THE COMPARATIVE STUDY OF PREFABRICATION ON PROFITABILITY OVER TRADITIONAL CONSTRUCTION

Nitesh j Ramchandani [1] Prof:Hemant Salunkhe[2]

[1] M.E. Students (Construction & Management),Department of Civil Engineering D. Y. Patil Institute of Engineering & Technology, Ambi Pune

[2] Faculty in Department of Civil Engineering Department of Civil Engineering D. Y. Patil Institute of Engineering & Technology, Ambi Pune

ABSTRACT

Prefabrication has been widely regarded as a sustainable construction method in terms of its impact on environmental protection. One important aspect of this perspective is the influence of prefabrication on construction waste reduction and the subsequent waste handling activities, including waste sorting, reuse, recycle, and disposal. The main objective of the present work is to study the present situation of the precast construction industry in India. Suggestions for improvement of the industry and study on cost effectiveness of precast concrete construction for single andmulti-story residential buildings are to be given. A literature survey was carried out in order to obtain the comparison between the conventional buildings with precast concrete buildings in India and some field visits are conducted to collect data to investigate the current situation regarding precast industry in India. In order to compare the cost of precast and in-situ construction, 10 Storey residential buildings is considered. This paper proposes the evaluating the possible impacts arising from the application of prefabrication technology on construction waste reduction and the subsequent waste handling activities. The object of this project is to identify new technologies or methodologies in the Construction Industry that could require new training or up-skilling of the trades and semi-skilled workforce. Prefabricated buildings and structures are mounted from uniform prefabricated three-dimensional units, providing strength, preset thermal properties of structures, dynamic stability, and immutability of geometric dimensions of the prefabricated elements during their manufacture, transportation, and installation in special and difficult conditions. Prefabrication has been widely regarded as a sustainable construction method in terms of its impact on environmental protection. One important aspect of this perspective is the influence of prefabrication on construction waste reduction and the subsequent waste handling activities, including waste sorting, reuse, recycle, and disposal Suggestions for improvement of the industry and study on cost effectiveness of precast concrete construction.

Keywords: Prefabrication, Industrialization, Modularization, Preassembly, waste reduction

1. INTRODUCTION

Prefabrication is the Practice of assembling components of a structure in a factory or other Manufacturing site and transporting complete assemblies to the construction site where the structure is to be located. The role of prefabrication in architecture has been lauded for its potential to increase productivity and efficiency while not sacrificing quality. The values of better, faster and cheaper are applicable to developed countries such as the U.S., Japan, and Europe, whose middle class continues to demand this equation in buildings that range from the remarkable to the prosaic. Developing countries, including China, India, Africa and many parts of South America, that are beginning to rely on prefabrication have the potential advantages of realizing housing quickly and affordably; however, greater reliance on manufactured production has possibly more disadvantages than advantages for these cultures. With prefabrication, improved working conditions would seem to be agreeable to everyone: instead of building in the weather, international fabricators supply controlled environments with ergonomically considered equipment and yet in many fabrication environments, reliance on minimal skills, and a disconnect with the community in which workers live, leaves little room for continued fostering of personal and collaborative skills, culture, tradition and community building.

The potential for Prefabrication to be used to create a bland, monotonous landscape is an issue that developed countries' construction professionals must grapple with. Countries such as India are undoubtedly suffering a greater banality in the built environment by embracing prefabrication. Prefabrication is touted as offering a more sustainable solution to building, but developing counties already rely on vernacular practices for design and construction that require relatively low life cycle energy.

Problem Statement

In Conventional Approach the subject of construction as an environmentally unfriendly activity has become arguably redundant. The level of pollution generated by construction alone is overwhelming and has been worsened globally due to the rapid rate of urban development also lacking in dynamic nature for quantitatively evaluating the possible impacts arising from the application of prefabrication technology on construction waste reduction. New technologies or methodologies in the Construction are completely absent.

Objectives

1) To identify the possible impacts arising from the application of prefabrication technology on construction waste reduction.
2) To identify new technologies or methodologies in the Construction Industry that could require new training or up-skilling of the trades.
3) To study and analyses Correlation and regression analyses will be used to analyses the data.
4) To compare the cost & duration of conventional building to the prefab building by analyses.

Aim

1) To effect economy in cost
2) To improve in quality as the components can be manufactured under controlled conditions.
3) To speed up construction since no curing is necessary.
4) To use the materials which possess their innate characteristics like light weight, easy workability, thermal insulation and combustibility etc.

2. LITERATURE REVIEW

1) **WajihaShahzad, Jasper Mbachu, and Niluka Domingo**.,Prefab content versus cost and time savings in Construction projects Using a case study research approach, 30 light to medium commercial buildings completed New Zealand, were investigated. The project details acquired included initial cost estimate, final completion cost, estimated duration, actual duration, gross floor area and the value of prefab content as percentage of the final contract sum.

2) **Chantelle Grills.**, Industrialization of the Construction Industry through Prefabrication and Adoption of Current Technologies In this project, it is performed in a factory, allowing for the use of automated equipment to reduce labor and full-time factory employees ensure that project delays due to the unavailability of skilled tradespeople are avoided. Improved product quality is achieved through highly sophisticated equipment, better supervision, and climatic protection.

3) **The Impact of New Technologies on the Construction Industry** By Construction Training Fund, U.K May 2014 There is no single system of building construction classification (as opinionated by Warswaski, 1999). The author believed that such a classification was relative to the user/producer and varied from one to another, usually based on the choice of construction technology. Based on this, it was asserted that four systems could be distinguished as determined by the main structural and enveloping materials of the building: timber, steel, cast in-situ concrete, and precast concrete systems. Warswaski (1999) also suggested that for further classification, the geometric configuration of the components of the building's mainframe could be used as follows: linear or skeletal system (beams and columns); planar panel) system; and three-dimensional.

4) **Amanda Marquit**.,A History of Prefabricated and Modular Housing Commissioner Robert D. LiMandrin carrying out the literature review, a note-worthy conflict in the classification of prefabrication was observed. Several definitions of prefabrication are clearly in favour of a system that consists entirely of offsite (factory-based) production of its components. However, Abdul Kadir et al. (2006) state that a fully prefabricated system could be one of two categories depending on the site of production: on-site or off-site (factory-produced). They argue that on- site prefabrication differs from the cast in-situ method. Here, the on-site system means that structural building components are cast in the site before being erected at the actual location. In their opinion, the on-site system also provides more advantage over the cast in-situ method.

3. CONCEPTUAL BACKGROUND

A prefabricated structure is defined as a structure built through the association and/or completion on site of several elements built in a factory or assembled on site. For example new Italian seismic legislation defines a prefabricated

structure as being composed of elements in prestressed reinforced concrete, assembled on site or in dedicated factories with industrial processes and assembled on site using dry or wet structural assembly. The parts that comprise a prefabricated building can be divided as follows:

a. Main structural elements that have to resist stress deriving from its own weight, from loads they bear and stress transmitted from elements connected to them. They have to make the structure solid as a whole forming rigid floors as in the case of floors;
b. Secondary structural elements, with load bearing functions, not essential to the general stability of the building that should be able to resist actions with adequate safety (own weight and loads they bear).

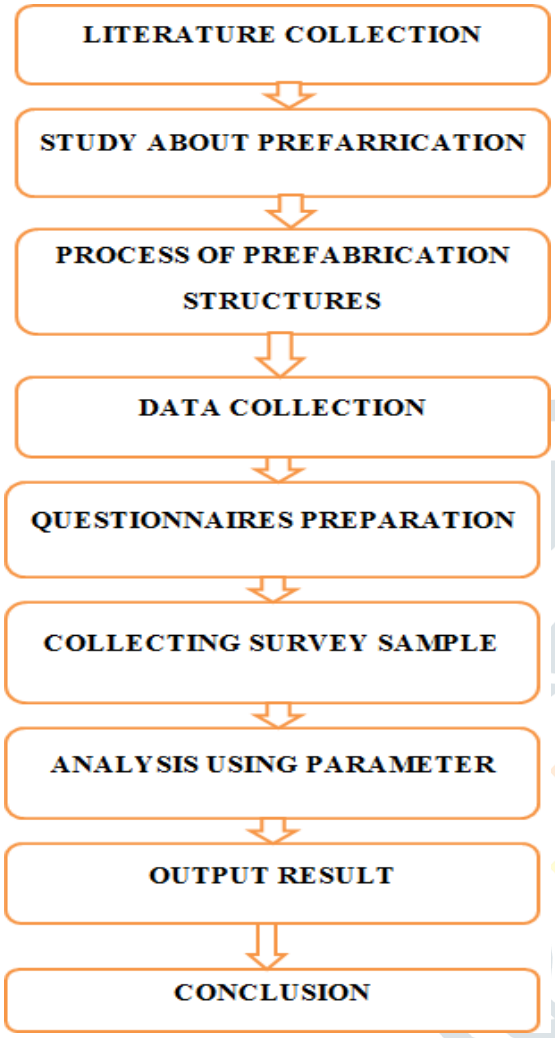

Figure 1: Flow of the project

4. RESEARCH METHODOLOGY

General

This chapter presents the method of the study on comparison of prefabrication construction with conventional construction. A residential building is taken for comparing and it includes the preparation of plan, data collection from precast industry, estimation of quantities, and determination of project duration.

Plan Preparation

Plan preparation is done for residential building to estimate the quantities of conventional and precast constructions. 10 Storey building is taken to estimate the quantities.

Estimation of Quantities

Estimation is used to find out the requirement of the materials for both the constructions. The details of the materials which are used in the construction from the companies were collected. By getting these details we can estimate the quantities of the materials. The estimation of quantities for the 10 Store building is presented instable.

Project Duration

Project duration of the each construction was collected from the similar companies and compares the time of completion period by using Critical Path method and gives the project duration of precast and conventional construction of the building

Cost Analysis

This is the main factor which is considered in the project is to find out the comparison of cost analysis of 10 Storey building for the prefab construction and conventional construction. In this analysis we want to consider the resources of labor, material and machineries.

Figure 2 : Plan of Building for up to 10 Floor (G+10)

Site details

Aipl Construction, S. N road, Swastik Plaza, Thane Mumbai Pin- 400 604.

Contact Person- Mr. Ashish Jagtap.

Building Type- Residential

5. RESULTS AND DISCUSSION

Project Duration **Sr.No**	**DESCRIPTION**	**Duration**
1	Sub Structure - (Site cleaning, Earthwork, Foundation, Basement, Soil filling& Consolidation.)	130 Days
2	Super Structure – (Wall panels framing and Roofing slabs.)	150 Days
3	Finishing Works –(Electrical, Plumbing Painting, Tiling, and Windows, Extra items.)	165 Days
	Total	445 Days

Table No 1: Total Duration for Prefabrication Construction

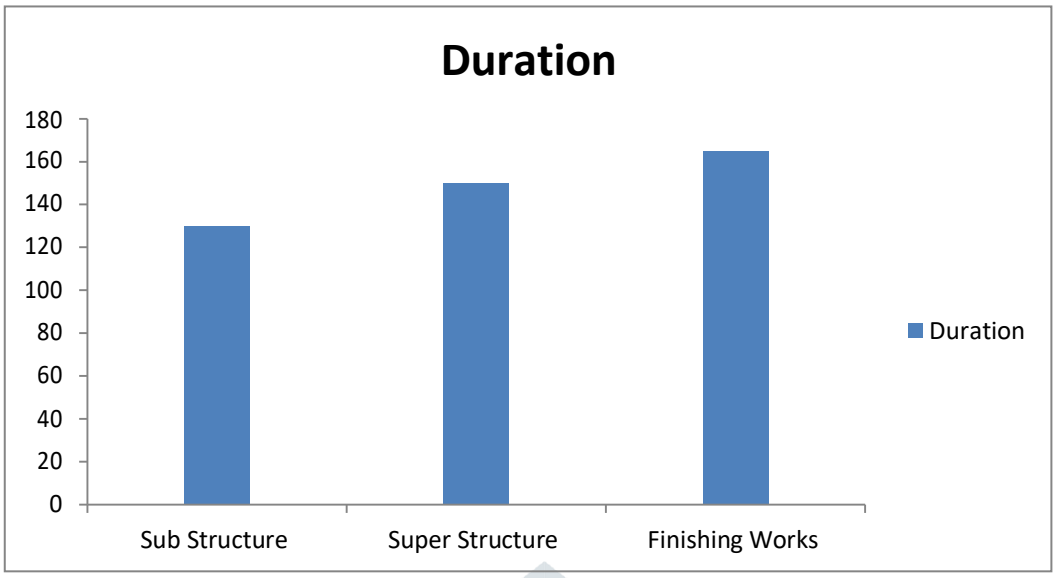

Figure 3: Duration for Prefabrication Construction

The duration of the prefab construction was calculated through the data collected from precast company, which help to find the duration of erection for the super structure of prefabrication construction. The duration of the projects shown in three different stages. The duration of substructure was the same as conventional construction because of same method is used to construct in the prefab. But the super-structures in the prefab were completed earlier when compared to conventional construction. The project duration of super-structure has a huge variation and it's an advantage of prefab construction. The walls and slabs are manufactured in factory and installed in site, which reduces the duration of the super-structure. The prefab construction takes less time duration in finishing works when compared to conventional construction, because of the electrical piping work was fitted already in precast walls and slabs. The plastering work is no need for precast elements, which is good in appearance and finishing. The total duration of the residential building for prefabrication construction is 445 days which is shown in table.

Sr.No	DESCRIPTION	Duration
1	Sub Structure - (Site cleaning, Earthwork, Foundation, Basement, and Soil filling &Consolidation.)	160 Days
2	Super Structure (Columns, Lintel & sunshade, Beams, Roof slabs, Brick work, Plastering.)	170 Days
3	Finishing Works – (Electrical, Plumbing Painting, Tiling, and Installation of doors& Windows, Extra items.)	179 Days
	Total	509 Days

Table No 2: Total Duration for Conventional Construction

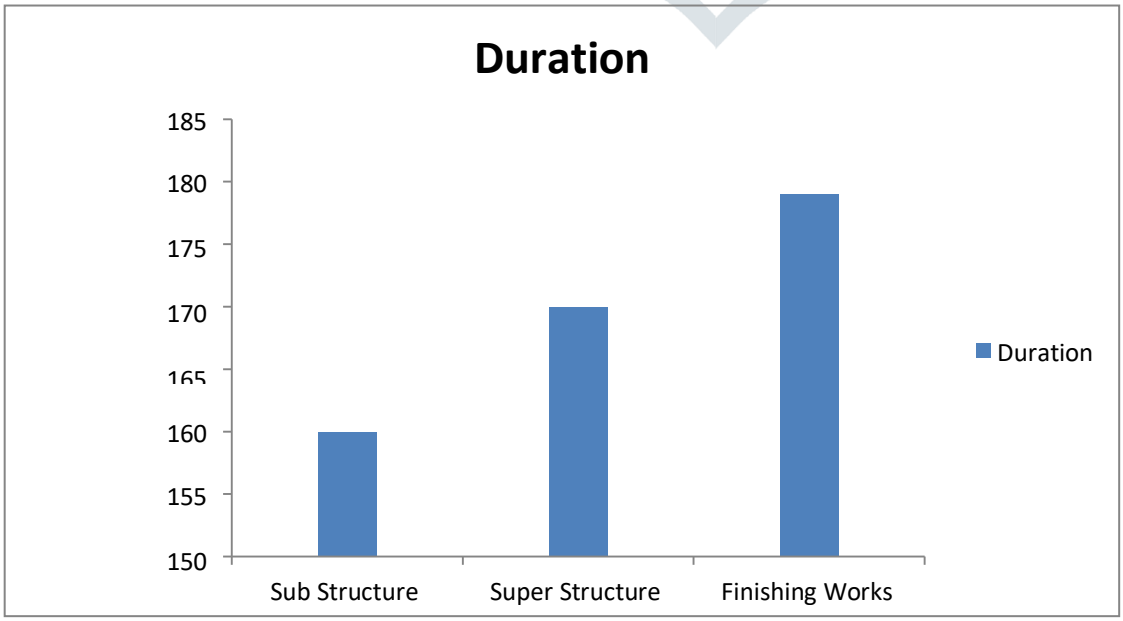

Figure 4: Duration for Conventional Construction

The duration of the conventional construction was calculated through the data collected from conventional company and CPWD engineering data, which help to find the duration for the conventional construction. The duration of the project is shown in three different stages. The duration of sub-structure was same for both constructions which used same method to construct. Butte super- structures in the conventional takes long time to complete when compared to prefab construction. The project duration of super-structure has a huge variation and it is a main delay to the project in conventional construction and finishing work also the conventional construction takes more time duration when compared to prefab construction, because of the electrical and plastering work is done only in site condition. The total duration of the residential building for conventional construction is 509 days which is shown instable in this analysis, we had known about the total project duration of both prefab and conventional constructions. The figure shows the comparison of project duration for the both prefab and conventional construction in three different stages. As in the figure the sub- structure has taken the same duration for complete the project for both construction of residential building, because of the sub- structure was done by the traditional method.

Cost Analysis

Sr.No	DESCRIPTION	Cost (Rs.)
1	Sub Structure - (Site cleaning, Earthwork, Foundation, Basement, Soil filling& Consolidation.)	52,60,000
2	Super Structure- (Wall panel's framing and Roofing slabs.)	3,21,18,000
3	Finishing Works – (Electrical, plumbing Painting, Tiling, and Installation of doors & Windows, Extra items.)	2,14,12,000
	Total Cost	5,87,90,000

Table No 3: Total cost for prefabrication construction

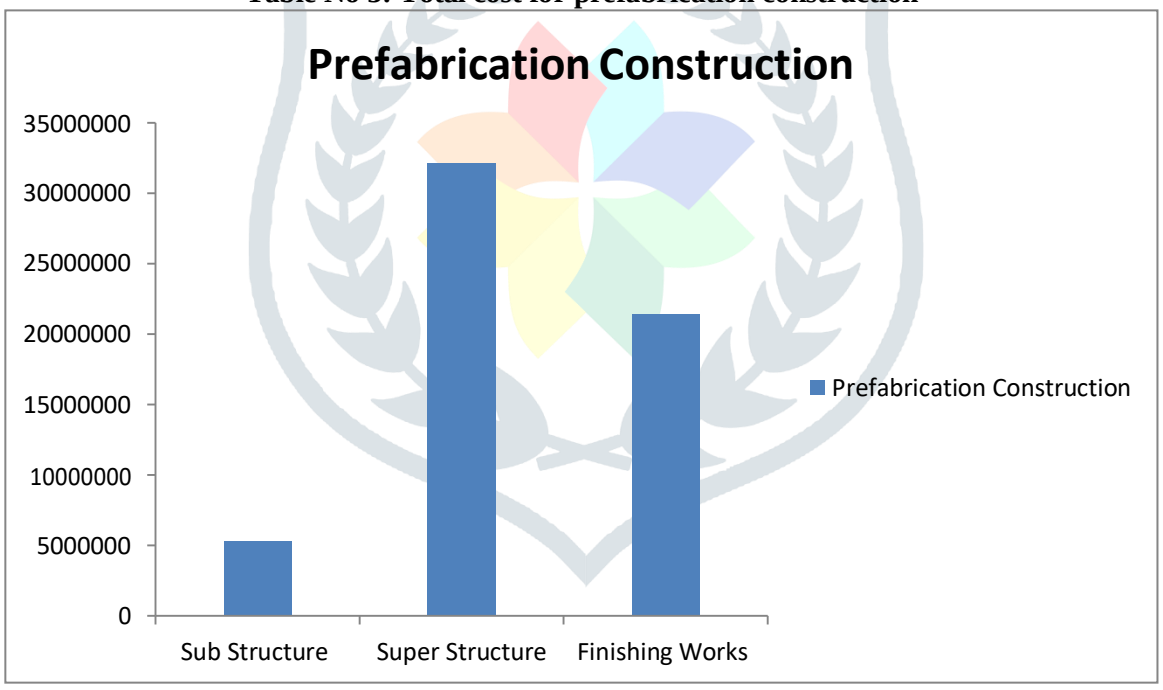

Figure 5: Cost for prefabrication construction

The cost of the prefab construction was calculated through the data collected from precast company, which help to find the cost of the super structure of prefabrication construction. The sub-structure and finishing work cost was the same as conventional construction because of same method is used to constructing the prefab. The cost of the project is shown in three different stages. The total cost of the residential building for prefabrication construction is 5,87,90,000.00 (five crore eighty seven lakh ninety thousand rupees only).

Sr.No	DESCRIPTION	Cost (Rs)
1	Sub Structure – (Site cleaning, Earthwork, Foundation, Basement, Soil filling & Consolidation.)	98,50,000
2	Super Structure – (Columns, Lintel & sunshade, Beams, Roof slabs, Brickwork, Plastering.)	4,37,52,000
3	Finishing Works – (Electrical, Plumbing, Painting, Tiling, and Installation of doors& Windows, Staircase, Extra items.)	2,91,68,000
	Total Cost	8,27,70,000

Table No 4: Total cost for conventional construction Material and labor cost for total project

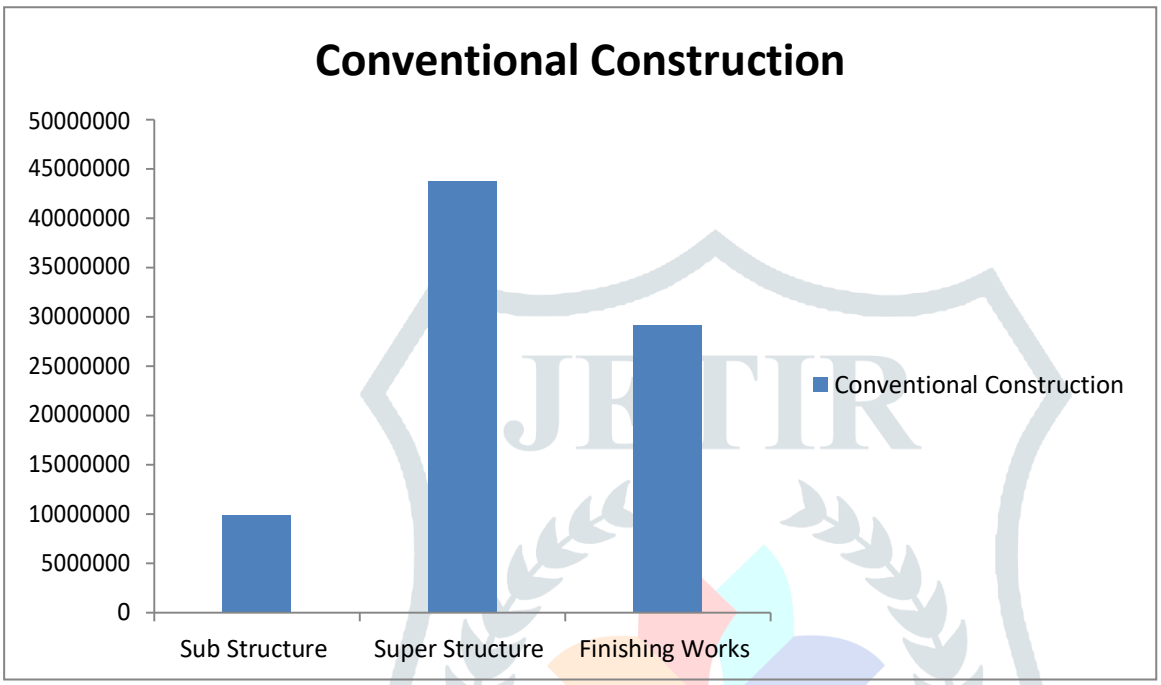

Figure 6: Total cost for conventional construction Material and labor cost for total project

Recent Trends

The first aim of the survey was to find out, what are the recent trends of prefabrication in the construction industry. Question 1 of the survey states, "What is the average use of prefabrication for projects you are familiar with today, in terms of % of overall project work? Respondents reported that they use prefabrication for 5% of overall project work.

5.3.1 Use of Prefabrication

Understanding that many of the reasons for performing prefabrication are well known, it was of interest to determine if one factor dominates the others, or if new technology drivers were beginning to emerge. Question #2states, "Of all the factors that are currently driving the use of prefabrication, what single factor is the most important?" When forced to choose a single driving factor in prefabrication, the respondents collectively chose cost and schedule as the most critical factors .A number of respondents also indicated that shop labor is cheaper. Additionally, productivity was indicated to be higher in shop work than field work. The third driving factor is workforce, in terms of prefabrication as a way to deal with the shortage of skilled construction workers. The fourth and fifth most important factors chosen are safety and quality, respectively. The cost of the conventional construction was calculated through the data collected from Conventional construction Company, which help to find the cost of the total project. The sub-structure and finishing work cost was taken to the prefab construction from the conventional. So there are no cost variations in both constructions for these stages. But the cost variation was in the super-structure and which is low when compared tithe prefab construction for residential building. Total cost of the residential building for conventional construction is Rs 8,27,70,000.00 (eight crore twenty seven lakh seventy thousand rupees only).

Waste Reduction with the help of pre fabrication construction.

It is found that timber formwork used for in-situ concrete casting, enjoys the greatest potential in waste reduction with an average avoidable wastage level of 58.2% . The use of drywall system (made of lightweight concrete) can reduce the wastage on bricklaying. Although floor screeding has the lowest average avoidable wastage level of 32.1%, the use of precast slab and staircase with the elimination of in-situ screeding can make some contribution to waste

reduction. It is also found that the opinion on waste reduction for in-situ concreting, timber formwork and bricklaying is very consistent in a sense that all respondents argued for certain degree of waste reduction.

In fact, the survey shows that all the construction activities under study, namely, in-situ concreting, timber formwork, bricklaying, plastering, screeding, tiling, rebar fixing and bamboo scaffolding, can enjoy some degree of potentials of waste reduction, depending on the degree of prefabrication or the numbers of prefabricated building components used for the particular projects and the natures of buildings. It infers that prefabrication is an effective construction method for waste minimization.

It can be found that "poor workmanship" is considered as the most important cause leading to the wastage of plastering / screeding. In concreting and bricklaying, "poor workmanship" is considered as the second important cause. On explaining the importance of workmanship on these trades, for examples, plastering needs applying various layers and thus improving the performance of the outlook; therefore, one of the interviewed engineers explained that the techniques of the workers are directly affected the final quality of the plastering work.

As the quality of these trades is based upon on the performance of the workers, improving the quality of workers by training, certification and skill development is essential in cutting construction wastage. "Damage during transportation" in bricklaying is the major cause of wastage, which can be reduced or eliminated by replacing site bricklaying with drywall panel systems. Wastage in tiling caused by "cutting", "over-order" and "poor workmanship" can be reduced after using prefabricated building components. However by simple applications of modular dimensioning on tiling, a potential reduction in wastage can also be achieved. The reduction of wastage in rebar is considered moderate. However rebar is of less concern in waste minimization as it is recyclable.

In general, the major causes of construction wastage, namely, "cutting", "over-order", "damage during transportation", "lost during installation", "poor workmanship" and "change of design", can be effectively reduced by adopting prefabrication. Prefabricated construction is the practice of assembling a variety of components of a structure at a manufacturing site and transporting those sub- assemblies to the location of the construction jobsite. Prefabricated construction is sometimes thought of as a low-end and mass produced mode of construction. In reality however, it is quite the opposite. Prefabricated construction is becoming more common, improving in quality and has become available in a variety of budgets. Despite the perception of prefabrication, there are numerous benefits to this type of construction. This article assesses the advantages that prefabricated construction presents for both businesses and customers.

Sr.No	Materials	% Waste
1	Bricks	6.82%
2	Tiles	6.68%
3	Plaster from mortar	6.63%
4	Wood	6.41%
5	Paints	6.00%
6	Ceramics	5.51%
7	Wires and cables	5.34%
8	Reinforced cement concrete	5.16%
9	Thermopore sheets	5.16%
10	Plastic pipes	4.95%
11	Glass	4.92%
12	Polythene sheets	4.89%
13	Steel rebar's	4.76%
14	Aluminum	4.74%
15	Plain cement concrete	4.39%
16	Marble	4.37%
17	Ceiling boards	4.32%
18	Bitumen	4.29%

19	Natural Rocks	4.14%
20	Steel railings	4.00%
21	Metals	3.61%
22	Mild steel GI pipes	3.57%
23	Mild steel sections	3.41%
24	Anti-termites	2.92%
25	Water proofers	2.61%
26	Diesel	2.34%

Table No 5: Percentage of Material Mastage on Conventional Site.

The results reveal significant variations in waste generation for some materials such as bricks (2%– 12%), wood (2%–15%), and PCC (1%–10%). The diverse range of wastage is partially due to variation in applied technology and construction practices from contractor to contractor. The findings reveal that on average bricks are the most wasteful material at a rate of 6.82% followed by tiles (6.68%) and plaster from mortar (6.63%). On the other hand, anti-termites (2.92%), water proofers (2.61%), and diesel (2.34%) were found to be the least wasteful material

- **Eco-Friendly**: Modular construction is often commended for energy efficiency and sustainable construction. Traditional construction methods require extra materials that lead to increased waste. However, since prefabricated sub-assemblies are constructed in a factory, extra materials can be recycled in-house. This is a considerable improvement over sending waste directly to a landfill from a traditional construction site. Also, the controlled environment of a factory allows for more accurate construction, tighter joints and better air filtration, which in turn allows for better wall insulation and an increase in energy efficiency. For more on the benefits of green technology in the construction industry.

- **Financial Savings**: One of the greatest advantages of prefabricated construction would be financial savings. Although the perception of custom-made pieces may seem expensive, with prefabricated or modular construction, this is not the case. Modular construction targets all budgets and price points, creating an affordable option. Prefabrication manufacturers often receive bulk discounts from material suppliers which then trickles down to the cost of a construction project. Modular construction also sidesteps the possibility of unreliable contractors and unproductive staff. Additionally, the reduction in construction time can significantly save on construction financing costs.

- **Flexibility**: Modular construction can be easily be disassembled and relocated to different sites. This significantly reduces the demand for raw materials, minimizes expended energy and decreases time overall. Also, modular construction allows for flexibility in the design of the structure allowing for a limitless number of opportunities. Since prefabricated construction units can be used in different spaces, its neutral aesthetics is able to blend in with almost any building type.

- **Consistent Quality**: Since prefabricated construction occurs in a controlled manufacturing environment and follows specified standards, the sub-assemblies of the structure will be built to a uniform quality. Construction site-built structures are dependent upon varying skill levels and the schedules of independent contractors. These all contribute to the craftsmanship and overall quality of given structure. With prefabrication, each sub-assembly is built by an experienced crew in a weather-resistant factory, with multiple quality checks throughout the entire process. Some components of the building are constructed using precise machine equipment to ensure conformity to building code.

- **Reduced Site Disruption**: Since many components of a building are completed in the factory, there is significantly less truck traffic, equipment and material suppliers around the final construction site. This limits the disruption of traditional jobsites that suffer from noise, pollution, waste and other common irritants. This streamlined approach to construction provides a far more efficient atmosphere for productivity, and eliminates unnecessary distractions and interference that are typical of construction sites.

- **Shorter Construction Time**: Portable construction takes significantly less time to build than on- site construction. In many instances, prefabrication takes less than half the time when compared to traditional construction. This is due to better upfront planning, elimination of on-site weather factors, subcontractor scheduling delays and quicker fabrication as multiple pieces can be constructed simultaneously. Shorter construction times allows construction companies to take on multiple projects at once, allowing businesses to grow rather than putting all their focus and resources on one or a few projects at a time.

- **Safety**: Since sub-assemblies are created in a factory-controlled environment utilizing dry materials, there is less risk for problems associated with moisture, environmental hazards and dirt. This ensures that those on the construction site, as well as a project's eventual tenants are less likely to be exposed to weather-related health risks. Also, an indoor construction environment presents considerably fewer risks for accidents and other liabilities. There are strict factory processes and procedures that protect the worker from on-the-job injury. At a construction site, although safety is of utmost importance, workers are subjected to weather-related conditions, changing ground conditions, wind and other crew members who are at the site.

- **Panelized Wood Framing**: Used typically for roofs, these are long pieces of frames built from laminated timber, covered either by plywood or some board roof deck. Panelized frames can be up to 72 feet long; these roof panels can save construction time and make roof construction a much safer activity.

- **Sandwich Panels**: Made from 2 thin facings of materials like concrete, plywood, or stainless steel. The facings are then stuck to an insulating core, made typically of materials like foam, paper, cloth or rubber.

- **Steel Framing**: For ages, steel has been one popular and trusted building material for commercial and residential construction. Steel framing uses this strong and durable material to create prefab panels which can be used to construct buildings.

- **Timber Framing**: Not very common in India, timber framing panels are quite popular in other countries where timber homes are common. These framings are built in factories and then used in erecting timber homes.

- **Concrete Systems**: Having concrete fragments of a prefabricated building cast in the factory provides more versatility and also saves time. Even though architectural elements like concrete panels are heavier than other building components, they are typically sturdier and can improve a building's aesthetics.

- **Modular Systems**: These systems use all prefab styles and create a whole building structure typically made from factory-constructed units. The buildings are transported to the final construction site and then simply connected to a prepared foundation.

- **Final Thoughts**: With the continued popularity of prefabricated construction, it is likely that it will only continue to grow in popularity. Customers who choose this option are able to enjoy a high quality, quicker, cost-effective, and eco-friendly construction method. Furthermore, construction companies may soon increase their investment in modular construction processes, benefiting both their business and customer relationships. Prefabricated construction is proving to be an extremely viable option, and as manufacturing technology continues to improve, expect to see its benefits and advantages rise in the future.

RESULT & DISCUSSION

The Data collection phase done for the Site selection, site details, Duration of site, cost of construction, Percentage of waste generated and then results tabulated and analysed.

The duration of the prefab construction was calculated through the data collected from precast company, which help to find the duration of erection for the super structure of prefabrication construction. The duration of the projects shown in three different stages.

The total project duration were calculated for both construction. The duration of the prefabrication construction is lower than the conventional construction. The time duration of the project difference is 63 days between the prefabrication and conventional construction. This contains very low time duration compared to the conventional method for the individual building.

The cost of the prefab construction was calculated through the data collected from precast company, which help to find the cost of the super structure of prefabrication construction. The cost of the project is shown in three different stages. The total cost of the residential building for prefabrication construction is 5,87,90,000.00 (Five crore eighty seven lakh and nineteen thousand rupees only).

The total project cost were calculated for both construction and shown in the Figure. The figure represents the cost of the prefabrication construction is lower than the conventional construction. The cost difference is Rs 2,39,80,000.00

rupees between the prefabrication and conventional construction. It is proposed that the firms should draw up working procedures for waste to guide site personnel in the use of materials on site. It is also stressed that both head office personnel and site personnel should be educated waste prevention. Contractors and other stakeholders must be educated and sensitized about the strategies and benefits of waste minimization on construction projects and the cost saving measures that can be followed in waste reduction which can ultimately result in increased profit margins.

CONCLUSION

The main goals of the work have been achieved. The total cost and total duration for the residential building have been determined for both prefab and conventional construction. And also we had known about the advantages and disadvantages of both prefabrication and conventional construction by the survey conducted in similar companies. The comparison showed there is enormous cost difference between the methods, which the prefab is low when compared to conventional on this type of Residential Structure. The prefab construction for individual residential building cost is 15% less than the conventional construction. At the same time the prefab construction is easy to work and reduces the project duration, is reduced by 64 days when compared to the conventional. It's the main advantages for prefab construction and also it helps when there is labour shortage. As a result of survey we had known that the prefab construction have more advantages and procurement in industrialized, heavy infrastructures. But in individual houses there are lot of constraints and lack of knowledge its get struggling to implement in our country.

Contractors and other stakeholders must be educated and sensitized about the strategies and benefits of waste minimization on construction projects and the cost saving measures that can be followed in waste reduction which can ultimately result in increased profit I would also recommend having a waste officer in the organisation will dedicatedly work on waste preventions.

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