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IMPLEMENTING PROJECT MANAGEMENT SYSYEM IN CONSTRUCTION INDUSTRY USING PRIMAVERA SOFTWARE

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Abstract: Prefabrication Technology is one of the most wonderful inventions of the 20th century. If offers various advantages over traditional construction methods and effects into project completion much ahead of prescribed time with least site disturbance, risk aversion and with finest quality structures. Globally, Prefabrication was adopted during early 1900s and in India 1940s saw the entry of this excellent technology. Even after having such a long history to its name, Prefabrication and Precast technology has seen multiple hurdles and reluctance to acceptance from the industry professionals and the public at large. There is a sense of insecurity and doubt among the general public and the stakeholders of any project about the trustworthiness of this technology and its long-term durability. Hence, there is a need to examine the governing factors that drive the adoption of Prefabrication technology in the construction industry as well as the Barriers that are hindering the penetration of Prefabrication at a large scale. This study focusses on identifying various governing factors that help in the adoption of Prefabrication technology and the Barriers – Psychological, Economic, Political, Cultural, that are still curbing the widespread acceptance of Prefabrication Technology in India.

Index Terms - Project Management, Construction, Primavera.

I. INTRODUCTION

Prefabrication has been used since ancient times. For example, it is claimed that the world's oldest known engineered roadway, the Sweet Track constructed in England around 3800 BC, employed prefabricated timber sections brought to the site rather than assembled on-site. [5]. Early years of 1900 saw the evolution of Prefabrication in the U.S and was extensively used during World War II. In India, Prefabrication was developed in the 1950s to mitigate the shortage of homes arising out of heavy influx of refugees from West Pakistan. [2]

Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site, and transporting complete assemblies or sub-assemblies to the construction site where the structure is to be located. The term is used to distinguish this process from the more conventional construction practice of transporting the basic materials to the construction site where all assembly is carried out. 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.

Prefabrication and modular construction are processes that have been used by generations of construction professionals. Over the past century, these processes have developed a stigma of “cheapness” and “poor quality.” [3] But with the advancement of technology and owing to continuous research and developments, the quality of prefabricated products has radically enhanced in the recent years and the technology is slowly gaining a reputation in the industry.

Prefabrication has the 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. [1]
The quality of construction is much higher when components are manufactured in a stable environment such as the factory. This is especially true in India where today, prefabrication has become synonymous with durable, modern, and western construction methods. Materials are used more efficiently, are safer from climatic damage, and can be reused in the material stream. Because

of these benefits, a general consensus in India is to move prefabricated building systems beyond precast concrete for large-scale construction to additional market sectors including a resurgent interest in applying prefabrication technology to housing.

Traditional construction techniques involve the use of timber molds or shuttering for roof spans and other structural systems. These temporary timber structures have a short lifespan and due to the volume of construction in the peak seasons of spring and summer for larger well-funded projects are often unavailable. This hinders construction schedules and does not allow projects to be completed before cooler or rainy seasons begin. However, construction does not stop in the summer despite the lack of proper equipment and material. Instead, using makeshift methods for construction on site leads to inappropriate means and hence a substandard quality of construction in finished buildings. The prefabricated alternative to roof construction removes the issues of timber molds and shuttering. Prefabrication in Indian housing improves uniformity and brings unskilled labor inside where work is supervised, monitored and controlled.[2]

Despite of such a huge list of benefits and prolonged market existence, Prefabrication technology has been unable to create a widespread acceptance from the industry till date upto the level it deserves. This research is aimed at identifying and studying the different governing factors and barriers for the acceptance of Prefabrication technology especially in Indian context and attempts to suggest some suitable solutions to increase its adaptation in the construction industry.

II. LITERATURE REVIEW

The subject of Prefabrication is not at all new and is been followed through since ancient times. The first use of Prefabrication is believed to be in the form of timber roads during as early as 3800 BC in England. [5]

A vast amount of literature has been published after extensive research conducted by scholars on this topic addressing a plethora of issues, challenges, applicability, benefits and limitations. A list of literature referred and studied for the purpose of this research is presented below.

[1.] History & Current State-of-the-Art

mentioned that Prefabrication has been used since ancient times. For example, it is claimed that the world's oldest known engineered roadway, the Sweet Track constructed in England around 3800 BC, employed prefabricated timber sections brought to the site rather than assembled on-site.

Early years of 1900 saw the evolution of Prefabrication in the U.S and was extensively used during World War II. In India, Prefabrication was developed in the 1950s to mitigate the shortage of homes arising out of heavy influx of refugees from West Pakistan.

[3] conducted an extensive study and compiled a report on current state-of-art on prefabrication technology. The results of their study indicate that today only about a third of the users (37%) of construction projects are built using modular or prefabrication technology. The main reason behind not using prefabrication into the projects by non-users of prefabrication was reported to be “Owner Resistance”, although the usage of prefabrication is expected to rise in the future. They concluded with presenting the drivers of change in the construction technology from in-situ to off-site (prefabrication) in the current and future markets.

presented a study on current state-of-art on prefabrication in India. They concluded that owing to the large scale and long term multi-dimensional benefits, a general consensus in India is to move prefabricated building systems beyond precast concrete for large-scale construction to additional market sectors including a resurgent interest in applying prefabrication technology to housing.

[2.] Benefits & Applications

Showed that there are issues in the life cycle design of prefabricated buildings in Hong Kong. The findings of this research showed advantages when adopting prefabrication such as waste reduction, improved quality control, and reduction of material use. Their research concluded that the future promotion of a closed-loop material cycle will significantly contribute to sustainability thus minimizing carbon-dioxide emissions, natural resources consumption.

Pointed out that current implementation of prefabrication is unable to provide satisfactory results to the construction industry. They carried a feasibility study to prove that prefabrication can provide a better solution to the problems of huge waste generation of site activities. Prefabrication would also help in reducing long term construction costs, even if the initial cost of implementation is much higher.

Studied the effectiveness of Prefabrication technology in minimizing construction waste in building projects. Through four case studies they found that prefabrication can result in significant waste reduction, as high as upto 100% for major construction activities on site.

A 2011 report on a conference by a research institute [8] organised among architects, engineers, contractors, and building owners supports the arguments that speed to completion, quality, and safety can be increased with modular construction, while overall costs, material waste, and the impact on the environment can be reduced.

examined the evolution of precast technology in high-rise residential developments in Hong Kong, and explored the technological influences in both sectors. The findings revealed a greater extent of prefabrication use over the years, in terms of precast percentage by volume and types of precast elements utilised. Major prefabrication innovations, in both sectors, influenced the technological advancement in prefabrication.

[10] Reported an ongoing study on prefabrication in buildings of Hong Kong and its impact on waste reduction. Their study revealed that construction waste reduction is one of the major benefits of prefabrication as compared to the conventional method with an average of 52% waste reduction. Their results implied that a wider use of prefabrication could considerably reduce construction waste generation in Hong Kong and alleviate the burdens associated with its management.

Researchers [11] examined the sustainable construction aspects of adopting prefabrication in high-rise buildings, and assessed the economic, environmental and social aspects of using prefabrication. Their findings revealed that environmental, economic and social benefits of using prefabrication were significant when compared to conventional construction methods, implying that a wider use of prefabrication techniques could contribute to sustainable construction in a dense urban environment.

[12] Identified the causes of building waste and tried to quantify the waste levels of various building trades. They emphasized on the need to implement an effective material control strategy which would call for commitment from all parties involved in the construction process. They stressed on the ways to implement such a robust strategy with collaboration from all the parties involved.

[13] Studied the state-of-art of prefabricated building construction systems adopted in Hong Kong and came out with positive news for the prefabrication technology regarding cost cutting, improved quality and drastic reduction in project completion time.

[14] Studied the benefits of prefabrication in construction projects and their results pointed out two major benefits of this technology. One was reduction on-site activities resulting in the dramatic reduction in overall project schedule and the second was reduction in the requirement for on-site labour strength due to the simplified work content and increased productivity.

[3.] Environmental Impacts

In their research analysed the industrialized technologies in construction of school buildings from a technical and sustainable point of view, in order to determine how they improve the quality of these buildings and reduce their environmental impact. They found that all of these technologies have weak points and hence recommended a new optimized technology based on them. They concluded that a future development of renewed current technologies could reduce both resources consumption and waste generation but would never be able to close the materials cycle as the recommended technology does.

Governing Factors & Major Barriers

Conducted research to investigate the readiness of construction project organizations (CPOs) to accommodate new project environments that demand a more extensive use of prefabrication. The results indicate that although CPOs were well aware of the need to change operational practices to make full use of the benefits of prefabrication, they fail to realize the organizational

change. They concluded with the future need for emergent organizational change strategies like rewarding innovation and fostering bottom-up communication to increase mass level adoption of prefabrication in the industry.

conducted research to assess UK architects' and contractors' attitudes towards waste minimisation, by investigating the integration of waste minimisation strategies into current design processes. Their study revealed that very few attempts are made to reduce waste during the design process. The results reveal that poorly defined responsibilities are leading to confusion regarding who should control and monitor waste management. Both architects and contractors are constrained by internal and external factors.

Indicated that although prefabrication as a technology has been long promoted in Hong Kong, its adoption is still limited to Government Housing Projects. The reasons being high initial cost, time consuming initial design development process, limited working space on site for installation of building components, lack of experience, lack of demand, water leakage issues and non-standardized design. They recommended measures for effectively implementing Prefabrication on different project types to promote more effective use of prefabrication in them and to fulfil future environmental requirements.

[6-TAM] studied the major hindrances for widespread adoption of prefabrication technology in Hong Kong and concluded that the major obstacles were high land costs for setting up Prefabrication Yards, lack of experience of site staff and workers, high delay rates for delivery of building components on site due to congested road network, and reluctance of consultants and designers on adoption of prefabrication due to design constrains. Their research proposed stimulators to facilitate and encourage the adoption of prefabrication, including implementing more stringent environmental regulations, highlighting and promoting high savings through this technology and granting relaxation in gross floor area for adopting prefabrication. Finally, they concluded that future rise in adoption of this excellent technology could only be possible if the industry realizes the benefits of cost savings which could be brought about through full mechanization of prefabrication industry and the use of recycled materials for building components.

III. FINDING OF LITERATURE REVIEW

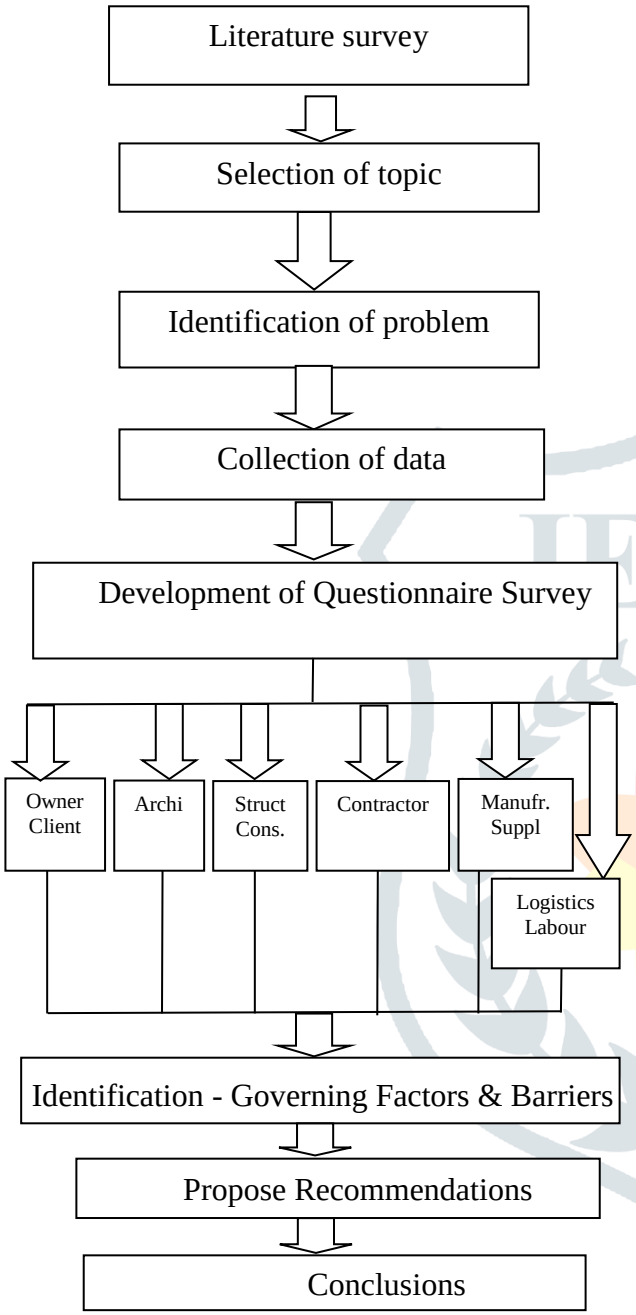
From the literature review conducted herein, it was found that extensive research has been done till now on the topic of prefabrication as a technology regarding its characteristics, usage, benefits, limitations and future scope etc. The conclusions of the literature review study have been summarized as below:

Prefabrication as a technology is quite old with inception evidence of more than 5000 years ago, while modern age prefabrication was first used in America during the early 1900s.As a technology prefabrication has a wide range of benefits and outperforms the traditional construction methods in almost every aspect. In spite of having such a vast history and a great list of superior benefits, prefabrication has not been able to penetrate deeply and its usage is still low in the construction industry. Very little research has been carried out in the previous studies on prefabrication to address the issue of low adoption. Hence, there is a need to identify the governing factors which have a direct implication on the mass adoption of prefabrication in the construction industry in the future.

IV. METHODOLOGY

The present study is mainly aimed at identifying the root causes of poor adoption of prefabrication in the construction technology. For this, there is a need to get on the field and investigate the real opinions, perceptions, experiences, problems of the practicing professionals at all levels. A Problem Oriented Qualitative type of Research (POQR) methodology is used for the purpose of this thesis. The method of Questionnaire Survey is resorted to get an insight into the industry opinions, experiences and challenges faced both by users of prefabrication and non-users. A structured format of the questionnaire is prepared for this purpose and the researcher has visited a large number of construction industry professionals including the existing users of prefabrication and also to get an insight into the perceptions of the non-users. The format of the questionnaire survey is shown in Annexure A. The acquired data is then segregated into suitable groups of interviewees like Project Owner, Architect, Structural Consultant,

Contractor, Manufacturer, Supplier, Logistics professional, and Labour etc. Finally, after in-depth analysis of the collected data, the real governing factors and barriers to widespread adoption of prefabrication technology are identified, and suitable recommendations to overcome the present challenges which would act as catalysts for future growth in large scale adoption of prefabrication in construction are suggested.



DATA COLLECTION:

Introduction

A large amount of research has been previously done on the topic of prefabrication and hence plenty of data is available in the form of experiences, statistical records, and some data are generated through questionnaires and interviews. As discussed earlier, since this research focusses on acquiring in-depth, real information on industry opinion, experiences, optimism, challenges, future scope etc. hence the researcher had to perform an exhaustive field survey and visit a large amount of industry professionals from project owners/ clients, architects, consultants and contractors etc. The data collection with just a couple of case studies is not sufficient for this type of qualitative research method.

Data Types

The different basic concepts about Prefabrication need to be first discussed before we actually get into the topic of the research. Hence the data is grouped into two main categories. First is the basic information about Prefabrication as a technology along with its characteristics, benefits, limitations, usability etc. obtained through Literature Survey.Once we get the basic understanding of the subject, then we deal with the real problem to be tackled that is finding the root causes of poor acceptance of prefabrication technology in the construction industry Concept of Prefabrication A prefabricated structure or building is a structure that has several factory built components that are assembled on a site. These pre-made components can consist of panels, modules or transportable sections. The word "Prefab" is not an industry term like modular home, manufactured home, panelised home, or site-built home. The term is an amalgamation of panelised and modular building systems, and can mean either one. In today's usage the term "Prefab" is more closely related to the style of home, usually modernist, rather than to a particular method of home construction."Prefabricated" may refer to buildings built in components (e.g. panels), modules (modular homes) or transportable sections (manufactured homes), and may also be used to refer as mobile homes, i.e., houses on wheels. Although similar, the methods and design of the three vary wildly. There are two-level home plans, as well as custom home plans. There are considerable differences in the construction types. Modular homes are created in sections, and then transported to the home site for construction and installation. These are typically installed and treated like a regular house, for financing, appraisal and construction purposes, and are usually the most expensive of the three. Although the sections of the house are prefabricated, the sections, or modules, are put together at the construction much like a typical home. Manufactured and mobile houses are rated as personal property and depreciate over time. The modular houses are constructed in accordance with the IBC (International Building Code).

Constructing manufactured homes typically involves connecting plumbing and electrical lines across the sections, and sealing the sections. Manufactured homes can be built onto a permanent foundation, and if designed correctly, can be difficult to distinguish from a stick-built home to the untrained eye.

Manufactured homes are typically purchased from a retail sales company, initially assembled by a local contracting company, and follow-up repairs performed by the manufactured home company under warranty.

A manufactured home, once assembled, goes through a "settling-in" period, where the home will settle into its location. During this period, some drywall cracking may appear, and any incorrectly installed appliances, wiring, or plumbing should be repaired, hopefully under warranty. If not covered under warranty, the costs will be borne by the consumer. For this reason, it is important that the consumer ensure that a reputable and honest contractor is used for the initial set-up. If any repairs are not completed by the initial set-up crew, the manufacturer will send repair crews to repair anything covered by the warranty. The secondary repair team must be scheduled, and may not be available immediately for most repairs. Just because a manufactured home has been assembled does not mean it is immediately inhabitable; appropriate ventilation, heating, plumbing, and electrical systems must be installed by a set-up crew, otherwise, the buyer must wait for the manufacturer repair team or do it themselves.

Concept of Prefabrication

The designs are so unique that they greatly influence practical engineering and contemporary architecture. The entire fabrication works are done using contemporary architectural principles. Moreover, all the industrial prefabricated structures, office prefabricated structures are custom designed, according to the needs and preferences of the customers. The structures can be applied to numerous applications and are ideal for any non-residential low-rise building. Some of the application areas include

Residential houses

Factory Building

Multi-Purpose Hall

Workshop Warehouse Exhibition centre Showrooms Aircraft hangers Supermarkets Sports centres Auditoriums Gas stations Bridges Railway Platforms etc.

Case Study - II

1. Consultant : RASS Project Consultants Pvt. Ltd.
2. Project Name : Construction of Factory Building
3. Name of Owner: Bobst (I) Pvt. Ltd.
4. Location : Pirangut, Pune.
5. Area of Site :
6. Type of Structure : Prefabricated Steel Structure
7. Number of Floors : Ground Floor Only

8. Plan Area of the Structure: 3200 SQ.M

V. RESULTS

A total of 70 questionnaires were distributed among industry professionals. Till now, 6 forms have been returned with filled in opinions. The respondents of this survey consist of various professionals from construction industry like Architects, Contractors, Structural Consultants, Fabricators, and Suppliers etc.

Likert Scale

The responses obtained from the respondents were entered in the database and analysed further with the Likert Scale and Mean Score methods as explained below.

Sr. No.	Construction Method:	No. of Respondents for each Rank					
		1	2	3	4	5	Total
1.	Familiarity with the method	0	3	1	1	0	5
2.	Labour dependence requirement	0	0	3	1	1	5
3.	Construction Cost	0	0	0	0	5	5
4.	Construction Time	0	0	0	2	3	5
5.	Client requirement	0	0	0	0	5	5
6.	Waste reduction	0	0	1	4	0	5
7.	Availability of Resources	0	1	4	0	0	5
8.	Delivery Logistics	0	1	1	3	0	5

A Sample Likert Scale for factor - Construction Method:

Similar Likert Scales were developed for other factors like Benefits of Prefabrication Technology, Barriers and Satisfaction Levels of the users of Prefabrication Technology.

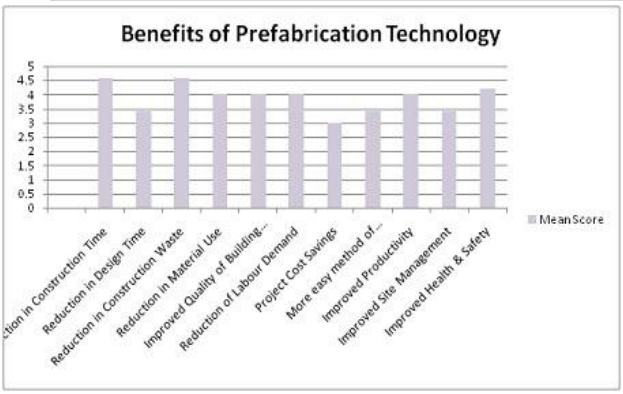
Mean Score Method

The mean score method is used to rank various governing factors and barriers from the responses obtained as perceived by the interviewees.

Barriers

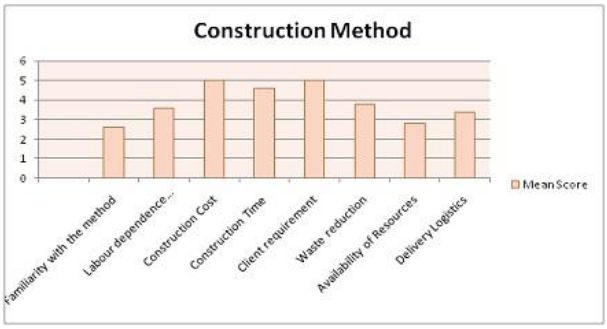
Sr. No.	Barriers	Mean Score
1.	Conflict with traditional Design Process	3.2
2.	Conflict with traditional Construction Process	3.6
3.	Insufficient Market Demand	2.3
4.	Need Organisation change	2.8
5.	Need Specification change	3.3
6.	Lack of Professional Technical Knowledge	3.4
7.	Lack of Standard Components	3.4
8.	Lack of Skilled Labour	3.6
9.	Lack of adequate Transport Vehicle	4.4
10.	Lack of Hoist equipment Capacity	4.0
11.	Breakage/Cracks/ Bends in products during transit	3.8
12.	Client Reluctance	4.0
13.	Labour Reluctance	3.4
14.	High Overall Cost	3.2

Sr. No.	Satisfaction	Mean Score
1.	Overall Satisfaction	4.0
2.	Final Cost	3.4
3.	Material Cost	3.0
4.	Design	2.8
5.	Monitoring/ Production techniques	3.4
6.	Products Delivery to Site on time	3.0
7.	Reliability of Product	3.6
8.	Reduction in Construction Time	4.2
9.	Reduction in Construction Cost	3.8



Sr. No.	Benefits:	Mean Score
1.	Reduction in Construction Time	4.6
2.	Reduction in Design Time	3.4
3.	Reduction in Construction Waste	4.6
4.	Reduction in Material Use	4.0
5.	Improved Quality of Building Elements	4.0
6.	Reduction of Labour Demand	4.0
7.	Project Cost Savings	3.0
8.	More easy method of Construction	3.4
9.	Improved Productivity	4.0
10.	Improved Site Management	3.4
11.	Improved Health & Safety	4.2

Sr. No.	Construction Method:	Mean Score
1.	Familiarity with the method	2.6
2.	Labour dependence requirement	3.6
3.	Construction Cost	5.0
4.	Construction Time	4.6
5.	Client requirement	5.0
6.	Waste reduction	3.8
7.	Availability of Resources	2.8
8.	Delivery Logistics	3.4



DISCUSSIONS

After recording the obtained data on Likert Scale and finding the Mean Scores of each governing factor and barrier, very significant and crucial information was achieved. The top scorers in each governing factor and barrier were noted and are discussed below. From the above exercise, the following results can be deduced.

A. The most important factors in choosing the Construction Method were reported to be the Construction Cost and Client requirement. As the cost of construction using Prefabrication method significantly increases with respect to traditional in-situ method, while the major tendency of the stakeholders involved is to save on capital investment. Both these method scored the top ranking with mean score of 5.0 out of 5.0.

B. As per the respondents the most beneficial characteristics of Prefabrication Technology were the Reduction in Construction Time and Reduction in Construction Waste both scoring the highest score of 4.6 on the scale of 5.

C. The most satisfying characteristic of Prefabrication technology was reported to be the Reduction in Construction Time with the score of 4.2 on the scale of 5.

D. The biggest barrier in the adoption of Prefabrication Technology in the construction technology was believed to be Lack of Transport Vehicle.

CONCLUSION:

The present research study focuses on identifying the factors governing factors driving the change in construction methodologies from conventional in-situ to prefabrication and the barriers responsible for poor adoption of prefabrication in the construction industry.

After the extensive literature study, it was observed that shortened construction duration, reduced labour requirement and dependency, high quality of products and minimum waste generation were prominent benefits of prefabrication, while high initial cost and lack of confidence in the technology and reluctance from many project owners/ clients and some contractors were the primary barriers responsible for poor adoption of prefabrication.

Structured questionnaires were sent to construction industry professionals to obtain their views, opinions, experiences and perceptions of advantages and barriers regarding prefabrication. The results are awaited and the research will further continue with the analysis of the questionnaire survey once they are received.

Further Work will include the following activities:

1. Acquiring the responses of questionnaire survey from the respondents.
2. Analysing the relative strengths of the governing factors and barriers from the obtained data by rating and finding the mean score.
3. Proposing suitable recommendations to overcome the present barriers and help to boost further large scale adoption of prefabrication.

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