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COMPARATIVE ANALYSIS OF VARIOUS FORMWORK SYSTEM

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ABSTRACT

As urban areas face increasing space constraints, high-rise structures are becoming more prevalent. Globally, many of these buildings are constructed using steel. However, in India, reinforced cement concrete (RCC) is the predominant material for high-rise buildings. Despite advancements in construction technologies, the availability of a large labor force and semi-skilled workers has limited the mechanization of construction activities. While concrete manufacturing in urban areas has largely been mechanized, the corresponding progress in formwork has lagged. For high-rise structures, the cost of formwork and concreting are major considerations.

Keywords: materials, formwork, high-rise structures, construction

1. INRODUCTION

1.1 GENERAL:

Day by day due to shortage of space many high-rise structures are coming into urban areas. If we study globally the construction of high-rise structures, most of them are made of steel. However, in India most of the high-rise buildings are in Reinforced Cement Concrete (R C C). Despite a lot of development in constructions, due to availability of large-scale labors and semi-skilled people mechanization of construction activities progressed only to a limited extent. In urban areas the manufacturing of concrete is largely mechanized, however matching progress in related formwork is not seen. For high rise structures the cost of formwork and concreting are the main activities.

Formwork in construction is the use of support structures and molds to create structures out of concrete which is poured into the molds. Formwork can be made using molds out of steel, wood, aluminum and/or prefabricated form. Formwork is an ancillary construction, used as a mold for a structure. Into this mold, fresh concrete is placed only to harden subsequently. The operation of removing the formwork is known as stripping. Stripped formwork can be reused. Reusable forms are known as panel forms and non-usable are called stationary forms.

1.1 HISTORICAL DEVELOPMENT: -

Conventionally for multi storied buildings wooden formwork was used. Shortage of space in urban areas forced us to go for tall structures. Day by day the height of the buildings is increasing. As the multistoried buildings construction became popular, due to a greater number of repetitions, plastic coated or formwork with marine plywood was started with wooden props. Due to the rise in price and shortage of sand, the concept of form finish for R C C members became popular. Big size plywood sheets were used for slab formwork with telescopic spans and wooden or steel props. However, due to the rising cost of raw materials and limitations of nos of repetitions, steel plates were introduced along with steel props of adjustable height. These practices were performing satisfactory for buildings up to G+7 floors. As the height of building increased, the cost of formwork units and its transportation increased. Due to mechanization in concrete production, supply, placing and finishing large volumes of good quality high strength concrete is easily available. However matching development in formwork for buildings is not seen. Many places still conventional formwork systems are used. However, many modern formworks systems are in use for high rise building and other types of structure constructions. Awareness of these systems needs to be done to young engineers, practicing architects and Government bodies. We will see the different types of formwork systems; their advantages and disadvantages will be discussed.

1.2 TYPES OF FORMWORKS: -

1.2.1 Conventional formwork:

The formwork is built on site out of timber and plywood or moisture resistant particleboard. It is easy to produce but time-consuming for larger structures, and the plywood facing has a relatively short lifespan. It is still used extensively where the labor costs are lower than the costs for procuring reusable formwork. It is also the most flexible type of formwork, so even where other systems are in use, complicated sections may use it.

Figure *Error! No text of specified style in document.*.**1**: Conventional formwork

2. LITERATURE SURVEY

Terzioglu, T., et al (2021) [1] The authors stress the importance of selecting the appropriate formwork system for successful project completion and effective construction operations. The report analyses several variables that should be considered when choosing a formwork system. Cost, construction speed, adaptability, durability, safety, and environmental effect are some of these considerations. Each element is covered in depth by the authors, who also offer information on how it affects the decision-making process.

Li, W., et al (2022) [2] It emphasizes the necessity of a methodical assessment of various formwork systems based on the noted parameters. The need to consider project-specific requirements, such as the type of structure, building process, budget, and timeline, is highlighted by them. The writers also go into the benefits and drawbacks of various formwork systems, such as conventional timber formwork, metal formwork, and modular formwork. They offer case studies and real-world examples to demonstrate how these technologies are used in building projects and how well they work.

Rane, N. L., et al (2023) [3] The importance of formwork in building and how it affects project cost, timeline, and quality are covered by the authors. Based on factors including cost, construction speed, reusability, durability, adaptability, and environmental impact, they assess various formwork methods. Case studies and examples of formwork systems, such as conventional timber formwork, metal formwork, and modular formwork, are included in the article. The writers evaluate the benefits and drawbacks of each method, considering elements like the accessibility of materials, the simplicity of construction, the stability of the structure, and the cost-effectiveness.

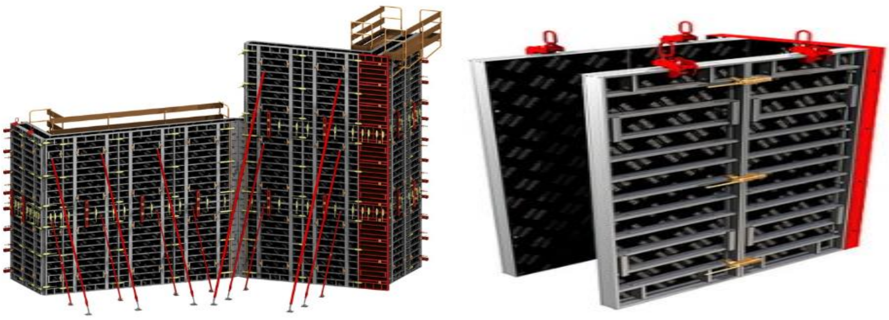
Hyun, C., et al (2018) [4] The writers also go over recent developments in formwork technology, namely precast formwork systems and lightweight materials. They draw attention to the advantages and drawbacks of these advancements, such as increased sustainability and building efficiency. The review examines and contrasts the usage of Modular formwork versus conventional formwork in buildings. The term "conventional formwork" describes the age-old practice of building forms out of plywood and wood. The writers emphasize its adaptability, affordability, and accessibility.

Sai, G. M., et al (2020) [5] On the other side, Modular formwork is a contemporary method that makes use of aluminum panels and a network of connected parts. The writers go over its benefits, which include quicker construction, lower labor costs, higher quality, and enhanced safety. These two formwork techniques are thoroughly compared in the review paper, considering things like cost, time, labor, quality, and safety. It seeks to help building professionals make educated decisions on the use of formwork techniques based on project needs.

3. METHODOLOGY

3.1 VERTICAL FORMWORK

This design note provides the calculation for vertical formwork for a retaining wall using the Alisply Manual system. The formwork is designed to support a wall height of 3.6 meters. The Alisply system is chosen for its efficiency and effectiveness in handling the specific requirements of this vertical formwork application.



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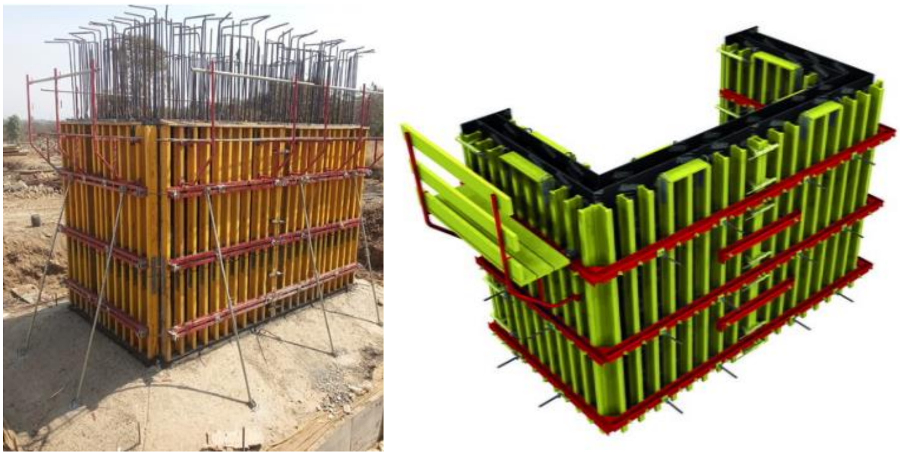

Figure Error! No text of specified style in document.**.2***:* Various Vertical Formwork System

Design data: -

Density of Concrete - 26 kN/m3 (Assume extra for safer side).

Density of steel – 78.5 kN/m3

Lateral pressure due to concrete on side shutter: - (By CIRIA Report).

Pmax**.** =

$$D[C_1 * \sqrt{R} + C_2 * K * \sqrt{(H - C_1 * \sqrt{R})}]$$

or Pmax. = DxH.

C_1 - Coefficient dependent on the size & shape Formwork.

C_2 - Coefficient dependent on the constituent material of concrete`.

K - Temperature coefficient. (36/(T+16))2, T= temp. in 0C.

R - Rate of rise in m/hr.

D - Density of concrete.

H - Vertical form height.

So lets consider,

H – 3.6 m.

R – 1.8 m/hr.

T – 25 0C

K – 0.77

C1 – 1 (For Walls)

C2 – 0.45

D - 26 kN/m3

Pmax**.** =

$$D[C_1 * \sqrt{R} + C_2 * K * \sqrt{(H - C_1 * \sqrt{R})}]$$

= 48.4 kN/m2

Pmax. = D x H = 93.60 kN/m2

Therefore, **Pmax** = **48.4 kN/m2, Say Pmax = 50 kN/m2**.

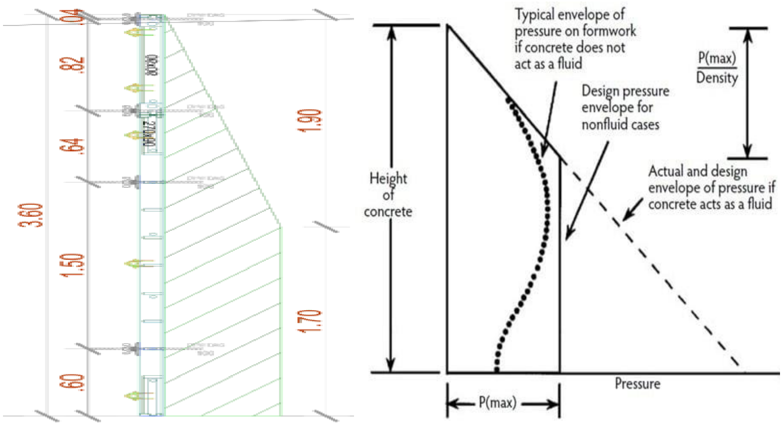

Figure Error! No text of specified style in document.**.3***:* Pressure Diagram

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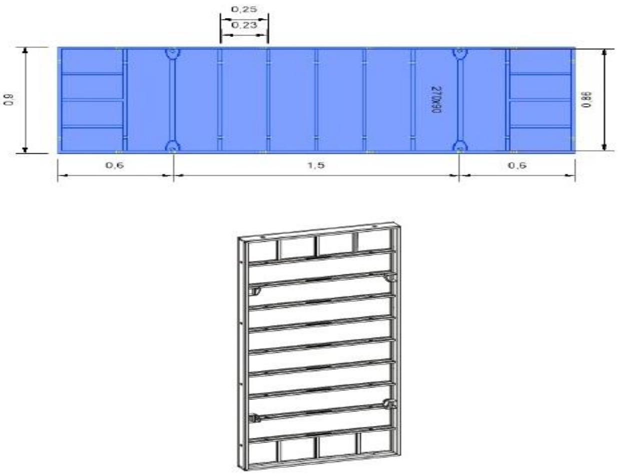
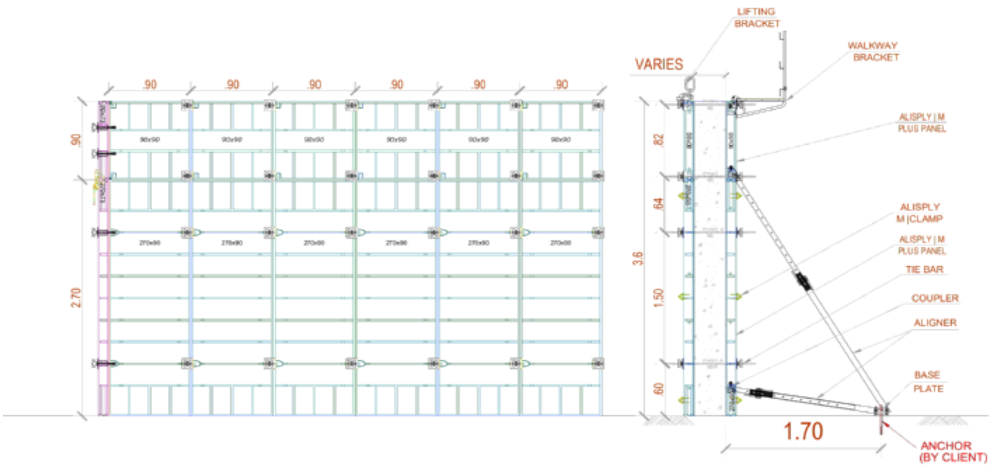


Figure Error! No text of specified style in document.**.4*:*** Panel Geometry

CHECK FOR TIE BAR:



Spacing of Tie bar in X - direction = 0.9 m (max).

Spacing of Tie bar in Y direction (1.5/2 +0.60) = 1.35 m (max).

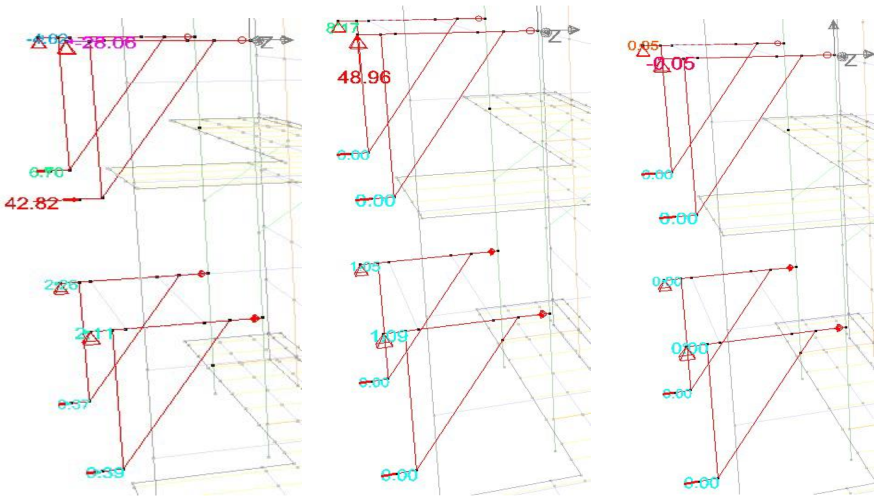
Actual Force on Tie, Fact = 60.75 kN.

Using, DYWIDAG Tie Rod 15mm dia

Permissible working Force, Fper = 90 kN > 60.75 kN

Hence Safe.

4. RESULTS AND DISCUSSIONS



Reactions Rx (SLS) in kN Reactions Ry (SLS) in kN Reactions Rz (SLS) in kN

Figure Error! No text of specified style in document.**.5*:*** Working Condition Reactions

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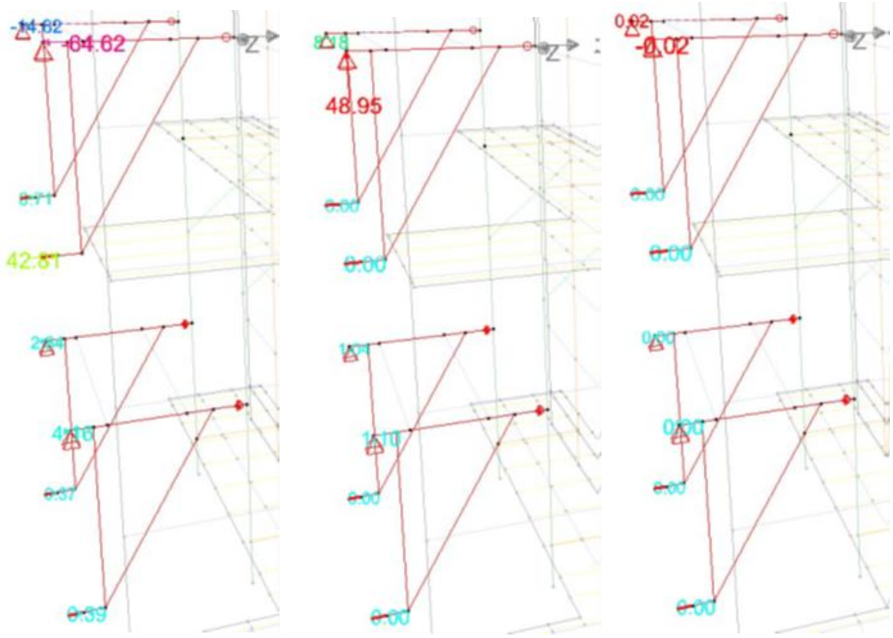
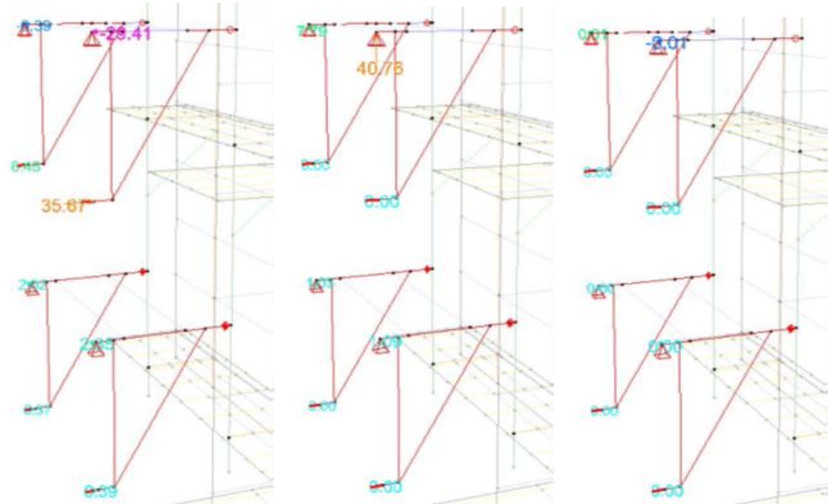


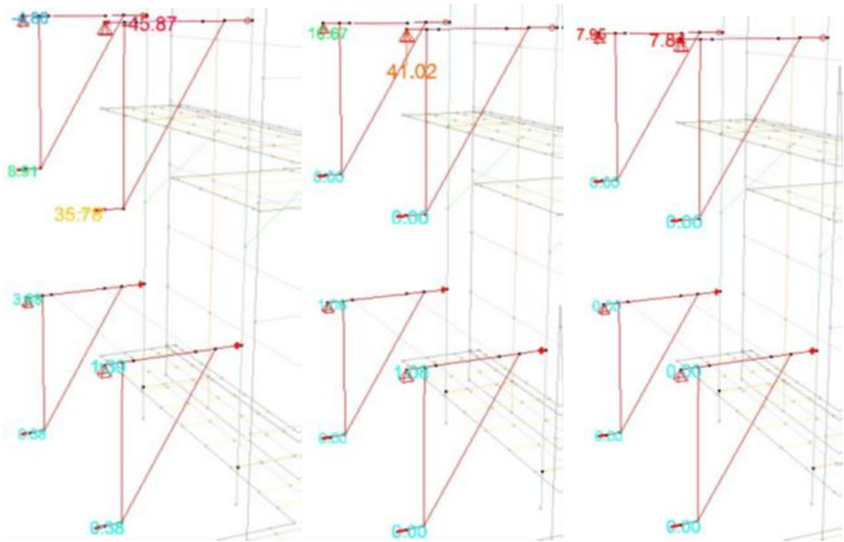
Reactions Rx (SLS) in kN Reactions Ry (SLS) in kN Reactions Rz (SLS) in kN

Figure Error! No text of specified style in document.**.6*:*** Live load and negative wind load X



Reactions Rx (SLS) in kN Reactions Ry (SLS) in kN Reactions Rz (SLS) in kN

Figure Error! No text of specified style in document.**.7*:*** Climbing Condition Reactions



Reactions Rx (SLS) in kN Reactions Ry (SLS) in kN Reactions Rz (SLS) in kN

Figure Error! No text of specified style in document.**.8*:*** Out Of Service Condition Reactions

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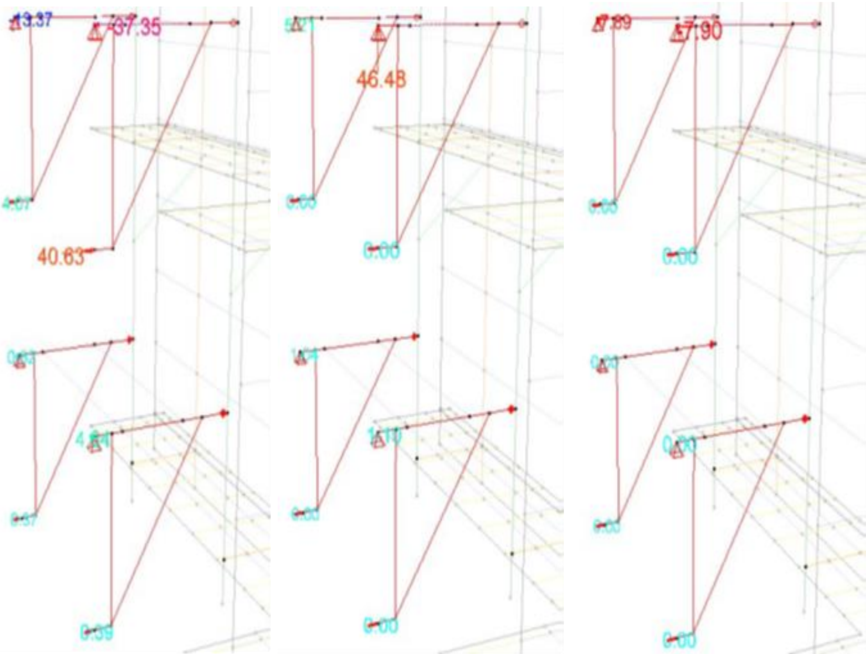

Reactions Rx (SLS) in kN Reactions Ry (SLS) in kN Reactions Rz (SLS) in kN

Figure Error! No text of specified style in document.**.9***:* Out Of Service Condition Reactions

5. CONCLUSIONS

1. Control of Pouring Pressure

The pouring pressure during the casting procedure is a critical factor that must be controlled by the site manager. It's essential to maintain this pressure below the maximum allowable limit of 60 kN/m². This is to ensure the structural integrity of the cast and prevent any potential damage. Given the specific weight of concrete is 25 kN/m³, maintaining the pouring pressure below this threshold helps in avoiding excessive force that could compromise the formwork or the concrete itself.

2. Working Load of Platforms

The platforms used in the construction process have been designed to withstand a working load of 200 kg/m². This specification ensures that the platforms are capable of supporting the weight of workers, equipment, and materials safely. Adhering to this load limit is crucial for preventing accidents and ensuring the safety of personnel on-site.

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