e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:06/Issue:03/March-2024 Impact Factor- 7.868 www.irjmets.com

COMPARATIVE ANALYSIS OF HEALTH AND SAFETY BENEFITS: PREFABRICATED CONSTRUCTION VS. TRADITIONAL BUILDING METHODS IN SINDH

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DOI : https://www.doi.org/10.56726/IRJMETS50096

ABSTRACT

Prefabricated construction, an innovative approach to building, holds immense potential for revolutionizing the construction landscape, yet its implications for worker health and safety in the Sindh region of Pakistan remain inadequately explored. This study addresses this gap by conducting a comprehensive investigation into the health and safety benefits associated with prefabricated warehouse construction in comparison to traditional building methods. Through an extensive literature review, a multitude of advantages linked to prefabricated construction emerged, ranging from environmental benefits like reduced greenhouse gas emissions and improved resilience against natural elements to ergonomic advantages that alleviate physical strain and lower the risk of musculoskeletal injuries among workers. Furthermore, empirical data gathered from 30 construction professionals in Sindh underscored additional benefits, including noise reduction, decreased reliance on formwork, and diminished need for bending during construction activities. Employing the Relative Importance Index (RII) technique, the study ranked these benefits. The mitigation of health and safety threats linked to confined spaces topped the list as the most significant advantage with an RII score of 0.793. Additionally, "Safeguard against natural hazards such as wind and rain" and "Mitigate construction-related falls, trips, and slips" ranked second and third, respectively, with considerable RII scores. However, variations in prioritization across studies highlight the nuanced nature of safety considerations in prefabricated construction, emphasizing the necessity for tailored safety management approaches. Overall, this research sheds light on the substantial health and safety advantages offered by prefabricated construction, thereby informing future practices and policies in the construction industry.

Keywords: Prefabricated Construction, Health and Safety, Environmental Benefits, Relative Importance Index (RII), Sindh Region.

I. INTRODUCTION

The construction industry in developing economies, including Pakistan, serves as a critical driver of economic growth and infrastructure development. Despite its significant contributions to the Gross Domestic Product (GDP) and provision of housing solutions, the sector grapples with challenges, particularly concerning project efficiency and worker safety. Traditional construction methods, prevalent in Pakistan, encounter criticism for inefficiencies, project delays, and safety concerns [1, 2]. In response, there is a burgeoning interest in prefabricated construction as a safer and more efficient alternative. Prefabricated construction involves manufacturing structural components off-site before on-site assembly, offering potential benefits in terms of project streamlining and occupational health and safety [3]. Within this context, the focus on warehouse construction is particularly significant, given its importance in logistics and supply chain management. Traditional warehouse construction methods often lead to prolonged project durations and increased costs, highlighting the need for more efficient approaches [4, 5]. Amidst these considerations, ensuring the health and safety of construction workers remains paramount, especially in environments where regulatory enforcement may vary [6, 7]. Prefabricated construction presents an opportunity to mitigate these risks by reducing on-site activities and creating safer working conditions [8]. Therefore, understanding the role of prefabricated construction materials in enhancing occupational health and safety concerns is crucial for the sustainable development of the construction industry in regions like Sindh, Pakistan.

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II. LITERATURE REVIEW

The construction industry in Pakistan serves as a vital pillar of the economy, employing millions of workers and significantly contributing to the country's GDP. However, alongside its economic contributions, the industry faces persistent challenges, particularly concerning occupational health and safety (OHS) [9, 10].

Prefabricated Construction: A Promising Solution

The adoption of innovative construction methods is crucial to address these challenges and promote safer working conditions. Prefabricated construction emerges as a promising solution, offering benefits such as improved efficiency, enhanced quality control, and reduced on-site hazards.

Occupational Health and Safety Concerns in the Construction Industry

Despite various regulations and efforts to improve safety standards, construction sites remain high-risk environments for workers, with accidents and fatalities occurring at alarming rates [9, 10].

Conceptual Overview of Prefabricated Construction

Prefabricated construction, also known as modular or offsite construction, involves manufacturing building components in controlled factory environments before assembly at the construction site. In the context of warehouses, prefabricated construction offers unique advantages, including rapid deployment, cost-effectiveness, and scalability [11, 12].

However, despite its potential, the utilization of prefabrication in Pakistan's construction industry remains limited, primarily focusing on certain components like doors and window panels. Comparative studies between prefabricated and traditional construction methods provide valuable insights into the advantages and limitations of each approach, particularly in the context of warehouses [13, 14].

Comparative Analysis: Prefabricated vs. Traditional Construction

While prefabricated construction offers superior structural integrity and durability, traditional construction methods allow for greater customization but pose significant risks to worker safety. Moreover, the timeline and cost implications of prefabricated construction vary depending on factors such as project scale and negotiation power [5, 15].

Impact of Prefabricated Construction on Occupational Health and Safety

The impact of prefabricated construction on occupational health and safety (OHS) standards is significant. Prefabrication minimizes on-site hazards and enhances worker welfare by reducing accidents, injuries, and fatalities compared to traditional construction practices. The controlled environment of prefabrication facilities ensures consistency and reliability in quality control measures, further enhancing safety on construction sites [16, 17].

III. METHODOLOGY

This study employs a mixed-methods approach to identify and analyze the health and safety advantages of prefabricated construction compared to traditional building methods.

Literature Review

The advantages of prefabrication concerning health and safety will be identified through an extensive literature review. Peer-reviewed articles, research papers, and industry reports will be systematically searched and analyzed to gather relevant data on the topic.

Open-ended Questionnaire Survey

An open-ended questionnaire survey will be conducted among construction professionals in the Sindh region with a minimum of 8 years of experience. This survey aims to gather qualitative insights and opinions from experts in the field regarding the health and safety advantages of prefabricated construction. Questions will be designed to explore their experiences, observations, and perceptions related to prefabrication in comparison to traditional building methods.

Close-ended Questionnaire Survey

A close-ended questionnaire survey will be conducted among a diverse group of construction professionals, including engineers, architects, project managers, and workers, with varying levels of experience. The questionnaire will include structured questions designed to assess their opinions and perceptions regarding

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the health and safety advantages of prefabricated construction. Data collected from this survey will be quantitatively analyzed using statistical tools to provide a comprehensive understanding of the topic.

Data Analysis

Data collected from the literature review and both questionnaire surveys will be analyzed using appropriate qualitative and quantitative methods. Qualitative data from the open-ended questionnaire survey will be thematically analyzed to identify common themes and patterns related to health and safety advantages of prefabricated construction. Quantitative data from the close-ended questionnaire survey will be analyzed using statistical tools such as descriptive statistics and Relative Importance Index (RII) to examine relationships and trends. The findings from the literature review and both questionnaire surveys will be integrated to provide conclusive results and insights into the health and safety advantages of prefabricated construction.

The research methodology outlined above aims to provide a comprehensive analysis of the health and safety advantages of prefabricated construction compared to traditional building methods. By integrating insights from the literature review and input from construction professionals, this study seeks to contribute to the existing knowledge base and inform decision-making in the construction industry.

IV. RESULTS AND DISCUSSION

This study aimed to comprehensively assess the health and safety advantages offered by prefabricated construction of warehouses compared to traditional building techniques. Drawing upon an extensive literature review and input from construction professionals, a diverse array of benefits associated with prefabricated construction emerged.

The literature review revealed several key advantages of prefabricated construction in enhancing health and safety outcomes that were coded as follows.

Table 1. Health and Safety Advantages of Prefabrication Identified from Literature

S. No.	Advantage Code	Advantage Description	Rank	No. of Reference(s)
1	A1	Reduce environmental risks and lower emissions of greenhouse gases and CO_2.	1st	13
2	A2	Protect against natural elements like wind and rain.	1st	13
3	A3	Minimize waste and reduce pollution during construction.	1st	13
4	A4	Prevent falls, trips, and slips on construction sites.	2nd	8
5	A5	Addresses ergonomic hazards to reduce the risk of MSDs and RSIs.	2nd	8
6	A6	Manage confined spaces to improve health and safety.	3rd	7
7	A7	Reduce the occurrence of fatalities.	3rd	7
8	A8	Minimize manual handling of materials.	4th	6
9	A9	Decrease hand injuries and cuts from sharp objects.	5th	5
10	A10	Lower exposure to chemical hazards.	5th	5
11	A11	Mitigate the risk of electrocution.	5th	5
12	A12	Decrease the likelihood of contact dermatitis.	6th	4
13	A13	Minimize the need for scaffolding.	7th	3
14	A14	Reduce exposure to hazards related to steel reinforcement.	8th	2
15	A15	Decrease reliance on personal protective equipment (PPE).	8th	2

Further insights were gathered through open-ended questionnaires and interviews with 30 construction professionals in the Sindh region, specifically focusing on prefabricated construction of warehouses. These interactions identified three additional health and safety advantages and were coded systematically.

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Table 2. Health and Safety Advantages of Prefabrication Identified from Open-ended Questionnaires of Construction Professionals in Sindh

S. No.	Advantage Code	Advantage Description
1	A16	Decrease noise levels.
2	A17	Minimize the requirement for formwork.
3	A18	Reduce the necessity for bending.

To quantitatively assess the perceived importance of these 18 identified advantages, a structured survey was administered to a variety of construction professionals with varying levels of experience. Respondents were asked to rate each advantage on a 5-point Likert scale. Relative Importance Index (RII) technique was employed to rank the advantages, providing valuable insights into the relative significance attributed to each health and safety benefit associated with prefabricated construction.

$$RII = \frac{\sum(Wi*Xi)}{N*M} \quad \text{..... (i)}$$

Where,

- **Wi** represents the weight assigned to each response category (ranging from 1 to 5 for a 5-point Likert scale).
- **Xi** represents the frequency of respondents selecting each response category.
- **N** is the total number of respondents i.e., 300.
- **M** is the highest possible weight assigned to a response category (in this case, 5 for a 5-point Likert scale).

Table 3. Relative Importance Index (RII) Ranking of Health and Safety Advantages in Prefabricated Warehouse Construction

S. No.	Advantage Code	Advantage Description	Mean	RII	Rank
1	A6	Manage confined spaces to improve health and safety.	3.963	0.793	1st
2	A2	Protect against natural elements like wind and rain.	3.750	0.750	2nd
3	A4	Prevent falls, trips, and slips on construction sites.	3.687	0.737	3rd
4	A3	Minimize waste and reduce pollution during construction.	3.633	0.727	4th
5	A5	Addresses ergonomic hazards to reduce the risk of MSDs and RSIs.	3.623	0.725	5th
6	A10	Lower exposure to chemical hazards.	3.467	0.693	6th
7	A8	Minimize manual handling of materials.	3.327	0.665	7th
8	A9	Decrease hand injuries and cuts from sharp objects.	3.317	0.663	8th
9	A12	Decrease the likelihood of contact dermatitis.	3.307	0.661	9th
10	A1	Reduce environmental risks and lower emissions of greenhouse gases and CO_2.	3.293	0.659	10th
11	A11	Mitigate the risk of electrocution.	3.237	0.647	11th
12	A7	Reduce the occurrence of fatalities.	3.173	0.635	12th
13	A15	Decrease reliance on personal protective equipment (PPE).	3.037	0.607	13th
14	A13	Minimize the need for scaffolding.	3.003	0.601	14th
15	A18	Reduce the necessity for bending.	2.977	0.595	15th
16	A14	Reduce exposure to hazards related to steel reinforcement.	2.957	0.591	16th
17	A17	Minimize the requirement for formwork.	2.957	0.591	16th
18	A16	Decrease noise levels.	2.853	0.571	17th

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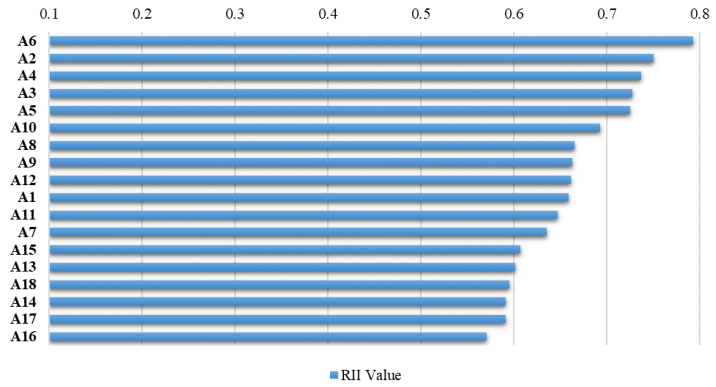

Figure 1. Relative Importance Index (RII) Ranking of Health and Safety Advantages in Prefabricated Warehouse Construction

V. CONCLUSION

The results of this study underscore the substantial health and safety advantages offered by prefabricated construction in warehouse projects located in Sindh, Pakistan. From mitigating environmental hazards to reducing construction-related accidents and minimizing physical strain on workers, prefabricated construction emerges as a promising solution to enhance safety outcomes in the construction industry. The additional insights gathered through open-ended questionnaires and interviews further enrich our understanding of the practical implications of prefabrication in real-world construction settings. By quantitatively assessing the perceived importance of these advantages, this study provides valuable guidance for stakeholders involved in the adoption and implementation of prefabricated construction methods.

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