under normal conditions, while the covering material—whether wood, steel, or aluminum—may require periodic replacement. Steel or aluminum coverings can withstand up to two thousand uses with proper care and maintenance, making them highly cost-effective over time.

Fig 9: Engineered/Prefabricated Formworks

III. CLIMBING FORMWORK SYSTEM

The climbing formwork is a shaping strategy for tall structures in which concrete is poured into a persistently moving formwork. The formwork is encompassed by a three-story-high stage on which laborers stand, put steel strengthening bars into the concrete and guaranteeing a smooth pour and wrap up the afterward portion of wrapped up concrete surface. The concrete shape and working stage are raised together, by implies of water powered jacks settled over rail on the outside surface.

IV. AIM

The point of the extend is almost the formwork innovation utilized in different sorts of RCC structure like tall rise building, bridges, dams, chimney, atomic control arrange etc.; by utilizing modern innovations in formwork, development can presently accomplish the casting of bigger

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components in a single pour. This progression not as it were minimizing time and labor required but moreover outflanks customary strategies. Formwork innovation is based on the taken a toll, time, and quality of extend conveyance. The consideration is almost the preferences of measured formwork with ordinary frameworks in terms of taken a toll and quality analysis.

V. CONCLUSION

Automatic climbing formwork systems offer significant advantages over other frameworks in terms of quality and maintainability. These systems are designed to enhance the efficiency and precision of construction processes, resulting in superior structural integrity and reduced long-term maintenance needs. However, despite these benefits, automatic climbing formwork frameworks tend to have notable drawbacks concerning safety compared to crane-dependent climbing systems.

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