ASSESSMENT OF CRITICAL FACTORS INFLUENCING CONSTRUCTION TIME IN PREFABRICATED RESIDENTIAL HOUSING

Amila Suljić[1]

[1]International Burch University, Sarajevo, Bosnia and Herzegovina
*corresponding author: amila.suljic@stu.ibu.edu.ba

Paper type: Original scientific paper
Received: 2025-08-22
Accepted: 2025-09-15
Published: 2025-09-30

UDK: 005.8:69.057
DOI: 10.14415/JFCE-923

ABSTRACT:

The needs of today require that everything is available quickly, within reach, and with consistent quality. In construction, prefabrication addresses these demands, especially in prefabricated residential housing. This paper examines the history of prefabrication and technological advancements, focusing on the challenges of such projects and the factors that influence their speed of completion. The organization of the company, work methods, and resources form the foundation of a prefabricated housing project. Key features include the use of BIM software, standardization, and careful pre-planning. Companies should invest in software, machinery, trained staff, and quality materials. Although some factors are beyond control, project management coordinates all participants and resources to ensure successful outcomes. Through interviews and literature review, this paper identifies factors within and beyond company influence, emphasizing the importance of communication and collaboration with investors.

KEYWORDS:

Prefabricated housing, project management, project delivery, internal and external factors, positive and negative impact

1 INTRODUCTION

A residential house project may not appear highly complex in itself, but prefabricated residential construction is often perceived as relatively straightforward, with the use of prefabricated elements enabling faster execution. However, many processes that seem simple on the surface involve complex tasks and require careful coordination. What sets prefabricated construction apart from traditional methods is the use of machinery in a controlled environment, reducing physical labor, minimizing human error and weather-related delays, and notably shortening construction time through the use of ready-made materials. History shows that it takes time for such ideas to take root, supported by industrial and technological development, to enable the rapid delivery of environmentally sustainable housing. Additionally, the success of this construction method depends on the integration of construction, architecture, business, technology, and software tools. This paper aims to identify the key factors that must be aligned and managed to ensure the successful delivery of prefabricated housing projects, through the analysis of existing literature, applied research, and quantitative data.

2 THEORETICAL BACKGROUND

2.1 HISTORY OF PREFABRICATION

It is impossible to discuss history without referencing architecture. From the very beginning, humans sought shelter from the elements and dangers, thereby establishing the foundations of architectural practice. Gradually—through fulfilling their most basic needs—this practice evolved. In the earliest phase, people used readily available materials such as leaves, branches, or animal skin, which could be quickly assembled into temporary shelters and easily transported, anticipating principles of prefabrication. Over time, these provisional structures gave way to more permanent methods, leading to what is now known as traditional construction. The Greeks and Romans—renowned for their temples and carefully planned cities—used finely worked stone, joined by dry-fit connections or secured with iron and bronze clamps. Their achievements rested on rigorous mathematical calculation, precise drawing, and codified design principles. Vitruvius synthesized these ideas in his work "The Ten Books on Architecture", laying the theoretical foundations for both architectural design and structural engineering. [1]

A pronounced need for rapid and efficient construction methods arose during and after both World Wars. Renowned architects—Le Corbusier, Frank Lloyd Wright, Jean Prouvé, as well as the German architects Konrad Wachsmann and Walter Gropius, all of whom found success in the United States—took it upon themselves to devise a solution. This solution entailed the use of lightweight materials that could be produced, transported, and assembled quickly, while still ensuring the comfort of a home—that is, prefabricated housing. [2]

The Industrial Revolution resulted in the continuous production of components and material processing. Over time, it became possible to produce components with identical characteristics, leading to standardization. The machine industry has resulted in increasing automation, accelerating processes and leading to mass production. As products are manufactured and repeated relatively quickly, prices decrease. Continuous development in industry and technology also includes software innovations, and thanks to automation, costs have been reduced, production standardized, and customization increased. [3]

2.2 TYPES OF PREFABRICATION

The basic classification of prefabricated construction is small, medium, and large prefabrication, which essentially depends on the size of the building and the number of components used. Elements can be a certain component or a panel of defined dimensions. Cast in-situ and off-site or factory prefabrication have a similar essence; the same standardized molds are used and are pre-planned, but the production location differs. The methods of assembling prefabricated buildings include open and closed system prefabrication. Open system prefabrication means there is a skeleton onto which prefabricated elements are added, either from one manufacturer or multiple ones, while closed system prefabrication is rigid and can only be assembled by a single manufacturer. Finally, there are partial and total prefabrication, which may or may not include a combination of prefabricated and traditional construction methods. A key part of total prefabrication is modules, which are assembled on-site with exceptional speed and are entirely produced in the factory. [4]

2.3 TECHNOLOGICAL ADVANCES

In architecture, especially in prefabricated construction, the term BIM (Building Information Modeling) is indispensable and in everyday use. A key feature is that it allows all project participants to monitor activities and resources from the beginning to the end of the project, through various phases: preparation, measurements, design, structure, mechanical, electrical, plumbing (MEP), scheduling, and budget tracking. All studies have proven that BIM significantly positively impacts the quality and speed of project execution, reducing time and costs by more than 50%. [5] Naturally, it requires expert personnel and technology that someone must possess. The preparation phase truly being half of the project is demonstrated by BIM’s greatest impact during project preparation. The design phase is carried out precisely and quickly, with possibilities for 2D and 3D project presentations, including sections and views. It also has the capability to detect errors and allows quick corrections and adjustments. Thus, it creates schedules and production requirements, reducing risks. [6] BIM, combined with software programs used by companies, represents a bridge between design, business, and project execution. One of the well-known programs is Enterprise Resource Planning (ERP), which companies use as their database. Within this database, an important part is manufacturing, of course, when it is the nature of the company. In the case of prefabricated houses, production occurs in a controlled environment, meaning constant monitoring must be respected. As part of ERP usage, the Manufacturing Execution System (MES) closely cooperates with BIM.

It is very important that the project has "Flow." "Flow" means that all activities and resources are synchronized and without interruption. This is established using tools for easier project management—the Critical Path Method (CPM) and Gantt Chart. [7]

At the beginning of the 20th century, the time analysis method REFA was developed. To know how much time is needed for a specific task, continuous analyses are necessary for progress and efficiency. Initially, a watch was used as a tool, but nowadays, many programs ensure accuracy and quality. [8]

2.4 BENEFITS AND DRAWBACKS OF PREFABRICATED HOUSING

Table 5: Benefits and Drawbacks [9] [10] [11] [4] [12] [13]

Benefits	Drawbacks
Standardized work – efficient and accelerated	Corrosion and damage
Controlled environment production	Special expertise required for handling elements
Easier and faster customization	Particular attention to joints
Mass production	Expensive and complex transport and logistics plan
Reduced number of subcontractors	Repetition and mass production lead to monotony
Reduced number of working hours and prices	Obligation for the manufacturer to continuously invest in the company, machines, workers, and other resources
Made to be easily transported	Houses are not resistant to natural disasters
Workers and materials are not kept unnecessarily on site	
Ability to recycle	
Sustainable and eco-friendly	
Pollution and noise control during assembly	
Manufacturer can move faster to the next project	
Strategic economy – manufacturing with cheaper labor	
Minimal impact of weather conditions on construction time	

2.5 CONSTRUCTION PROJECT MANAGEMENT IN PREFABRICATED CONSTRUCTION

Since organization is crucial in every project, project management plays the most important role in this regard. The task of project management is to negotiate, plan, organize, lead, and control the preparation, design, production, and execution of works. In this process, the most important factors of prefabrication are: cost, time, quality, environment, design capability, and safety. It has been proven that producing a prefabricated house saves 40% of the time and generates 50% less waste compared to building a traditional house. [11]

Companies have an organizational hierarchy, which means that everyone knows their task, whom they are responsible to, and who they must report to. Therefore, decisions are made faster and easier, specialists are consulted for specific issues, and unnecessary delays are avoided. Problems arising within the company are timely resolved by the responsible parties, as well as through analyses used to detect or improve them. Risk management addresses potential problems that may be internal or external; however, the company cannot influence external risks. [14]

Risks exist during all phases of the project and can impact the project duration as well as resources. Project risks include cost, time, scope and change management, quality and safety, procurement and contracts, information and people management, as well as overall external influences. The Risk Breakdown Structure (RBS) is an important tool used to analyze risks based on urgency and impact, group them, and assign responsible persons. [15]

3 METHODOLOGY

The study employs both qualitative and quantitative data collection methods. Through quantitative data collection, information is investigated from literature, previous research, experiments, and analyses.

Delivering a project on time means coordinating all factors influencing it. Based on quantitative analysis, an interview consisting of 11 questions was created to collect qualitative data. The target respondents are individuals with experience in project management, supervision, or production roles. The questions are focused so that respondents describe in detail all steps and processes belonging to different phases of the prefabricated house project—from initial client contact, documentation processing, and design, to production and final installation. Special attention should be given to individual tasks, the time needed for each, and how schedules are created. Since resources are an indispensable factor in every project, in prefabricated house projects it is important to examine what the company owns, what it procures, and what can be rented. In each question, it is essential to analyze the steps, principles, and practices that provide a time advantage for project completion, as well as the risks that can easily disrupt the entire "flow."

4 RESULTS AND DISCUSSION

4.1 INTERNAL FACTORS

During the interviews, each question and answer focused on factors affecting tasks and steps within the prefabricated house project, emphasizing that every task plays a crucial role where there is no time to waste. At every stage of the project, there are positive and negative factors influencing the project completion time. These factors are divided into internal and external groups, with a clear predominance of internal factors that the company can influence, anticipate, avoid, or plan risk management for. Projects in which tasks are performed efficiently and with quality are preceded by flawless organization, and since implementation is under constant control, the risks from negative factors are reduced.

Table 2: Internal factors – Planning and Preparation

Internal	Positive	Negative
Planning and Preparation	Prepared Check List	Coordination Challenges
	Deadlines Defined	Scheduling Challenges
	Preliminary Planning	Delayed Procurement
	Manufacturing Preparedness	Waiting List
	Systematic Scheduling	Stakeholder Impact
	Project Schedule	
	Procurement Process Consistency	
	Team Structure	
	Accessible Technology	
	Logistics Organization	
	Prepared Documentation	
	Stakeholder Collaboration	

Considering the demand for prefabricated houses, many companies have waiting lists. Customers go through phases of reaching an agreement with sales, design, and organization, and honest communication is essential in order to reach the best solution. What the customer wants usually dictates the way the project is planned, and everything starts with the selection of the plot, house typology, or specific wishes. The flexibility that is seen as a positive aspect for the client can have a negative impact on the project timeline. The beginning is important for defining details, as well as for following a checklist that contains all the critical points of agreement.

Table 3: Internal factors – Design and Standardization

Design and Standardization	BIM	Limited Adaptability
	Standardization	Stakeholder-Oriented
	Design Optimization	Workshop Drawing
	Design Phase Reduction	
	Catalog Design	
	Adaptable Design	
	Machine-Cut Design	
	Error Recognition	

BIM is considered a major advantage in this project. With all its features and functions, it enables precision, efficiency, and speed. Although the influence and wishes of the customers can sometimes complicate things, BIM quickly adapts and accepts changes.

Although in rare cases companies produce their own carpentry—for example, windows that must be made before the walls—in most cases, the production of elements takes place simultaneously. A controlled environment, work safety, training, and timely maintenance ensure that production does not experience delays. Companies organize their operations to prevent problems in advance.

Table 4: Internal factors – Production and Logistics

Production and Logistics	Timely Procurement	Material Supply Dependency
	Manufacturing Assembly	Sequencing
	Process Optimization	
	Simultaneous Manufacturing	
	Logistics Optimization	
	Optimized Delivery	
	Loading Plan	
	Sequence-Free Operation	
	Safety	
	Defect Mitigation	
	Organizational Hierarchy	

Table 5: Internal factors – Assembly and Installation

Assembly and Installation	Accelerated Installation	Subcontractor Collaboration Challenges
	Instant Placement	
	Partition Construction	
	Supervised Work	
	Rapid Occupancy	
	Establishing Loading Plan	

The efficiency of the final steps of the project is actually secured by the initial steps. At the beginning, the logistics plan, transport possibilities, and site accessibility are clearly defined and agreed upon. If the plot is harder to access, the prefabricated elements must be smaller, and the assembly will take longer. This is also important for creating a loading plan that ensures materials and elements are not unnecessarily stored on site and that the installation order is efficient.

Table 6: Internal factors – Coordination and Guidance

Coordination and Guidance	Communication	Miscommunication
	Role Definition	Responsibility Challenges
	Participant Collaboration	Schedule Disturbance
	Subcontractor Management	Project Evaluation Delay

The organizational hierarchy is the backbone of the company, and the order of communication and responsibilities is clearly defined. Subcontractors can cooperate directly with the company, in which case the work is done faster, but subcontractors can also be hired by the investor, which can have consequences on timing. According to the loading plan, houses are stored and wait their turn for installation. The customer is obligated to provide the plot on time, secure the construction site, prepare the machinery, and complete all the preparations agreed upon in the initial contract.

Quality control is carried out on time, including material control, element control during and after production, and before loading for transport. If everything is correct, another milestone in project management is successfully completed.

Table 7: Internal factors – Quality and Control

Quality and Control	Error Mitigation	Documentation Delays
	Continuous Quality Control	Control Delays
	Precision	
	Controlled Environment Production	

4.2 EXTERNAL FACTORS

On the other hand, external factors are usually related to laws and regulations, and the work of authorities and adherence to protocols are beyond the company's influence.

Table 8: External factors

External	Positive	Negative
Planning and Preparation	Standardized Guidance	Authorities Approvals
		International Logistics Planning Challenges
		Licensing Requirements
		Plot Access Uncertainty
		Financial Pressure
Design and Standardization	Precisely Defined Design Regulations	Limited Design Freedom
	Environmental Regulations	
Production and Logistics	Material Standards	Export Challenges
		Traffic Restrictions
		Labor Regulations
		Supply Interruptions
Assembly and Installation	Safety Regulations	Weather Dependency
		Site Access Challenges
Coordination and Guidance	Defined Responsibilities	
Quality and Control	Product Standards and Certifications	Documentation Requirements
	Mandatory Inspections	Inspection Delays
		Changing Standards

Every step of the project includes clearly defined guidelines that help with following laws and regulations. Naturally, since those who enforce regulations must do their part, this can affect the project timeline. Obtaining necessary permits can sometimes take a lot of time, but even that period is accounted for in the project management buffer zone. Transport and export of prefabricated houses, especially from non-EU countries into the EU, requires special attention, and all permits and standards must always be met. Through experience and years of practice, interviewed companies from Bosnia and Herzegovina, Germany, Serbia, and the Czech Republic have, despite external risks, consistently met deadlines and excelled in quality business operations and products.

5 CONCLUSION

Thanks to technological advancements and the development of the machinery industry, it can be concluded that the production of prefabricated houses is widespread. Depending on the country and geographic area, companies establish their headquarters and operate in locations that give them a competitive advantage, influencing client decisions. The success of the research lies in the detailed elaboration of all project phases and is useful to all project participants, with investors being among the most significant. The research shows that investor involvement, communication, and responsibility are key factors. The identification, criticality assessment, action planning, and monitoring of factors and risks could be of valuable importance for further research, given that organization represents a large part of the already accomplished work.

REFERENCES

[1] G. Staib, A. Dorrhofer and M. Rosenthal, Components and systems: Modular construction, Dresden: Kosel GmbH & Co. KG, Altrusied-Krugzell, 2008.

[2] C. Davies, The Prefabricated Home, London: Cromwell Press, Trowbridge, Wiltshire, 2005.

[3] R. E. Smith, Prefab Architecture: A guide to modular design and construction, New Jersey: John Wiley and Sons, Inc., 2010.

[4] S. Gopalakrishnan, Prefabricated structures, Sasurie, 2024.

[5] M. N. Sholeh, S. Fauziyah and R. R. Khasani, "Effect of Building Information Modeling (BIM) on reduced construction time-costs: a case study," *Web of Conferences* , November 2020.

[6] H. Sarvari, M. Rakhshanifar, D. W. M. Chan and N. Banaitiene, "Evaluating the Impact of Building Information Modeling (BIM) on Mass House Building Projects," *Buildings,* 2020.

[7] M. Stevens and W. Zhou, "Enhancing An Industrialised Building System Through Hybrid Information Technologies," in *46th Annual AUBEA Conference*, New Zealand, November 2024.

[8] I. Ekström, "TBW Organisation und Unternehmensführung Band 1," 18 September 2018. [Online]. Available: https://slideplayer.org/slide/14031439/?utm_source=chatgpt.com.

[9] P. K. Adlakha and H. C. Puri, "Prefabrication Building Methodologies for Low Cost Housing," *Institution of Engineers Journal,* pp. 4-9, 2013.

[10] L. Bildsten, "Exploring the opportunities and barriers of using prefabricated house components," *19th Annual Conference of the International Group for Lean Construction,* 15 July 2011.

[11] S. T.-L. Chiu, *An analysis on: The potential of prefabricated construction industry,* 2012.

[12] R. Patwari, "A quantitative study of the sustainability of prefabricated buildings," January 2020. [Online]. Available:

https://www.researchgate.net/publication/350014706_A_QUALITATIVE_STUDY_OF_THE_SUSTAINABILITY_OF_PREFABRICATED_BUILDINGS. [Accessed 25 Oktober 2024].

[13] P. Paudel, S. Dulal, M. Bhandari and A. K. Tomar, "Study on Pre-fabricated Modular and Steel Structures," *SSRG International Journal of Civil Engineering (SSRG – IJCE),* pp. 8-14, 2016.

[14] A. Walker, Project Management in Construction, Chichester: John Wiley & Sons, Ltd., 2015.

[15] O. Cretu, R. Stewart and T. Berends, Risk Management for Design and Construction, Hoboken, New Jersey: John Wiley & Sons, Inc., 2011.