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Constructability Assessment of Climbing Formwork Systems Using Building Information Modeling

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Abstract

Vertical development is the ideal solution to meet the demand of land for the fast growing urban population in India. It is the construction of tall structures such as high-rise buildings, sky scrapers and sky towers etc., rather than constructing laterally to accommodate large population in quiet a lesser area. However the construction of high-rise buildings are highly complex and requires advanced construction techniques and equipment. One of the most important requirements is the advancement in forming technology. Though the conventional or traditional method of forming high-rise building is economical, it suffers seriously on the time, quality, safety and sustainability factors. Therefore, the advanced systems known as climbing formwork was introduced later. The climbing formwork is relatively new technology developed from the slipform in late 1960s. Unlike the developed countries, the practice of climbing formwork is adopted only in the specialized construction projects in India. The reason being, lack of awareness about the climbing formwork among many construction personnel and misconception about the erection and operation processes. Thus to reinforce the importance of climbing formwork in the Indian construction, a firm research is carried out on the selection and operation of different climbing formwork using constructability survey. A valid comparison of different climbing formwork with the conventional formwork is done for the lift core-wall in the 20 storey high-rise building model using Building Information Modeling (BIM). From the developed 3D BIM model, the cost, time, quality, safety and sustainability factors of both conventional and climbing formwork are explored in detail by quantitative and qualitative indices. The constructability factors associated with the conventional and different climbing formwork systems are generated.

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1. Introduction

India measures 3,214 km from North to South and 2,933 km from East to West. It has a land frontier of 15,200 km and a coastline of 7,516.5 km. It has a population of approximately 1.21 billion people (2011 Census), which is the second most populous country in the world. Although India occupies only 2.4% of the world's land area, it supports more than 17.5% (2011 Census) of the world's population. The population of India is forecast to be 1.63 billion people in 2050, which is expected to exceed China (1.4 billion people in 2050).

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For the past 30 years, unlike the rural regions, the population of urban regions is increasing rapidly due to the factors like modernization, increased employment opportunities and so on. At present, the percentage of land use in the urban regions is increasing drastically. Most of the agricultural lands are getting converted into construction grounds due to unavailability of land. This is the major setback for the sustainable development.

To cater the needs of land for the growing population, the best solution is the vertical development which is the construction of tall structures such as sky scrapers and sky towers, etc. Thus to accommodate the future growing population, there should be reduction in the lateral construction and instead vertical development is promoted. However, the implementation of vertical development is not so easy since the construction of tall structures are highly complex and requires higher degree of construction techniques and equipments and thus it could not be achieved by the present ordinary construction methods and equipments. For the construction of high-rise structures, many critical factors have to be considered and the most important factor is the formwork operation, which influence highly on the construction time, cost and profitability of the project itself.

1.1. Formwork practice in India

For many years reinforced concrete construction is predominantly followed in India, thus the formwork plays a vital role in the Indian construction. The most commonly used type of formwork systems are the traditional or conventional systems made of dressed lumber and fabricated at site during construction as shown in Fig.1(a). They are also known as as-built formwork. Currently even for construction of wide variety of structures from small to medium sized projects, the conventional formwork systems are used. Quality, safety and economy are the three objectives of formwork construction [1]. The conventional formwork systems could account only for the economy aspects of form construction, thus the modern formwork systems known as Engineered or System Formwork Systems was developed later.

System Formworks are built of prefabricated modules (standard timber beams) with the metal frames and patented plywood sheathings. Since 1980, the concept of system formwork is improving tremendously due to the advancement in forming technology and fabrication process. New and innovative materials such as Plastic, FRP (Fibre Reinforced Polymer), Aluminium, etc., are used as an alternatives for the timber components as shown in Fig 1(b).

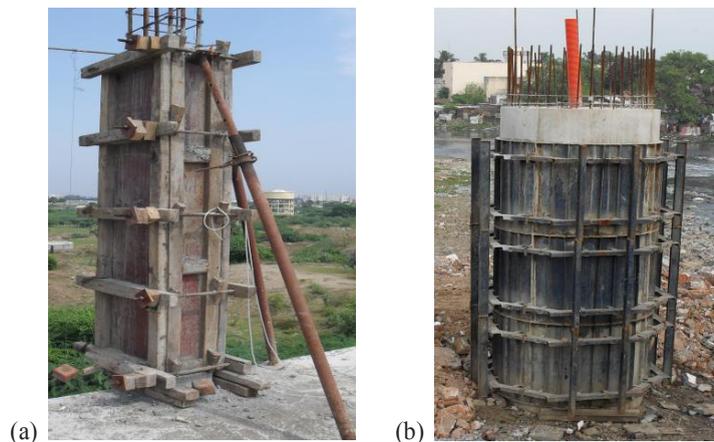


Fig. 1. (a) Conventional formwork system; (b) System formwork.

The two major advantages of system formwork over conventional timber formwork systems are as follows.

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

Though the system formwork has many advantages over traditional or conventional formwork, their usage in the Indian construction is very minimal. The reason being, lack of awareness, misconception among the Indian construction personnel, that these formworks are costlier and heavier, requirement of highly skilled labours and supervisors, requirement of specialised equipments for erection and assembly but in reality it is the most effective system [5].

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