

STUDY OF MODULAR BUILDING CONSTRUCTION USING PRIMAVERA

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ABSTRACT

This research studies the need and importance of **modular building construction** in this fast developing countries like India. In this research firstly we study about the basic principles and criteria's to be used in the modular construction technique. The pros and cons of construction of modules are also studied. And also the difficulties faced in the installation of modules and how to overcome from these and to make it a best method of construction in this modern era is also discussed in this project. **Modular construction** has the advantage of producing structures quickly and efficiently, while not requiring the resources to build a structure to be co-located with the construction site. An additional advantage is that once the modules are on-site, construction can proceed extremely quickly. This is ideal for situations where compressed schedules are required in order to meet client's time constraints. This paper examines using software simulation, specifically Primavera. Here in this research apart from discussing about the ease and fast methods of construction using modular method, also studies how to incorporate the software **primavera** in modular construction, thus making the whole process of construction more easier. By coupling modular building construction with primavera software we can save a lot of time and energy, also we can decrease the overall budget of construction. Thus this method is the best suitable way of construction which has to be adopted in fast growing countries like India.

INTRODUCTION

A modular building is a prefabricated building that consists of repeated sections called modules. Modularity involves constructing sections away from the building site, then delivering them to the intended site. Installation of the prefabricated sections is completed on site. Prefabricated sections are sometimes placed using a crane. The modules can be placed side-by-side, end-to-end, or stacked, allowing for a variety of configurations and styles. After placement, the modules are joined together using inter-module connections, also known as inter-connections. The inter-connections tie the individual modules together to form the overall building structure. Modular construction is a process in which a building is constructed off-site, under controlled plant conditions, using the same materials and designing to the same codes

and standards as conventionally built facilities – but in about half the time. Buildings are produced in “modules” that when put together on site, reflect the identical design intent and specifications of the most sophisticated site-built facility – without compromise.

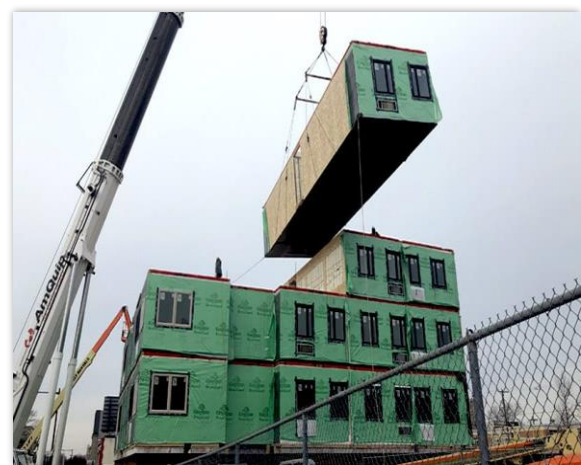


Fig 1: Modules of a modular building

Civil Engineers with knowledge in Primavera leads to the field of planning Engineering and become planning Engineers/Planners/Schedulers/Control engineers. It also leads to specialization called Planning forensics Consultancy where an engineer or scheduler will have to conduct delay analysis in times of disputes between client and contractor.

While preparing construction program, you will have to coordinate with Construction Execution Team including Projects Manager and calculate Resources for each activity based on Quantity and Productivity Norms. Having knowledge in Primavera will fetch you hand some pay if you are well versed/have full knowledge in Primavera an implement those on practical field.

After all the tasks are entered along with their respective duration, the information of task dependencies is specified by specifying predecessor of each of the task. The information is entered using predecessor column of the software. The four types of task relationships or inter dependency are FS, SS, FF and SF. The default relationship in the software is finish to start with zero lead and lag.

A manpower can be defined as the number of people that is completed with the activities, duration, start and finish dates for each activity and for the whole project, next step is to define and assign resource to the activities then to find the estimated cost for the activities is required to complete the task and is assigned to an activity. It is suggested to create and allocate the minimum number of resources to activities.

Primavera P6 enables project planning, management, and process monitoring in addition to the organisation of project activities. Specifically, one can plan around 100,000

operations with numerous target objectives and resources.

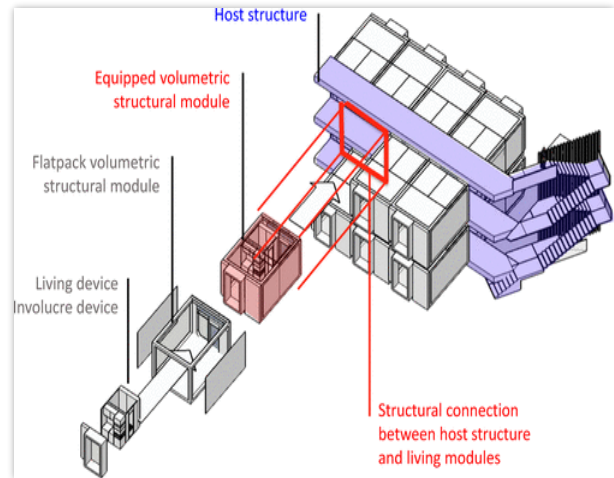


Fig 2: Schematic diagram of a modular building

The tool provides thorough scheduling and planning. Experts from different departments, including project managers, planning controllers, project planners, and other professionals participating in projects, can quickly obtain the required information by clicking a button.

Effective in cost cutting: Using Primavera P6, you can find and address improbable events or other variables that lead to excessive spending at the planning stage or a later stage. This helps you to track your spending and control it within the budget.

Updated forecasting strategies: Primavera provides fast access to all information for all project departments, enabling forecasting with the most recent data.

The most recent information allows for identifying and eliminating underutilised resources and other potential project-affecting problems. Primavera allows better resource, activity, and other factor forecasting by giving

users access to up-to-date data. Identification of risks: Primavera helps identify and mitigate any risks to the project's success.

Primavera, therefore, provides several benefits, especially in resource management, risk reduction, and corporate growth projection. It should come as no surprise that there is always a need for civil engineers who have a thorough understanding of the software.

LITERATURE REVIEW

4.1 GENERAL

Review of literature will give a deep knowledge in the minds of the reader on the specific topic of interest. Various literatures were reviewed based on the objectives of study.

This chapter commences with reviewing the most notable works in the field under study. Each subchapter ends with the hypothesis of the corresponding principle. The final subchapter then presents the theoretical model constructed by the authors, which lays the foundation of the present research.

4.2 REVIEW OF LITERATURE

4.2.1 Modular Construction and its Adaptation in India

By Palak Sachdev(2018) Student, Department of Architecture, SDPS College, Indore, India

An analysis method has been proposed to evaluate modular construction methods quantitatively based on cost per square foot of construction, and on a qualitative way by listing benefits of each construction method and thinking about the tradeoffs between them. Through this method, it is possible to evaluate the cost-effectiveness of the two construction methods for multi-story commercial projects in a way that could serve as a valuable tool for decision making.

4.2.2 Application of Modular Construction in High-Rise Buildings

R. Mark Lawson, M.ASCE; Ray G. Ogden; and Rory Bergin(JUNE 2012)

Modular construction is widely used in Europe for multi-story residential buildings. A review of modular technologies is presented, which shows how the basic cellular approach in modular construction may be applied to a wide range of building forms and heights. Case studies on 12-, 17-, and 25-story modular buildings give design and constructional information for these relatively tall buildings. The case studies also show how the structural action of modular systems affects the architectural design concept of the building. The combination of modules with steel or concrete frames increases the range of design opportunities, particularly for mixed-use commercial and residential buildings. An overview of the sustainability benefits and economics of modular construction is presented based on these case studies.

4.2.3 Post-COVID-19 modular building review on problem-seeking framework: function, form, economy, and time

Kyung-Eun Hwang, Inhan Kim

Modular building is an innovative and sustainable construction method and a notable architectural, engineering, and construction trend. Owing to the new constructability and sustainability, significant research efforts have been focused on the engineering aspects of modular building. Since the global outbreak of the COVID-19 pandemic, space utilization has changed radically, and a rethinking of modular building design has become essential. However, current literature lacks a comprehensive understanding of occupants' newly developed requirements and the relevant changes associated with engineering

developments. Therefore, this study aims to review the current status of residential modular building design and construction, define its problems, and identify the key factors necessary for modular design and construction during the post-COVID-19 period from the perspective of architectural design. A total of 220 articles were selected from the Scopus database, out of which 94 papers were selected for a systematic review. The findings indicate that the present academic research primarily focuses on the technical aspects of optimizing architecture and on modularized plans to facilitate cost-effective factory production. Modular residential design has rarely considered people and cultural factors. Therefore, the authors derived 15 problems by adapting four architectural programming frameworks; function, form, economy, and time. The identified problems are mapped for future development with 11 problem-solving proposals. The proposed method contributes to developing new insights into COVID-19's impacts on dwelling environments and can help introduce modular residential design responses that enhance the quality of life by creating better residential in the post-pandemic.

4.2.4 The State-of-the-Art Application of Modular Construction to Multi-Story Residential Buildings

Anthony C. Jellen P.E. and Ali. M. Memari PhD, P.E.(FEBRUARY 2013)

Modular construction methods show great potential as an alternative to traditional site-built methods and could be a means of providing much needed affordable housing in the dense, land deprived urban areas typical of US cities. The evolving field of modular construction will require significant investment in research to successfully integrate these powerful concepts into mainstream construction practice and provide the industry with the resources and tools

it needs to use these cost, time, and material saving construction methods effectively in future designs. This paper aims to review both the current state-of-the-art of multi-story construction and promote its utility for high performance, sustainable multifamily dwellings in U.S. urban areas, particularly for moderate income, one- or two-person families.

4.2.5 ANALYSING PRECAST & MODULAR CONSTRUCTION WITH RESPECT TO DESIGN AND COST

Shubham Jadhav and Amit Kadam (MAY 2022)

The article considers temporary methods of using modular units in construction. The advanced world experience in the construction of modular buildings is analyzed. It is emphasized that modular construction has the potential to shorten project design and engineering time, reduce costs and improve construction productivity. The installation of modular buildings is cost-efficient, safe and eco-friendly. Modern modular systems are based on using not only large elements such as block rooms but various small 3D building elements. The analysis result of Russian developments in the construction of modular buildings proves that Russia has great experience in the development of 3D reinforced concrete modules. As the research results the article shows promise for developing of modern modular construction systems in order to provide the population with affordable, comfortable and eco-friendly housing. The paper describes the prospects and relevance of introducing modular prefabricated units not only into low-rise but into multi-storey and high-rise construction as well.

4.2.6 A Study on Modular Construction Technique

By Sudheer Kantamneni, Dr K Chandramouli, J Sree Naga Chaitanya,A. Naga Sai

Modular construction technique is a technique that uses prefabricated modules/units and it is a technique that has perfect solution in remote, rural and urban areas where conventional or traditional construction may not be possible. 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. Therefore modular construction technique is much more efficient and sustainable.

4.2.7 Modular Buildings in Modern Construction December 2016

Authors: Elena M. Generalova, Viktor P. Generalov, Anna A. Kuznetsova

The article considers temporary methods of using modular units in construction. The advanced world experience in the construction of modular buildings is analyzed. It is emphasized that modular construction has the potential to shorten project design and engineering time, reduce costs and improve construction productivity. The installation of modular buildings is cost-efficient, safe and eco-friendly. Modern modular systems are based on using not only large elements such as block rooms but various small 3D building elements. The analysis result of Russian developments in the construction of modular buildings proves that Russia has great experience in the development of 3D reinforced concrete modules. As the research results the article shows promise for developing of modern modular construction systems in order to provide the population with affordable, comfortable and eco-friendly housing. The

paper describes the prospects and relevance of introducing modular prefabricated units not only into low-rise but into multi-storey and high-rise construction as well.

4.2.8 Towards the adoption of modular construction and prefabrication in the construction environment: A case study in Malaysia July 2016, Journal of Engineering and Applied Sciences

By: Muhamad Faiz Musa

Modular construction is classified as off-site prefabrication and modern method of construction and used in developed countries such as US, UK, Japan, European countries and Australia due to its benefits. Modular construction is also known as volumetric construction, modular building system or modular system. Modular construction was developed since the 1940's, during the World War 2 as a solution for the soldier's accommodation and after World War 2 due to the increase in housing demand in the US. Modular construction is a construction method to construct a building using three dimensional or modular units, which are assembled and produced in a factory. The three-dimensional units used for modular construction includes the logistic and assembly aspect of it, done in proper coordination through planning and integration. The research aims to investigate the definition, history, benefits, application and characteristics of modular construction and the adoption of modular construction in the Malaysian construction industry through a case study.

4.2.9 Modular construction: From projects to products

By Nick Bertram, Steffen Fuchs

The report put forward seven strategies to improve productivity by up to 60 percent. Collectively, they could generate \$1.6 trillion in

value—enough to fund roughly half of the world’s infrastructure spending. Our work also pointed to an even bigger long-term opportunity: shifting to a modular construction model based on more efficient manufacturing-style production systems and pre-fabricated components. While this has been tried before in various guises, it has never achieved full scale, nor demonstrated the revolutionary productivity gains it should be capable of. There is mounting evidence that this disruption is now happening.

4.2.10 FEASIBILITY, BENEFITS AND CHALLENGES OF MODULAR CONSTRUCTION IN HIGH : RISE DEVELOPMENT IN THE UNITED STATES: A DEVELOPER’S PERSPECTIVE(SEPTEMBER 2012)

By Sri Velamati, Bachelor of Science, Economics, University of Pennsylvania

Modular construction has long been utilized in the construction of residential and many other commercial product types as a means for potentially quicker construction delivery times. Over the past 5 years this construction technique has slowly been introduced into the high rise residential market throughout the world. The additional structural challenges of high rise construction make modular construction in this setting more challenging, but the high construction costs of high rise construction also make any savings in time and hard cost worth consideration. Based on case thesis will address the design, engineering, sustainability, scheduling, legal and financial considerations a developer would likely consider in adopting modular construction in a high rise project in the United States.

4.2.11 Literature Review on Analysis of Modular Building Using E-Tabs Software

By Safeek A.

Modular building with advantages of quick installation, good comfort, beautiful appearance and convenient turnover, is widely used in construction of temporary construction, business services, holiday villas and other projects. The paper aims an analysis of modular buildings by using E-tabs software. It focuses upon basic design assumptions that are accepted for modular buildings. There are so many software now a days to analyse a s structural buildings but in the case of modular buildings the analysis by using E-TABS is an innovative solution. And also to steel is better than an ordinary construction based on their strength and also regarding with other factors. The software is using here to analyse the modular construction. Different models were developed in the E-TABS Software to research the analytical performance of ordinary structures. Current project E-TABS is used to calculate the overall structural strength and stiffness, and the stress and displacement calculation results under the control of vertical load and horizontal wind load.

4.2.12 A study of literature in modular integrated construction - Critical review and future directions:

By Sherif Abdelmageed, Tarek Zayed

Modular integrated construction (MiC) has been an attractive research topic in the last decade. The adoption of this technology has increased in several countries worldwide, which shows the need for exploring its main research themes, characteristics, benefits, and challenges. Through a three-step research process integrating bibliometric search, quantitative analysis, and qualitative analysis, the literature of MiC was extensively analyzed. The aim was to identify ongoing research trends and current gaps that will benefit future research in this vital domain. The quantitative analysis of literature showed that almost 50% of research in MiC was conducted in only four countries. Science



mapping of author keywords showed the connection between MiC and topics, such as simulation, sustainability, and scheduling, which indicated the diverse nature of the existing literature. The qualitative analysis of the literature showed that the categories of building design and management aspects were dominating the research in the area. Future research directions comprise developing models to analyze stakeholder relationships during the design stage, examining contractual relationship among participants, investigating cost comparisons with different construction methods, and assessing the methods for introducing MiC into the curriculum of future engineers. This study provides a road map for future research projects and raise the practitioners' awareness of the latest methodologies and trends in global MiC research.

4.2.13 A Holistic Review of off-site Construction Literature Published between 2008 and 2018;

By Ruoyu Jina and Shang Gao

Off-site construction has become an emerging research domain in the recent decade. Through a holistic review approach incorporating scientometric analysis and follow-up in-depth qualitative analysis, this study contributes to the body of knowledge in off-site construction by summarizing the latest research keywords and main research topics. This study also identifies the current gaps in research and practice, as well as proposing future research directions in this research area. Off-site construction is a domain that can be extended to cross-disciplinary research from the perspectives of engineering, management, and technology. Existing research have been focusing on many research disciplines, such as structural behaviors and joint connections of prefabricated components, scheduling and planning of off-site activities, as

well as performance evaluation of off-site construction. However, further research is needed in integrating the emerging digital construction technology, integrated project delivery method, lean construction, and the issues of sustainability of off-site construction. There are already limited studies linking off-site construction to the concept of Design for Manufacturing and Assembly. Future research should also adopt a larger database and allow for comprehensive evaluation of off-site construction performance.

4.2.14 Manufacturing of modular buildings: a literature review

By YI YANG

The recent decade has seen a growing interest in applying modular construction in high-rise buildings. However, the manufacturing of modular buildings remains slow in making technical progress and the productivity in the factory is low. The production of modules is unique and complicated as it incorporates both manufacturing features and construction trades. Whereas previous studies have proposed technologies and tools associated with design, operation and optimisation of module manufacturing systems, this field of research is currently fragmented. This paper aims to provide a systematic review of existing academic perspectives and suggest future research directions to improve module manufacturing systems. The review explores critical research issues from five aspects: process and activities, organisation and people, factory configuration, technology, and information and control system. Outlined suggestions for research opportunities include increased utilisation of digital manufacturing, more exploration of strategies for the adoption of automated technologies, development of holistic and practical approaches to supporting DfMA methodology, well-defined information

management systems through BIM. The findings should contribute to a more comprehensive understanding of the practices, challenges and the state-of-the-art research in the manufacturing of modular buildings.

4.2.15 Artificial Intelligence and Robotics for Prefabricated and Modular Construction: A Systematic Literature Review

By Zhenjie Zheng and Wei Pan

Prefabrication and modularization have attracted much attention in building construction, and they are becoming increasingly important for the betterment of society. To fully benefit from prefabricated and modular construction, the application of artificial intelligence and robotics (AIR) is widely recognized as essential, but it has not yet been systematically studied. This paper aims to explore future research directions on AIR for prefabricated and modular construction through a systematic literature review drawing on a concept–methodology–value philosophical framework. The analysis involves 97 published journal articles carefully identified through the Web of Science and Scopus databases. The review specifically addresses four research questions aligned with the framework to synthesize previous research activities, and the paper proposes five directions that depict future research and practices: integrated AIR for large-scale modularization, multi-dimensional project management, intelligent postconstruction management, interdisciplinarity and interoperability, and moving beyond technical solutions. The findings and the philosophical framework should benefit succeeding exploration and practice.

CONCLUSION

From the above literature we can conclude that modular building construction is an efficient method of construction in this fast developing country like India. Review of literatures help us to develop the knowledge and understand the specific topic of interest.

Moreover, reading of various papers of this specified topic gives the skill to frame the methodology of the work for the particular study. The Methodology has been framed from the above literature study for the future purpose of the project. Various kinds of Knowledge are found in the literature. This chapter initially introduces the nature of the research as well as the methodology undertaken when conducting the literature review.

Proper planning and design are at the core of every project at Satellite Shelters. It helps keep your project within budget and, ultimately, results in a better process and completed product. Our planning process can also help identify any potential roadblocks before they happen. Total time for this phase depends primarily on your business's needs and internal approval processes, but typically we've found this phase can take anywhere from a few days to a couple of months.

The first step in the planning and design process is determining your budget. While modular buildings are cost-effective, they are just like any construction project in that budget constraints limit the array of solutions available to you. After all, you don't want to waste weeks or months designing and planning an intricate building only to realize you don't have the funds to complete the build, forcing you back to the drawing board.

Modular buildings can be used as semi-permanent buildings for long-term projects or as permanent solutions to your building needs.



These modular units are configurable, customizable, and expandable as needs change.

Modular construction is significantly faster than traditional construction. The start time to finish time, or critical path, of conventional construction is sequential. In other words, you can't start the next step of the building process until the previous process is complete. For modular construction, you can operate concurrently, meaning you can construct your building while your site work is being completed, for instance. The time between design approval and building construction can range from four to 16 weeks depending on production line times and the size of your project. However, once all the modules are shipped to your site, a modular building can be assembled in as little as a day. The most important quality of a build site is accessibility. Your modular building will be shipped in pieces as wide as 14 feet and as long as 60 feet. These oversized loads require trucks to be able to manoeuvre to the construction site, and it may be necessary to utilize additional heavy machinery, such as cranes, to assemble your building. At your job site, the modules are stacked or connected, then bolted and sealed together. Exterior work (such as roofing, siding, and stairs) is completed, followed by any interior details that remain, such as painting walls or adding appliances.

The chapter subsequently discusses the time horizon, data sampling and data collection method embraced by the authors. Finally the discussion ends with presenting the practical method employed, the ethical considerations made and assessing the quality criteria of the research.

REFERENCES

1. Modular Construction and its Adaptation in India

By Palak Sachdev(2018), Student, Department of Architecture, SDPS College, Indore, India

2. Application of Modular Construction in High-Rise Buildings

R. Mark Lawson, M.ASCE; Ray G. Ogden; and Rory Bergin (JUNE 2012)

3. Post-COVID-19 modular building review on problem-seeking framework: function, form, economy, and time : Kyung-Eun Hwang, Inhan Kim

4. The State-of-the-Art Application of Modular Construction to Multi-Story

Residential Buildings, Anthony C. Jellen P.E. and Ali. M. Memari PhD, P.E (FEBRUARY 2013)

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6. Analysing precast and modular construction with respect to design and cost: Shubham Jadhav and Amit Kadam (MAY 2022)

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9. Modular construction: From projects to products By Nick Bertram, Steffen Fuchs

10. Feasibility benefits and challenges of modern construction in high rise development in the United States: A developers perspective(September 2012) By Sri Velamati, Bachelor of Science, Economics, University of Pennsylvania

11. Literature Review on Analysis of Modular Building Using E-Tabs Software

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