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Prefabrication Technology - A Promising Alternative in Construction Industry

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Abstract: ***The construction industry is growing exponentially day by day and it makes a remarkable contribution in escalating the pace of development of the nation. Refinements are adapted and analyzed at each and every stage of construction. The reason of assessing all these refinements is to enhance the overall ease and feasibility of the work cycle. These refinements also make a significant change in the total cost of the project. Prefabricated components are increasingly becoming an eminently improving technology to achieve cost effective and speedy construction in the construction industry. This increasing trend for prefabricated components has now turned into numerous applications as they can provide a much faster output for the ever increasing urban construction demand. In addition to this, adopting prefabrication technology also promoted mechanization in the construction industry and created new areas of employment. The study emphasizes the effect of prefabrication technology on the profitability and its effect in the construction work cycle.***

Keywords: prefabrication technology, traditional construction.

1. Introduction

The use of prefabrication technology has proven to be more viable than ever due to various advances in design and construction technologies, combined with increasing emphasis of the industry to highlight cost, schedule and labour issues. The new technologies such as computer controlled fabrication equipment, 3D CAD, electronically controlled data and mechanization have provided opportunities for advances in design efficiency and coordination. While these technologies may provide overall project benefits regardless of the construction method, certain arrangements can be directly reduced through the use of these technologies. This paper accentuates review of prefabrication technology including principles, advantages, limitations and issues related to prefabrication technology.

2. Literature Review

N. Dineshkumar et al. (2015) conducted a comparative study on prefabrication construction with cast in-situ construction of residential buildings. The construction boom in India is developing at a fast rate of growth. It provides wide opportunity in India for a new entrant in prefab sector. At present precast concrete buildings are the advanced construction techniques available over worldwide. The prefab construction for individual double storey residential building cost is 13% more than the conventional construction. This is main drawback for prefab construction which is not economical to construct in this case. At the same time the prefab construction is easy to work and reduces the project duration, is reduced by 63 days when compared to the conventional.

C. Sivapriya et al. (2016) carried out an analysis of cost comparison of precast concrete construction with conventional construction. In case of cost overall cost required for constructing the building using precast concrete method is reduced by 20% when compared to conventional method. Economies are generated through reduced requirements for formwork, access scaffolding and less reliance on wet trades. Reduced on site - supervision by the main contractor is also a saving.

Compared to cast in situ, the following savings can be expected.

- Formwork 75%
- Scaffolding 75% to 90%
- Wet concrete 90%

Factory production ensures increased accuracy and quality of finish and decreases weather dependency. Compared with cast in situ structures, site labour is reduced by between 50% and 80% using precast. Work for following trades is reduced by between 30% and 50% depending upon finishes.

V. Prasanna et al. (2016) carried out study of various speedy techniques such as Aluminium Formwork Technology, Precast Technology, Autoclaved Aerated Concrete Blocks with Conventional method develops the pros and cone of the technology and helps in implementing the effective one on comparative basis and concluded that the productivity of AAC block construction is approximately 2 to 3 times more than the ordinary brick construction and the additional work like plastering is not necessary for AAC block construction we can go directly for putty work.

Evanjaline Libie (2016) carried out a study and concluded that precast concrete construction, besides the improvement of a building's sustainable performance, include shortened construction time; overall reduced costs; enhanced quality and durability; improved health and safety, conservation of materials and energy; waste reduction; and finally reduced environmental emissions.

Akash Lanke et al. (2016) carried out a design, cost & time analysis of Precast & RCC building and concluded that the cost of precast building is significantly reduces & duration of construction is also much lesser than traditional method. In

observation the most important thing is to be observed project is in precast construction technique is the time effective it require less time to construct. The main limitation of precast is transportation from place of manufacturing to place of site where it is to be fixed.

Joseph Yel Akok et al. (2017) carried out a study on the modular construction technique. The modules are produced in a factory, and are then transported to the construction site being prepared and then assembled. Modular construction of houses is an innovation that has potential to tackle issues related to environmental and sustainability concerns at a rapid rate, mechanizes the construction process, enabling mass manufacture of affordable houses in a short time period. Modular construction technique should be adopted for construction of buildings such as churches building, temple, mosque, medical and healthcare facilities and retail shops, fast food joints, etc. also the modular construction technique generate less waste on-site because building elements are prefabricated in the factory and then transported to the site for their final installation; therefore, saving time and money.

P. Karthigai Priya et al. (2018) carried out a comparative study on precast construction and conventional construction. In this study two main factors are considered for the comparative study. They are time and cost. In any construction project time and cost are the most important factors that have to be given more importance. If any delay occurs in the project these are the factors that get affected directly. After comparison it is found that the cost of precast construction is 1.4% higher than that of the conventional construction. The precast construction can be completed at a rate of 15.17% earlier than the conventional construction.

Dinoj K. Tony et al. carried out a detailed study on prefabrication technique in construction and its barriers. Prefabrication definitely has advantages over conventional technology in construction, but it has not really been able to compete with the conventional forms of construction. The main advantage of prefabrication is saves construction time, reduces construction waste, together with increased quality. The main barriers obtained from the survey were improper transportation facilities, logistical limitations to design and also prefabrication is more expensive than traditional construction method. This is because our society is mainly focused on cost effective construction and the fact that 'time is money' has little weight in less developed areas.

Rinkesh Patel et al. carried out a study on prefabrication technique and determined the total cost and total duration of double storey residential building for both prefab and conventional construction. The comparison showed there is enormous cost difference between the methods, which the prefab is very high when compared to conventional on this type of individual houses. The main advantages for prefab construction and also it helps when there is labour shortage. This is main drawback for prefab construction which is not economical to construct in this case.

3. Traditional Construction Method

Traditional construction method involves several chores like casting/laying of different building components and members, placing and erecting other building materials into required shapes and forms at the sites, finishing and curing. The speed of construction is much slower due to step by step completion of different stages of the activities such as erection of formwork, concreting and deshuttering and thereafter plastering and other finishing activities [3]. Formwork is used as a cast, where wet concrete, is poured into a temporary system. The formwork acts as a temporary support for the structures. An efficiently planned work may increase the productivity, speed and accuracy of construction. Traditional method uses lightweight formwork made of steel/fiberglass/aluminium that can be easily erected and dismantled afterwards. The steel reinforcement is placed within the formwork as they are being erected and concrete is poured into the mould. When the concrete is set according to the required strength the mould is dismantled. The workers are trained to erect the formwork and provide the steel reinforcement, as per design of concrete members.

4. Prefabrication Technology

Prefabrication technology aims at creating an accelerated method of construction where a building is constructed in parts that are prefabricated off site in well-equipped manufacturing facilities under controlled environment. The prefabricated units are then transported from the factory to the site and then installed as final and finished building components. The prefabrication process includes finalization of design of various components of structure, casting and curing of units, transportation of units on site and installation of these units. The prefabricated units may be whole or they may be parts of larger spaces which are combined together to form complete components.

Prefabrication method of construction as compared to the traditional in-situ construction of buildings results in faster rehabilitation models with more efficiency and reduced environmental damages [11]. The recognized definition of prefabrication is a process involving the creation of precast construction components of various dimensions at a warehouse, before delivery to a construction site for final erection and assembly. Prefabrication has often been the prelude to modernization in many fields: working conditions, advanced manufacturing technology, speed of construction and environmental friendliness [10]. Prefabrication is an appropriate construction system which allows pliability up to some extent in production as long as the required elements are delivered as per the required time schedule. The primary cost benefits of prefabrication technology acquire from the pace of construction and the optimization of building materials. The term prefabrication can apply to any construction method where a significant part of the construction takes place off-site in a factory that produces relatively large, complex pieces that are then assembled at the site into the finished building [9].

5. Principles of Prefabrication Technology

The important principles of prefabrication technology are as follows.

Cost - Prefabrication technology is known to be cost coherent at a greater extent as compared to other methods of construction. The cost inculcated in construction industry consists of three aspects on which prefabrication has a significant impact effect: material, labour and time. The initial approach to reduce cost is to diminish the amount of material implemented in a construction project. In a construction project, materials are ordered abundantly to ensure a sufficient quantity for the task to be completed and to get a discount as the material is ordered in a large quantity. As prefabrication technology may save considerably with regard to managing of materials, factory produced components may initially be extortionate. In case of small projects, due to the less number of components, it is economically inimical. Miscellaneous expenditure that may be incurred with prefabrication technology includes transportation and erection expenses.

Schedule - The savings in time as well as cost come with the practice to concurrently construct in the factory while work is being completed on site. In case of conventional traditional onsite construction processes, subcontractors have to wait until the predecessor contractor has completed its work, in a factory, teams may collaborate by allowing portions to be constructed by more than one trade. Time savings may also come by way of employing simultaneous production techniques. Decisions regarding prefabrication are pre-planned so that schedule savings may be perceived from the beginning of construction activity.

Labour - Yield is a measure of efficiency in labour. Due to adoption of offsite fabrication methods, technical changes including machinery in the factory, advancements in material science and digital revolutions have positively affected the productivity of workers in construction industry. Some of the productivity aspects are: enhanced human spirit to increase output, increased levels of dominance, clarity and accuracy, added variability to production manipulation and enhanced monitoring to reduce fatigue.

Quality – The quality of production and quality of design are the two most vital parameters which are taken into consideration in construction industry. As soon as the quality of production improves, structure becomes more standardized, while a highly customized design inevitably reflects lack of efficiency in production. Prefabrication technology can prominently increase the precision of the products and allow a superior control over each aspect of quality. In addition to increased precision the prefab components less divergence and variance. Prefabrication limits the risk of errors and eliminates the unknowns in a highly multivariable construction.

6. Advantages of Prefabrication Technology

Prefabrication Technology has following major advantages.

Overhauling the view with Energy Efficiency – In the beginning prefabricated structure was considered to possess having low quality. In order to stand out from the fierce construction market, builders are looking to augment energy efficiency through various methods such as recycling materials, using LED lighting and installing solar panels to harness solar energy. This ensures saving of money on the energy utilization to the point where one may be producing clean energy that will be put back into the energy grid which helps in reducing the impact on the environment.

Minimal wastage and Inspection struggle - The individual units are cast, cured and then transported to site and assembled using various erection machineries. As compared to structures built by using traditional method, prefabricated buildings produce minimum waste as all the required materials for construction arrive on site in preassembled condition. In addition to the simplicity of construction and energy advantages, prefabricated structures are always manufactured in accordance to the specific design codes so that there are no problems when the structure is being inspected by concerned government authorities.

Dependable Construction Plan – There are very few chances of deviations to occur in the time schedule because the casting of the individual units being carried out in a controlled environment that cannot be affected by climate causing delays. Due to absence of such interruptions, the average structure would be constructed in shortest possible time. During this construction process, workers are put in a low risk environment that elevates their feelings of safety and comfort. Due to all these factors it is certain that the structure will get all necessary care and attention to the details that it requires in order to be built correctly.

Pace of work - The off-site fabrication process may take place in the warehouse, in parallel to activities carried out on site. This may reduce the overall construction time of a project by a considerable and significant amount.

Security - Health and safety are easier to control in a warehouse as most of the work may be carried out at waist height and skilled labours know the process, machinery and systems of the warehouse.

Sustainability – Minimum site disturbances, carefully managed flow of material and construction waste, and pre-planned assembly and disassembly can reduce the environmental impact that occur due to construction activities.

Quality - A clearly defined quality may be achieved in a isolated and controlled process, and the indoor environment means buildings and components are protected from climate changes.

Due to the numerous advantages mentioned above the prefabrication technology has an increasing demand in urban construction.

7. Limitations of Prefabrication Technology

Prefabrication technology is known to have the following limitations.

Restricted options in Design – The availability of variety in the design depends on the firm or organization chosen to build the prefabricated structure with – one may be stuck with a limited amount of material options and possibilities of the layout. This implies that there are chances the structure may have less flexibility in the design than assumed or expected.

Decreased resell value - Majority of the people think they are of poor quality and low strength, which makes them extremely difficult to resell.

High initial investment – The adoption of prefabrication technology demands a high amount of initial investment.

Non-suitability for substructure – The prefabrication technology cannot be used in the construction of substructure. The construction of foundation and plinth is done by the conventional method and then the construction of superstructure is done by using prefabrication technology.

Transportation of precast units - Transportation can turn out to be expensive for construction of prefabricated structures. The actual transportation cost inculcated is based on numerous paramount factors such as transport distance, permit cost, and trailers expectations. Manufacturers of prefabricated components usually prefer ship their elements by truck and trailer to the construction site. According to the nature of the prefabricated system adopted and location of the site, certain complications can arise during transporting the precast elements.

Increases in miscellaneous risks – Several unanticipated risks are associated with prefabrication technique in comparison to the traditional construction method. This is due to the reason that the majority of the large building elements are constructed off-site; a huge amount of trust and responsibility is placed on the manufacturer to produce exactly what are as per specified requirements so even minor errors and discrepancies may put the entire structure in danger.

8. Issues in adopting Prefabrication Technology

The joints to be provided between the core structure and the components should be strong enough to transfer all types of stresses. The strength and stoutness of the entire structure depends totally on the strength of the joint. Therefore, it is necessary to have comprehensive studies on complete system rather than component based study.

Requirement of skilled labour at site and lack of onsite automation is one of the biggest issues in adoption of prefabrication technologies in construction which requires accuracy and preciseness. Therefore, skill development and native automation is required for installation of the prefabricated systems.

The prefabricated units are likely to get damaged during erection or transportation as heavy machineries are required for erection and the arrangement of the units has to be done accurately and the process becomes clumsy in a congested area.
Labour retention is another issue as skilled labour is required in the prefabricated construction because it is different from in-situ construction, which demands machine oriented skills both on-site and in the manufacturing process.

9. Sustainability Aspects of Prefabrication

Sustainability deals with the process of utilization of current resources in a way to avoid the depletion and maintain the ecological balance. The idea of sustainability in the construction industry refers to the reduction of impact on the environment and promoting the concept of green buildings as construction activities demand significant material flow, high demand of energy and certain unavoidable as well as irreversible impacts. Prefabrication technology has been identified as one of the alternatives having the potential to play a vital role in making construction activities more sustainable. The sustainability aspects of prefabrication can be bifurcated into three types viz. social, economic and environmental and is addressed by the acronym “SEE” aspects.

Social Aspects - The acceptance of prefabrication technology in the construction sector is a provocation in which other types of sectors are associated with low quality housing and even social exclusion. This is the main reason of the triumph of the prefabrication technology and both designers and manufacturers need to accept this fact. Over the course of time, numerous infrastructure developments have been procured through prefabrication technology but still there are some misconceptions because certain portion of the population still thinks that the buildings constructed using prefabrication technology has low quality, low strength etc.

Economic Aspects - The prefabricated buildings strive to achieve reduction of wastage of materials which eventually leads to reduction in cost and time of construction, minimization of time of construction so that overruns are avoided and decrease in construction defects as each and all prefab units are checked before sending on site. All these factors indicate that prefabrication technology may be part of the economic aspects of sustainability.

Environmental Aspects - The environmental sustainability aspects of prefabrication may be classified into six types viz. water, embodied energy, species index per hectare, transport energy, operational energy use and waste which may be addressed by the acronym “WESTOW” aspects. The increasing pollution is a paramount issue which is related to the damage caused by pollution due to construction activities. Prefab structures should have more control over plant-based prefabrication, which should reduce the risk of

contamination of the environment. Transport may be an environmental performance factor, where prefabrication may be worse than traditional buildings. Manufacturers of the prefabricated components should actively consider all the environmental impact of their products by developing better methods of materials procurement, recycling, pollution control and waste minimization standards.

10. Summary

Prefabrication construction technology generates less waste on site because building elements are cast in the warehouse and then transported to the site for final erection and installation. Therefore, saving in time as well as money is achieved. It is remarkably seen that the cost of building constructed using prefab technology is significantly less and duration of construction is also much lesser as compared to traditional method. The prefab construction method helps in reducing the adverse impacts on the environment and offers an environmental friendly construction. Hence, prefab construction technique is much more efficient and sustainable. The better quality control may be achieved if this technology is adopted for repetitive type of works. From the study one may conclude that the prefab technology is economical than conventional cast in place method, but still there are certain aspects as mentioned earlier which may be taken into consideration while using this technology. The sustainability aspects viz. social, economic and environmental may promote prefab technology as a promising alternative in construction industry.

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