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The Role of Advanced Construction Technology towards Speed in High Rise Construction

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Abstract **- The stage of construction is labour intensive and an important phase of the building. Transportation and use of materials, equipment and machinery and labour is required during this stage. It is a crucial task to complete the construction on time as it affects the cost as well as other factors. Since the past few years, the time required to construct a building has been decreasing. This is due to the advanced materials, mechanical equipment, machinery and technology that have made it possible. Thus speed of construction is associated with economy. As the days of construction increase, labour wages also increase along with rent of machinery, storage of materials, damage and wastage. The reason for focusing on high rise construction is due to the increasing number of high rise buildings in urban areas. Speed of construction is important nowadays to cater to increasing demands and the economy. Advanced Technology plays an important role in efficient construction on site. This paper is an attempt to understand the importance of speed of construction and the contribution of advanced materials and technology in the construction phase. Literature review and case studies reveal how advanced technology helps faster construction and enables economy.**

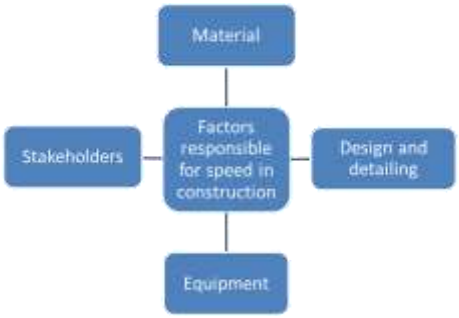
Index Terms - construction, highrise, equipment, technology

INTRODUCTION

India is a developing country with huge demand in real estate buildings. Employment is most dependent on the construction phase of the building which involves many stakeholders of knowledge, investment and work. [3] A large amount of equipment is brought on site for transportation of materials and execution of construction. Out of the key requirements as mentioned in Figure 1, Construction equipment are the most important as they are specially designed to carry out works in RCC, excavation, site modification, level construction, etc. The key aspects for these are proper maintenance, improved productivity and innovation. Proper maintenance is required to carry out works without wastage or complications. Productivity is the capacity of work the equipment can give in less time. [4] The more efficient the equipment is, the faster the work is done with better quality. Innovation is emerging day by day, new equipment made with innovation based on productivity, economy, efficiency are useful for better construction. However, innovation in material also plays an important role such as Autoclaved Aerated concrete blocks are lightweight and bigger in size thus the construction time of walls is two times more than fire bricks.

Construction equipment is specially designed to carry out construction work such as earthworks and RCC work. Innovation of equipment along with its productivity gives a good economic investment. [5] Its maintenance should be less and the amount of work done per unit should be more. The adoption of nanotechnology and the production of hybrids could be further possible directions of development.

FIGURE 1:
FACTORS RESPONSIBLE FOR FASTER AND EFFICIENT CONSTRUCTION



Referring to figure 1, four main factors are responsible for efficiency and speed in construction are; Proper design and detailing, Materials selected for construction, Equipment and stakeholders. Firstly, the planning and designing of the building should be done efficiently such as grid planning ensures proper marking on site and eliminates confusion. The detailing of each part such as architectural elements, working drawings, façade details should be given correct and on time. This factor enables efficient flow of construction in the expected time period. Materials selected should be locally available near the site. New innovative sustainable materials also save the construction time such as AAC blocks, precast concrete, panels, sustainable substitute materials, modular bamboo, and many more new innovative materials are being developed focusing on eco-friendly, sustainable and recyclable terms. Innovative equipment offers accelerated productivity per unit time, thus playing an important role. [8] Stakeholders are one of the important key roles; architects need to provide planning and design in required time, contractors must provide efficient

work and labour provision, financers and clients, engineers, supervisors, quantity surveyors, project managers, sanctioning authorities, etc. If any of one stakeholder is unable to complete the work due to disputes or any other reason. The focus of this research study is to identify how the construction time of high rise buildings has reduced over the time and what are the various challenges and future outcomes in the construction sector.
Aim: To study how the period of construction of high rise buildings has reduced due to advanced construction technology over time.

OBJECTIVES:

- Study the importance of advanced technology in construction stage
- Background of the study and interpretation from the literature review
- Case studies of high rise buildings

METHODOLOGY:

The author identifies four key factors that are important in faster construction through detailed literature review, secondary data and analysis of articles. Research papers from refereed journals and indexed publications identified appropriate outcomes. Case studies are identified and analyzed for analysis and findings. The paper identifies the key parameters of materials and equipment through literature review and qualitative analysis which are most desirable for faster construction focusing on high rise buildings. Case studies show the importance of material, equipment and stakeholders along with advanced technology has made high rise construction possible in recent years.

LITERATURE REVIEW:

H Agenbag and C Amoah, 'The impact of modern construction technology on the workforce in the construction industry' reveals that construction technology equipment offers faster construction of a huge amount of work, but labour is dependent on the construction industry for revenue, thus skilled labour is required for operating advanced machinery on site. The author conducts a questionnaire survey among contractors, project managers, engineers and professionals to find out the need and importance of advanced construction equipment in the construction sector along with its benefits and impacts.
A paper by D. B. Phadatare and S. B. Charhate titled 'Impact of Construction Equipment on Building Site Productivity' demonstrates the planning and maintenance of construction equipment for better productivity. The construction operations require a massive flow of mechanical equipment and tools. The cost required for this work has an impact of around 30% of total construction cost. The author states four types of maintenance and strategies for construction equipment. The work done daily by using equipment is planned; the methodology of the paper is qualitative research of case study of a building. The daily tasks, machinery used for construction is calculated which reveals that the most used equipment are concrete pumps, transit mixer, JCB, needle vibrator, electric vibrator, drilling machines, etc. The volume of work done is planned and the actual volume of work done on a daily basis is analysed. It has been found out that the equipment is responsible for timely work and productivity on site, however its planning of transportation, installation, selection, operation and maintenance has to be well done for maximum productivity.
A paper by A.R. Vishweswar, S. Janani and M.C. Akilarasu titled 'Study and Analysis of Time and Cost Overrun in the Construction Sector' states about the factors responsible for delay in construction. The author highlights that issues related to design, owner, contractor and materials are the cause for delay. A questionnaire survey was conducted with stakeholders of the construction industry. Based on major factors and subfactors, questions were asked to carry out the research. The results show that poor maintenance of stock (equipment or material) causes delay along with other factors; change in design, no use of advanced software, poor site management, equipment availability, material prices and cost, labour productivity and inefficient planning of projects.

CASE STUDIES:

1. SKY Towers, Mumbai India

This Indiabulls residential project was started around 2010 and completed in 2016. The whole project consists of four towers ranging from 257 to 300 meters in height and around 40-50 floors. [1] This project was constructed in a very densely populated area in downtown Mumbai. The challenges faced were changes in design and detailing during construction, speed of construction, introduction of new materials and technology, lifting materials at greater height and economy. To cater to these challenges, the Automatic Climbing Formwork System (ACS) was introduced to reduce the construction time of the core walls. The conventional technique of shuttering and reinforcement binding for shear walls takes a lot of time in high-rise construction. As the shear walls were 600mm to 900mm thick, a huge amount of concrete was required. External vibrators were used to compact the concrete. [1]

FIGURE 2
INDIABULLS SKY TOWER AT MUMBAI

Seven day slab cycle was the target to achieve, for this the main technologies adopted at construction was ACS system, guided climbing system for RCC walls, lightweight panel formwork used for columns and walls, generic panel slab formwork, high performance pumps, tower cranes, high speed hoist of sufficient capacity, advanced concrete mix and concrete booms. Due to space constraints, erection of tower cranes and other equipment was difficult. Thus a plan for bringing equipment on site and erecting them was done considering the traffic and dense area. The major equipment was selected and placed at a desired location to ensure ease of access and delivery. The vertical transportation system requires maintenance, proper analysis and modification constantly during the building construction. Seven self-climbing concrete booms which can be placed in the core lift shaft or on the slab. Vertical transportation of concrete before its initial setting time is a crucial task. This can only be possible by advanced equipment having a greater capacity of work done per unit time. The stakeholders play an important role in providing sufficient funds, expertise in construction management, introduction of new technology, consultation and proper design.

2. Three sixty West, Worali, Mumbai India

The Three Sixty West Tower formerly known as Oasis Tower is located at Worali, Mumbai; a high-rise mixed-use project consisting of twin towers, its construction period was started in 2011 and completed the first tower in 2014 and the second tower in 2021. It took 10 years to construct Tower A & B. Tower A is 255.6 meters – 56 floors and Tower B is 361.2 – 90 floors.

To meet the concrete requirements of the raft foundation, slabs, columns and beams, Fosroc's state of the art concrete lab has helped in testing and selection of the desired durable concrete mix to cater the needs. The raft and horizontal members required M40 grade while the vertical members required M50 to M80 grade concrete mix, having a workability retention of three hours. This was necessary to allow the concrete to be workable as much possible before the hardening process to gain adequate strength. Fosroc lab has developed a PCE based admixture designed specifically for this project. The Auramix 300 solution was used for the raft and horizontal members and Auramix 400 for high grade concrete i.e. the vertical members. For a high rise building the pumping of concrete mix to the vertical floors is a major challenge, thus testing must be done before on site. This test was conducted at a height of 290m using a Rheometer that is used to determine the shear resistance of concrete. The Fosroc lab had to develop a new Auramix 500 solution admixture for M200 grade concrete, which was the first time in India. The admixtures help in the workability of the concrete. Thus high rise individual projects have to develop new advanced material and equipment testing before execution of the project. Massive equipment was also used for vertical transportation of concrete mix, and other materials. Skilled labour and stakeholders made it possible for the execution of the construction work.

FIGURE 3:
TWIN TOWER OF THREE SIXTY WEST AT MUMBAI.

FINDINGS:

From the above literature study and case study analysis, it has proven that equipment, material, stakeholders and design with detailing are responsible for faster and efficient construction of high rise buildings. The new technology is developing such that floor modules can be erected on site and directly placed one over the other. This is known as modular construction or modular building in which components are transported on site, assembled and placed at the floor level. This ensures more speed in construction. Being faster in construction, modular buildings cost 30% less than conventional methods of the total building cost. However, more research and testing is required for its durability and stability for high rise structures. [2]

TABLE 1
FOCUS OF EACH PARAMETER THAT REDUCES CONSTRUCTION TIME

Material	Innovative, cost effective, strong and durable
Equipment	Conventional and mechanical, high capacity
Stakeholders	Management, execution, supervision, Funding, expertise
Design and detailing	Architectural features, earthquake/wind resistant design, aesthetics

Throughout the study, the major challenge identified was concrete mixing and transportation at vertical heights. Concrete has the tendency to set within 30 minutes initially, it loses its workability as time passes, thus to prevent this admixtures are used to increase the time of initial setting. Use of higher grade concrete needs to be tested properly before use. Mechanical equipment that pumps concrete at a greater volume per unit time is crucial. Site supervision and skilled labour are required in such conditions. Once the core is built stronger, the other works are carried out manually as there is access to upper floors. Site constraints are also an issue to store equipment and material. At every stage, the stakeholders must test the construction activities, materials, evaluate costs, work as per changes in design and many more jobs. Proper design given on time, detailing of architectural features is also a challenge for the Architect. All of these together make the project successful and possible to complete within the expected time period.

CONCLUSION:

In the emerging future of Architecture and Engineering, we shall witness more advanced technologies that make the construction of a high rise building faster and efficient. This paper contributes in highlighting the importance of construction management on site which make high rise building possible. The role of advanced technology is very important in timely completion of the project. Technology evolves according to the situations faced and encourages the construction industry. The case studies reveal the major challenges and how advanced technology was developed to provide solutions as well as faster construction. Literature studies state the importance of research towards this topic. Advanced technology has helped increase productivity, construct complex structures.

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