Abstract
Prefabricated buildings and structures are mounted from uniform prefabricated three-dimensional units, providing strength, preset thermal properties of structures, dynamic stability, 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: Impact, Prefabricated Technology, Equipment, Profitability, Primavera

1. INTRODUCTION

1.1 Definition
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.

1.1.1 Principles: (Aims)
- To effect economy in cost
- To improve in quality as the components can be manufactured under controlled conditions.
- To speed up construction since no curing is necessary.
- To use locally available materials with required characteristics.
- To use the materials which possess their innate characteristics like light weight, easy workability, thermal insulation and combustibility etc.

1.1.2 Need For Prefabrication
- Prefabricated structures are used for sites which are not suitable for normal construction method such as hilly region and also when normal construction materials are not easily available.
- PFS facilities can also be created at near a site as is done to make concrete blocks used in plane of conventional knick.
- Structures which are used repeatedly and can be standardized such as mass housing storage sheds, godowns, shelter, bus stand security cabins, site offices, foot over bridges road bridges. Tubular structures, concrete building blocks etc., are prefabricated structures.
1.1.3 Process Of Prefabrication
An example from house building illustrates the process of prefabrication. The Conventional method of building a house is to transport bricks, timber, cement, sand, Steel and construction aggregate, etc., to the site, and to construct the house on site from these materials. In prefabricated construction only the foundations are constructed in this way. While sections of walls, floors, and roof are prefabricated structures with windows and door frames included and transported to the site lifted in place by a crane and boiled together.

1.2 Prefabrication In India
The Hindustan Housing Factory pioneered the production of prestressed concrete railway sleepers to replace dilapidated wooden sleepers on Indian Railways. The company changed its name shortly thereafter to reflect the diversity of its operations. It is now known as the Hindustan Prefab Limited or HPL. Located in Delhi, today the government turns company prefabricates primarily precast concrete for architectural and civil projects throughout greater India. With the integration of sustainability into building systems and the alleviation of their negative environmental impacts, building construction has become more than a simple move from the drawing board to the construction site. Building design involves a plethora of factors; the ability to make intelligent design decisions and select the most suitable among construction alternatives is beneficial, especially in today’s competitive construction market.

2. METHODOLOGY
Figure 1 shows Methodology adopted in this study.

3. PREFABRICATION
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:

- 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;
- 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).

3.1 Fundamentals Of Prefabrication

3.1.1 Modularization
Modularization is defined as the off-site construction of a whole system prior to its transportation to the site of construction. The modules may often be required to be broken down into smaller sizes for ease of transportation. Modularization usually involves more than one trade.

3.1.2 Prefabrication
This usually involves a single skill or trade and is generally defined as a production process, which normally takes place at a specialized factory where different materials are combined to form the component of an end-product. As long as the component is manufactured at a factory and is not a whole system, it is regarded as prefabricated.

3.1.3 Preassembly
By definition, preassembly is the combination of various materials and prefabricated components at a separate facility before installation as a single unit. This installation is carried out similar to the process of modularization in which the manufactured components are assembled close to the site, followed by on-site installment. Commonly regarded as a combination of modularization and prefabrication, preassembly usually involves works from various crafts and parts of different systems.

3.1.4 Industrialization
This term refers to an inclusion of all three aforementioned categories of offsite construction. Industrialization is based on the concept of manufacturing and is defined as the procurement of technology, equipment and facilities in order to increase productivity, reduce manual labour and improve production quality.
3.2 Principles

3.2.1 Main Reasons To Choose Precast Construction Method Over Conventional In Method

- Economy in large scale project with high degree of repetition in work construction.
- Special requirement in finishing.
- Consistency in structural quality control.
- Fast speed of construction.
- Constraints in availability of site resources (e.g. materials & Laborites).
- Other space & environmental constraints.
- Overall assessment of some or all of the above factors which points to the superiority of adopting precast construction over convention method.
- The following details gives. The cost implications of precast construction & conventional in situ method.
- Large groups of buildings from the same type of prefabricated elements tend to look drab and monotonous.
- Local Jobs are last.

3.3 Classification

The Prefabrication is classified as follow from the view of degree of Precast construction.

- Small prefabrication
- Medium Prefabrication
- Large Prefabrication
- Cast in Site Prefabrication
- Off-Site (or) factory Prefabrication
- Open system of prefabrication
- Closed system of prefabrication
- Partial prefabrication
- Total prefabrication

3.3.1 Small Prefabrication

The first 3 types are mainly classified according to their degree of precast. Elements using in that construction for eg.: brick is a small unit precast and used in building. This is called as small prefabrication. That the degree of precast element is very low.

3.3.2 Medium Prefabrication

Suppose the roofing systems and horizontal members are provided with pretested elements those construction are known as medium prefabricated construction here the degree of precast elements are moderate.

3.3.3 Large Prefabrication

In large prefabrication most of the members like wall panels, roofing / flooring Systems, beams and columns are prefabricated. Here degree of precast elements are high.

3.3.4 Cast – In – Site Prefabrication: Off – Site (Factory) Prefabrication

One of the main factor which affect the factory prefabrication is transport. The width of mad walls, mode of transport, vehicles are the factors which prefabrication is to be done on site on factory.

3.3.5 Open System Of Prefabrication

In the total prefabrication systems, the space framers are casted as a single unit and erected at the site. The wall fitting and other fixing are done on site. This type of construction is known as open system of prefabrication.

3.3.6 Closed System Of Prefabrication

In this system the whole things are casted with fixings and erected on their position.

3.3.7 Partial Prefabrication

In this method of construction the building element (mostly horizontal) required are precast and then erected. Since the costing of horizontal elements (roof / floor) often take there time due to erection of from work the completion of the building is delayed and hence this method is restored. In most of the building sites this method is popular more. Son in industrial buildings where the elements have longer spans. Use of double tees, channel units, cored stabs, slabs, hyperboloid shall etc., are some of the horizontal elements.

3.4. Prefabrication Elements

- Flooring / Roofing system.
- Priciest Beams
- Precast Columns
- Precast wall panels.
- Precast Stabs.

3.4.1 Flooring / Roofing System

Depending upon the composition of units, precast flooring units could be homogeneous or non-homogeneous. (Figure.2)
1) **Homogeneous floors** could be solid slabs, cored slabs, ribbed or waffle slabs.

2) **Non-homogeneous floors** could be multilayered ones with combinations light weight concrete or reinforced / pre stressed concrete with filled blocks. Depending upon the way, the loads are transferred the precast floors could be classified as one way or two way systems.

**One Way System**

One way system transfers loads to the supporting members in one direction only. The precast elements of this category are channel slabs, hollow core slabs, hollow blocks and hollow plank system, channels and tiles system, light weight cellular concrete slab etc.

**Two Way Systems**

Transfer loads in precast element under this system etc.

3.4.2 Precast Concrete Beams And Girders

There are different kinds of precast concrete beams and girders, which serve as load-bearing support. These include the rectangular beam, L-shaped beam and inverted ‘T’ beam.(Figure.3). Figure 4 shows Precast columns.

**Longitudinal Wall System**

In this system, cross walls are non-bearing. Longitudinal walls are load bearing. This system is suitable for low rise buildings. A combination of the above systems with all load bearing walls can also be adopted.

- **Precast concrete walls could be**
  - 1) Homogeneous walls
  - 2) Non-homogeneous walls

**Homogeneous walls**

The walls could be solid or ribbed.

**Non-homogeneous walls**

Based on the structural functions of the walls, the walls could be classified as

- a. Load bearing walls
- b. Non-load bearing walls
- c. Shear walls

Based on their locations and functional requirements the walls are further classified as

(i) **External walls** which can be load or non-load bearing depending upon the layout. They are usually non-homogeneous walls of sandwiched type to impart better thermal comforts.

(ii) **Internal walls** which provide resistance against vertical loads, horizontal loads, fire etc. and are normally homogeneous.
3.4.2 Precast Concrete Stairs

![Precast concrete stairs](image)

**Figure. 6 Precast concrete stairs**

### 3.5 Process Of Prefabricated Construction

Prefabricated buildings are produced and manufactured in a controlled environment with the latest manufacturing technologies. They were designed with such flexibility to be able to adjust with changes made by the owner of the building. Repeatable design is one of the key benefits of using prefabricated buildings. Because of the consistent production of this material, the factory engineers are allowed to continually monitor the production process and make the necessary improvements whenever possible to be able to deliver the best quality for their products. The prefabricated building process usually starts with assembling of the steel, concrete and wood, or pure concrete frames. The machine-cut wood, steel, or concrete walls are usually added to the prefabricated buildings with exact design specifications. Then, the electrical wiring and the plumbing are installed before readying the unit for transport to the site. Sometimes, redundant quality controls are being done to check and confirm any spot-on manufacturing defects before the material leaves the factory.

### 3.6 Preparing Materials Onsite

Multitasking is one of the skills used when preparing prefabricated materials onsite. Prefabricated buildings are being made in the factory, while the construction service professionals are waiting at the site to prepare the foundation. This is where you will receive the completed frames and units of prefabricated buildings. The land on site is being graded, where as the cement foundation is poured onto the ground. Piers are also placed as needed to be able to give support to the completed prefabricated units.

### 3.7 Prefabricated Building Assembly And Finishing

Once all the units are completed, they are shipped to the site. There, the foundation is ready so that the prefabricated buildings are to be craned to be set into place. The unit will be connected to the foundation and to each other to be able to create a solid and durable building. Also, the utilities are to be connected and personally chosen exterior designs of finishes are being added upon erecting the units.

Prefabricated building or volumetric modular construction refers to a method of building a structure off-site, rather than a description of the finished product. Prefab buildings are typically built 60 to 90 percent off-site in a three-dimensional form, designed to be constructed at one location, and then used by occupants at another. Modern, custom, multi-story, factory-built buildings with concrete and steel floors, brick exteriors, sheetrock interiors, windows, lighting, computer hook-ups, electrical service, plumbing, heating, air conditioning and restrooms can include everything you need and can be constructed in half the time of a site-built building.

### 3.8 Stages Of Prefab Building

1. Design approval by the end user and any regulating authorities
2. Assembly of module components in a controlled environment
3. Transportation of modules to a final destination
4. Erection of modules to form a finished building.

### 3.9 Concurrent Activities Compress Overall Project Schedule

While modules are being constructed in a factory, site work is occurring at the same time. This allows for earlier building occupancy and contributes to a much shorter overall construction period. This process often allows modular construction times half of that of conventional, stick-built construction with the same life expectancy as traditionally built buildings.

The selection of construction methods as relative to health and safety is a crucial factor given that any construction project is unique. Since contractors are responsible for the execution of construction work, the question might be asked whether they should be responsible for selecting the construction method. The study suggests that designers should decide on which construction method should be adopted for construction projects. Arguably, this view may be underpinned by designers being obligated to select construction materials as part of formulating the design of the building or structure. Moreover, in the case of inexperienced clients and possibly the absence of a project manager, designers may be responsible for selecting the construction method. On the other hand construction clients who have experience in and knowledge of the construction industry might be responsible for selecting the construction method themselves.

The review of the literature suggested that designers and clients remained drivers and motivators for, or barriers to, the selection of prefabrication, preassembly and precast technologies. The findings of this study indicate that construction clients and their advisors had previously adopted prefabrication, preassembly and precasting on their construction projects. Evidently, only one respondent reported that prefabrication was adopted on most of his
projects. However, almost all respondents had adopted prefabrication on their projects to a greater or lesser degree. That this alternative construction method is not considered on every project suggests that construction clients and designers resist the utilization of prefabrication. Furthermore, the literature suggests that such resistance stems from the unfamiliarity of the benefits associated with prefabrication (Gibb, 2001). However, the findings reported that to varying degrees, clients and designers were aware of the benefits associated with the utilization of prefabrication. Increased productivity was perceived as the optimum benefit derived from the utilization of prefabrication including cost reduction, time and health safety improvements. Similarly, some of their reasons for adopting prefabrication were as follows:

- Reduction of time;
- Quality improvements;
- Reduction of cost;
- Health and safety performance improvements;
- Increased durability of prefabricated components relative to in situ methods;
- Reduction of rework;
- Reduction of Labour;
- Ease of installation;
- Reduction of scaffolding;
- Manufacturing processes that are more efficient than traditional onsite construction processes;
- Reduction of trades which are in short supply in favour of new skills which easily learnt in a short time span;
- Reduction of formwork; and
- Reduction of delays.

3.10 Advantages

The advantages of using prefabrication in housing are that:

- Prefabricated components speed up construction time, resulting in lower labour costs;
- prefabrication allows for year-round construction;
- Work is not affected by weather delays (related to excessive cold, heat, rain, snow, etc.);
- The mechanization used in prefabricated construction ensures precise conformity to building code standards and greater quality assurance;
- There are less wasted materials than in site-built construction;
- There is less theft of material/equipment (and less property damage due to vandalism);
- Materials are protected from exposure to the elements during construction;
- Worker safety and comfort level are higher than in site-built construction;
- Computerization of the production process permits a high degree of customization, at an affordable cost;
- Quality control and factory sealing and design can ensure high energy efficiency; and
- cost savings through prefabrication can reduce the income required to qualify for a high ratio mortgage by up to one third compared to a conventionally built home of the same size.
- Self supporting readymade components are used so the need for formwork shuttering and scaffolding is greatly reduced.
- Construction time is reduced and buildings are completed sooner allowing on earlier return of the capital invested.
- On-site construction and congestion is minimized.
- Quality control can be easier in a factory assembly line setting than a construction site setting.
- Prefabrication can be located where skilled labour and power materials space and overheads are lower.
- Time spent in bad weather or hazardous environments at the construction site is minimized
- Materials for scaffolding is stored partly or in full and used.

3.11 Uses Of Prefabrication

- The most widely used form of prefabrication in building and civil engineering is the use of Prefabricated Concrete & prefabricated steel sections in structures where a particular part on form is repeated many line.
- Pouring Concrete section in a factory brings the advantages of being able to re-use moulds and the concrete cab be mixed on the spot without having to be transported to and pumped wet on a congested construction site.
- Prefabricating Steel sections removes on site cutting and welding costs as well as the associated hazard’s.
- Prefabrication techniques are wood in the construction of apartment slacks and housing developments with repeated housing units.
- The technique is also used in office blocks, warehouses and factory buildings.
- Prefabricated Steel and glass sections are widely used for the exterior of large buildings.
- Prefabricated bridge elements and systems offer bridge designers & Contractors significant advantages in terms of construction time, safety environmental impact construct liability and cost.
- Prefabrication can also help minimize the impact from bridge building.
- Radio bowers for mobile phone and other service often consist of multiple prefabricated sections.
- Prefabricated has become widely used in the assembly of aircraft and space craft with component such as wings and fuselage sections after being manufactured in different countries or states from the final assembly site.

3.12 Disadvantages Of Prefabrication

- Careful handling of Prefabricated components such as concrete panels or steel and glass panels is required.
- Attention has to be paid to the strength and corrosion-resistance of the joining of prefabricated sections to avoid failure of the joint.
Similarly, leaks can form at joints in prefabricated components. Transportation costs may be higher for Voluminow. Prefabricated sections than for the materials of which they are made, which can often be packed more efficiently. Large Prefabricated Structures require heavy-duty cranes & Precision measurement and handling to place in position. Large group of buildings from the same type of Prefabricated elements tend to look drab and monotonous.

4. ABOUT SOFTWARE

It is primarily a visualization tool, which has improved the ability to exchange complex ideas among project participants. It has become easy to generate and reuse the information for construction projects. This is a 'CIEPM' (Computer Integrated Enterprise Project Management) concept which allows the meaningful extraction of project management data, information and knowledge from the participants beyond their imagination. A number of viewpoints have been given by the researchers to the practitioners for adopting this new technology for their own benefits. However, there seems to be some reluctance on the part of the practitioners, for adopting this technology, which will have to be overcome by the researchers. It should not be applied to one particular phase of construction project. In fact, many architectural/engineering/construction firms hesitate to invest and adopt in this primavera tool, because they don’t have sufficient time to study and analyze this technology. The objective of this study is to validate its applicability to the entire life-cycle of construction projects, including planning, design, construction and operation, and maintenance phases. Application of Primavera Project Management. Basically project management deals with project cost and resources. So this software enables an organization to deliver project on time and on budgets through reuse of best practices.

4.1 About Primavera

- Primavera enables the organizations to manage time, tasks, costs, resources, contracts, change and risks to consistently execute profitable projects.
- Primavera is the industry leading project and program management solution for projects of any size
- Organizations leverage Primavera to
- Effectively collaborate across the entire project team
- Proactively manage projects to meet success requirements
- Standardize business processes and best practice.

5. SURVEY SAMPLE

Questionnaire form prepared with company profile and conducted the survey

6. ANALYSIS RESULTS

Survey results analysed by using PRIMAVERA and results shown in Figure 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 and 17

Figure 6 Eps Window In Primavera

Figure 7 Calender Window In Primavera
Figure 8: Project Window in Primavera

Figure 9: Activities Window in Primavera

Figure 10: WBS Window in Primavera

Figure 11: Resources Window in Primavera

Figure 12: OBS Window in Primavera

Figure 13: Roles Window in Primavera
Prefabrication technology has not transferred as easily when compared with other technologies because it is a production technology or knowledge based and not a consumption technology or product based. Technology transfer of prefabrication is not as pertinent to architects as it is to manufacturers of building products, but we are caretakers of culture in the AEC industry. In many cases we are asked to help with many of the transfers that are occurring by way of global practice or working for multinational firms that are producing prefabricated components and entire buildings for India and elsewhere. Although transfers will continue to occur, especially in the area of prefabrication in building, we should be well aware of how the decisions of India and western architects may have an effect on the ethical dilemmas regarding less developed countries’ development and culture. A comparative survey found that prefabrication reduced activities associated with repetitive body movements, ergonomic challenges and ergonomic problems. The survey found that 92% workers reported that the use of prefabrication! preassembly and precast would reduce hazards related to material handling on site and that the reduction of scaffolding through the use of prefabricated /pre-assembly or precast components would lead to less falls on sites.

References


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