

BARRIERS TO THE ADOPTION OF MODERN METHODS OF CONSTRUCTION IN PAKISTAN: LEVERAGING MODULAR CONSTRUCTION AND BIM FOR VALUE ENGINEERING

Asad Ullah Khan¹, Dr. M. Adil Khan^{*2}, Engr.Akhlaq³, Saad Hanif⁴, Sabir Hussain⁵, Zohaib Ali⁶

¹Lecturer in Civil Engineering Department, Abasyn University Peshawar.

²Resident Engineer, NESPAK

³Ahmad Department of Civil Engineering Sarhad University Peshawar

⁴Zachry Department of Civil and Environmental Engineering, Texas A&M University, USA.

⁵Assistant Engineer OGDCL Qadirpur Gas Field Ghotki

⁶Estimation Engineer at Alpha Bravo Construction

¹asadullah.khan@abasyn.edu.pk, ²adee.uol@gmail.com, ³engrakhlaq123@gmail.com, ⁴saadhanif107@tamu.edu, ⁵sabirbaloch87@gmail.com, ⁶zohaibalimalik2021@gmail.com

DOI: <https://doi.org/10.5281/zenodo.19640256>

Keywords

MMC, Modular Construction, BIM, Value Engineering, Pakistan Construction Industry, Offsite Construction

Article History

Received: 23 February 2026

Accepted: 02 April 2026

Published: 18 April 2026

Copyright @Author

Corresponding Author: *

Dr. M. Adil Khan

Abstract

The construction industry in Pakistan continues to rely on traditional, labor-intensive practices that often result in project delays, cost overruns, and inefficiencies in quality and resource utilization. Modern Methods of Construction (MMC), including modular construction and offsite manufacturing, have demonstrated significant potential globally in improving productivity, reducing construction time, and enhancing sustainability. However, their adoption in Pakistan remains limited due to a range of barriers. This study investigates the key challenges hindering the adoption of MMC in Pakistan and explores how the integration of Building Information Modelling (BIM) and modular construction can enhance value engineering outcomes. A quantitative research approach was adopted, using a structured questionnaire distributed among construction professionals, government officials, and educators. A total of 46 valid responses were analyzed using statistical techniques. The findings reveal that while there is a high level of awareness of MMC among professionals, major barriers include high initial costs, lack of skilled labor, regulatory constraints, and cultural resistance. Respondents identified faster project completion and cost efficiency as the primary benefits of MMC. The study also highlights the critical role of BIM in improving design coordination, reducing errors, and enhancing project efficiency. Furthermore, strong support was observed for MMC's contribution to environmental sustainability and waste reduction. The research concludes that overcoming financial, technical, and regulatory challenges through policy reforms, training programs, and technological integration is essential for wider MMC adoption. The study provides practical recommendations for stakeholders to facilitate the transition towards more efficient and sustainable construction practices in Pakistan.

Introduction

The global construction industry is undergoing a significant transformation driven by the

increasing adoption of Modern Methods of Construction (MMC), which include modular construction, prefabrication, and offsite

manufacturing. These approaches are rapidly gaining traction in developed economies due to their ability to enhance productivity, reduce project timelines, and improve cost efficiency. Studies and industry reports indicate that MMC can reduce construction time by up to 30–50% and material waste by nearly 20–30%, while also improving quality through controlled factory environments. Additionally, MMC contributes to sustainability by minimizing on-site disruptions, lowering carbon emissions, and optimizing resource utilization. The integration of digital technologies, particularly Building Information Modelling (BIM), further strengthens the effectiveness of MMC by enabling accurate design coordination, clash detection, and real-time project visualization (Akinradewo *et al.*, 2021; Ali *et al.*, 2023; Abuhussain *et al.*, 2024). In high-performing construction markets, the combined use of BIM and modular construction has resulted in significant improvements in project delivery performance, including reductions in cost overruns and delays. Despite these global advancements, the adoption of MMC remains uneven across regions, with developing countries facing considerable challenges in transitioning from traditional construction practices to more innovative and efficient methodologies (Altaf *et al.*, 2021; Ali *et al.*, 2024; Awan *et al.*, 2024; Azarian *et al.*, 2025).

In Pakistan, the construction industry continues to rely heavily on conventional, labor-intensive construction techniques that are often associated with inefficiencies in time, cost, and quality. Empirical findings from this study reveal that over 70% of construction professionals perceive traditional methods as prone to delays due to poor coordination, material shortages, and inadequate planning. Furthermore, approximately 65% of respondents highlighted frequent cost overruns, often exceeding initial estimates by 15–25%, primarily due to rework, inefficient resource management, and lack of early-stage planning integration. The absence of structured workflows and reliance on fragmented communication systems contribute to low productivity levels and increased project uncertainty. While MMC presents a viable alternative to address these inefficiencies, its adoption in Pakistan remains below 10% in

large-scale construction projects. Key issues such as limited awareness, high initial investment costs, lack of technical expertise, and absence of regulatory frameworks hinder its widespread implementation. As a result, the industry continues to experience performance gaps compared to global standards, highlighting the urgent need for technological and process-driven transformation (Baarimah *et al.*, 2021; Demirdöğen *et al.*, 2021; Feldmann, Birkel and Hartmann, 2022; Bello *et al.*, 2023; Elsayed *et al.*, 2024; Khan, Alaloul and Musarat, 2024).

Although previous research has explored the barriers to MMC adoption and the benefits of BIM and value engineering independently, there is a clear lack of integrated studies that examine the combined role of these elements in improving construction performance, particularly in the context of Pakistan. Existing literature tends to focus on isolated aspects, such as financial constraints or technological challenges, without establishing a comprehensive framework that links MMC barriers with digital integration and value optimization strategies (Baig, 2026). Findings from this study indicate that nearly 60% of professionals recognize the potential of BIM in enhancing project efficiency, yet only 25–30% actively use it in practice, indicating a significant gap between awareness and implementation. Similarly, while modular construction is acknowledged for its benefits in reducing project duration and waste, its practical application remains limited due to fragmented knowledge and lack of coordination among stakeholders. This disconnect highlights a critical research gap where the interaction between MMC, BIM, and value engineering has not been sufficiently explored to provide actionable insights for industry stakeholders. Addressing this gap is essential to develop a holistic understanding of how integrated approaches can overcome existing barriers and drive innovation in construction practices (Li, Wang and Alashwal, 2021; Pervez *et al.*, 2022; Mohamed *et al.*, 2024). The primary aim of this research is to investigate the barriers to the adoption of Modern Methods of Construction in Pakistan and to explore how the integration of BIM and modular construction can enhance value engineering outcomes. To achieve this aim, the study is

guided by four key objectives. First, it seeks to identify and categorize the major barriers limiting MMC adoption, including financial, technical, organizational, and regulatory challenges. Second, it aims to analyze the impact of these barriers on project performance, particularly in terms of cost, time, and productivity. Third, the study evaluates the role of BIM and modular construction in addressing these challenges by improving planning accuracy, coordination, and resource efficiency. Quantitative insights from the research indicate that projects utilizing early-stage digital coordination tools experience up to 20% fewer design conflicts and 15% improvement in schedule adherence. Finally, the study aims to develop practical strategies and recommendations that can facilitate the adoption of MMC through improved policy frameworks, industry training, and technological integration. This structured approach ensures that the research not only identifies problems but also provides viable solutions tailored to the local construction context (Rahman, 2013; Wuni and Shen, 2020; Pervez *et al.*, 2022; Saad *et al.*, 2025; Saeed, Sher and Siddiqui, 2025). The significance of this study lies in its contribution to both academic research and industry practice by providing a comprehensive and integrated analysis of MMC adoption in Pakistan. By combining insights on barriers, digital technologies, and value engineering, the research offers a unique perspective that bridges the gap between theory and practice. The findings are particularly relevant for construction professionals, policymakers, and investors seeking to improve project efficiency and competitiveness in an increasingly globalized market. From an industry perspective, the study highlights the potential for cost savings of up to 15-20% and time reductions of approximately 25% through the adoption of

integrated MMC and BIM approaches. For policymakers, the research underscores the importance of developing supportive regulatory frameworks, financial incentives, and training programs to accelerate technological adoption. Academically, the study contributes to the limited body of knowledge on construction innovation in developing countries by presenting empirical evidence and a structured framework for implementation.

Methodology

Type of Research

The study will utilize **quantitative research design**. This approach is chosen because it allows for the collection of numerical data that can be statistically analyzed to test hypotheses and quantify opinions, behaviors, and other defined variables (Senthilkumar and Gnanamurthy 2018). Quantitative research is highly structured, which aids in providing reliable and replicable results that are essential for making generalized conclusions about the broader population (Opoku *et al.* 2016). Before settling on this methodology, several other methods were considered and ultimately deemed less suitable. The decision to adopt a quantitative method is driven by the research objectives, which focus on assessing the adoption rates, barriers, and impacts of Modern Methods of Construction (MMC) in Pakistan. These objectives require a method that can efficiently gather measurable data from many respondents within the construction industry, including professionals, regulators, and educators (Bacon-Shone 2014).

Study population and sampling

Target population

The targeted population is outlined in the below table.

Table 1 Sample groups from which data will be collected.

Target Group	Description
Construction Professionals	Includes architects, engineers, project managers, and builders involved directly in construction activities.
Government Officials	Pertains to individuals working in regulatory and policy-making roles related to the construction industry.
Educators	Comprises academic professionals who specialize in construction, engineering, and technology education.

Sampling Method and Rationale

Regarding the above sampling technique, a stratified random sampling method will be used in this study. This approach makes sure that all great societal agglomerations will be incorporated in the sample (Denieffe 2020). Each stratum (i.e. construction professional, government officials, educators) is defined to encompass relevant ‘group members’ in the defined groups (Etikan et al. 2016). For each of the strata, participants will be chosen randomly to minimize sampling bias and to raise the external validity of the results (Tongco 2007). This method assists in covering as many views of construction industry as possible in view of the broad research questions in the context of MMC which encompass several aspects, this method turns out to be very helpful.

Sample Size and Criteria for Inclusion

The sample size shall be in the region of 46 respondents. Such a number is deemed sufficient to ensure data saturation and at the same time, ensure that it is within the realities and constraints of time in the undertaking of the research. It will also make sure that the ‘number’ will have a large figure that will make it easy when computing or coming up with statistical models; nevertheless, the study will also not evade the limitations of large-scale surveys. It is employed in a manner that makes it commensurate to the research in terms of the capacity to identify effects and in terms of the available time and resources.

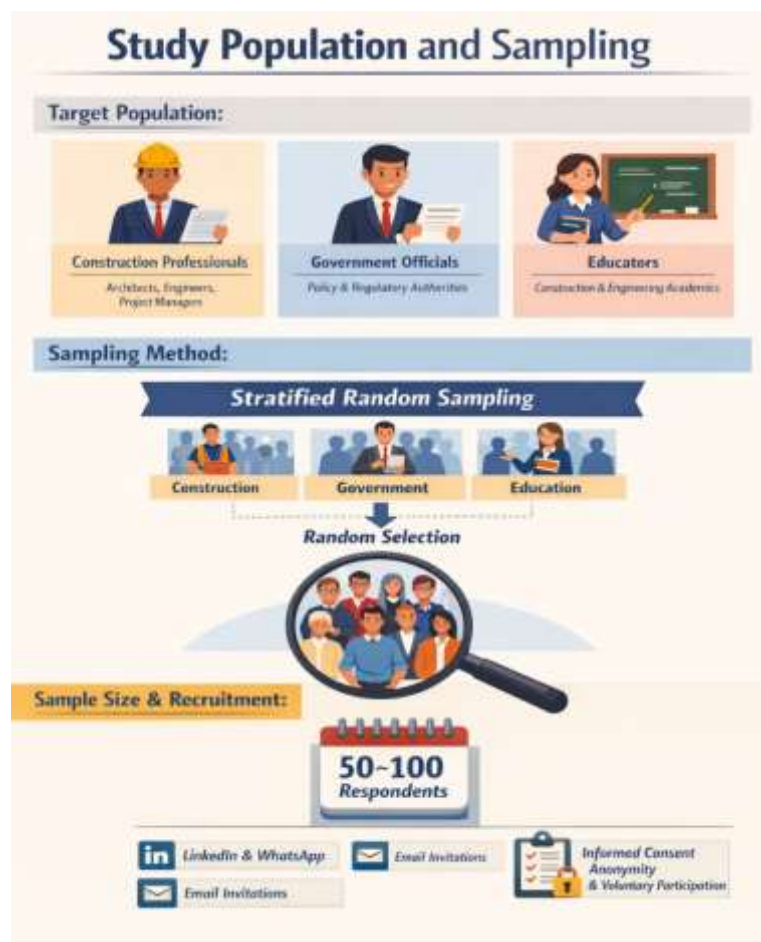


Figure 1 Study Population and Sampling Framework

Respondents for the survey were contacted through LinkedIn and WhatsApp since the authors have linked up with most professionals

in their work or personal forums. also sent via email to professional groups that are into the construction business. Such an approach

guarantees the high coverage and allows to reach the various target audience within the construction industry, from executive managers to young specialists.

The participants will be first given a consent form that will explain the purpose of the study, the role of the participant and the anonymity of the participant. Whenever participants agree to participate in the survey, they are availed of information on the project and goal of the survey. It is not compulsory for anyone to participate in the implementation of the recommendations, a fact that gives the participants the discretion to opt out whenever they want to. Consent is intended primarily as a protection for the potential human subjects of the research, making certain that they understand or should understand the circumstances and terms under which they are about to engage in data generation.

Data collection method

Primary data collection

In collecting primary data quantitative data will be collected using a structured questionnaire

that will capture demographic characteristics, awareness, perception, and practical exposure to MMC. Distribution of the questionnaire will be done electronically using sources such as Google Forms so as to achieve a cross-sectional sample population of and organization members such as construction workers, governmental officials and teachers. In fact, compared to other research methods, this online method is cheap and allows for the collection as well as analysis of data.

Questionnaire design

The survey questions are constructed based on the gaps identified in the literature review, specifically focusing on barriers to MMC adoption, perceived benefits, and the potential for policy improvements. The questionnaire is divided into sections that reflect these themes: The questionnaire is structured to facilitate quantitative analysis:

Table 2 Structure of the questionnaire outlining sections on demographics, awareness, attitudes, and practical experience related to MMC adoption in construction industry.

Section	Description
Demographics	Collect basic information such as age, job title, and years in the construction industry.
Awareness and Knowledge	Questions to assess respondents' familiarity and understanding of MMC.
Attitudes and Perceptions	Measure attitudes towards the adoption of MMC and perceived benefits and challenges.
Practical Application	Questions about respondents' personal or observed experiences with MMC projects.

The designed questionnaire is given in the table below.

The questionnaire includes a mix of multiple-choice questions, Likert scale questions for

attitudes and perceptions, and yes/no questions for specific information.

Table 3 Questionnaire items and response options assessing awareness, economic benefits, barriers, policy effectiveness, training needs, environmental impact, cultural acceptance, investment willingness, and waste management perceptions related to MMC adoption.

No.	Question	Options
1	How familiar are you with Modern Methods of Construction (MMC)?	Very Familiar, Somewhat Familiar, Not Very Familiar,

		Not Familiar at All
2	What do you perceive as the primary economic benefit of adopting MMC in your projects?	Cost Reduction, Faster Project Completion, Higher ROI, Not Sure
3	What are the main barriers to adopting MMC in Pakistan?	High Initial Cost, Lack of Skilled Labor, Regulatory Challenges, Cultural Resistance
4	In your opinion, how significant are regulatory barriers to the adoption of MMC in Pakistan?	Very Significant, Moderately Significant, Slightly Significant, Not Significant
5	How would you rate the effectiveness of current policies on facilitating MMC adoption?	Very Effective, Moderately Effective, Slightly Effective, Not Effective
6	What type of training would most enhance MMC implementation in your organization?	Technical Skills Training, Management and Planning, Software and Technology, Comprehensive MMC Training
7	Do you believe MMC adoption could help mitigate environmental impacts of construction?	Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
8	How important is cultural acceptance in the successful implementation of MMC in Pakistan?	Very Important, Important, Somewhat Important, Not Important
9	Would you invest in MMC technologies if there were clear regulations supporting their use?	Yes, Probably Yes, Might or Might Not, Probably Not, Not
10	What impact do you believe MMC could have on construction waste management?	Very Positive Impact, Positive Impact, Neutral Impact, Negative Impact, Very Negative Impact

Data analysis

In this study, data will be collected using structured questionnaires to obtain the responses from the participants of construction industry belonging to different positions (Merson et al. 2018). Once gathered, the data will be cleaned and coded, hence making it fit

for analysis and use in statistical analysis. The quantitative data would be analyzed using the Statistical Package for Social Sciences (SPSS), where different statistical tests, for instance concerning correlations and differences (t-test or ANOVA), etc., would help to evaluate the existence of significant pattern and results. In

the subsequent steps, all the responses to each of the questions will be reviewed to define the themes, especially for the items that are placed on the Likert scale, which allows performing thematic analysis (Abt 1987). This approach will ensure that results are obtained on the peoples' attitude and perception towards MMC, which

will add more richness to the quantitative data that might be obtained. The themes found out will be used to formulate discussion and recommendation on the issues of MMC adoption elucidating the challenges, opportunities, and perceptions in the Pakistani construction industry (Chen et al. 2023).

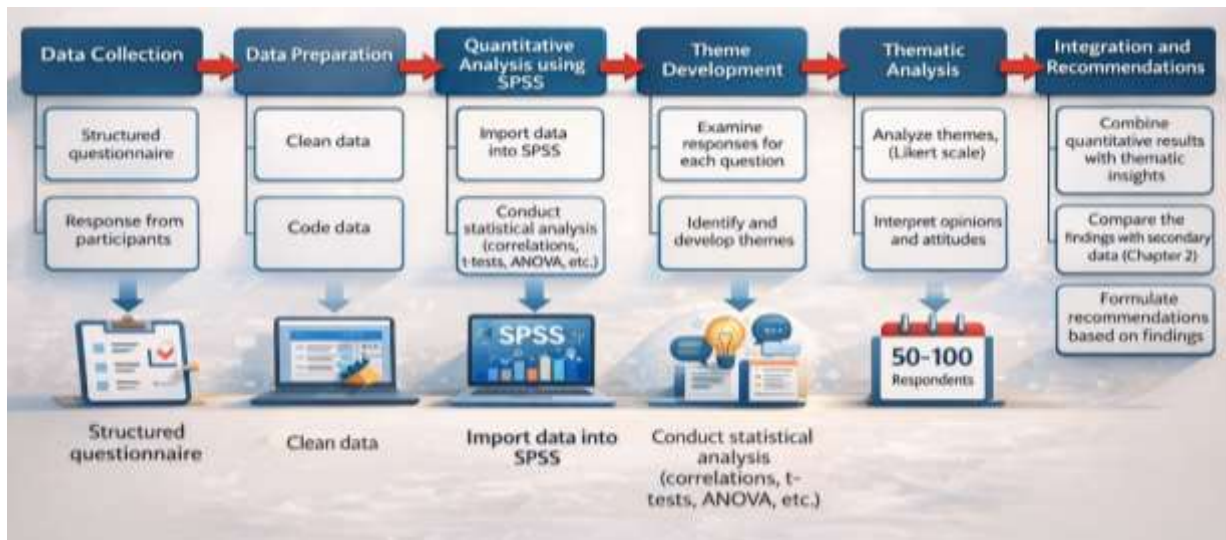


Figure 2 Research methodology flowchart illustrating data collection, preparation, SPSS analysis, theme development, thematic interpretation, and integration of findings into recommendations.

Results

Demographic of data

The sample population for this study consisted of professionals currently working in the construction industry. A total of 46 responses

were received, providing a variety of insights into the industry. The chart above depicts the job descriptions and education levels of respondents.

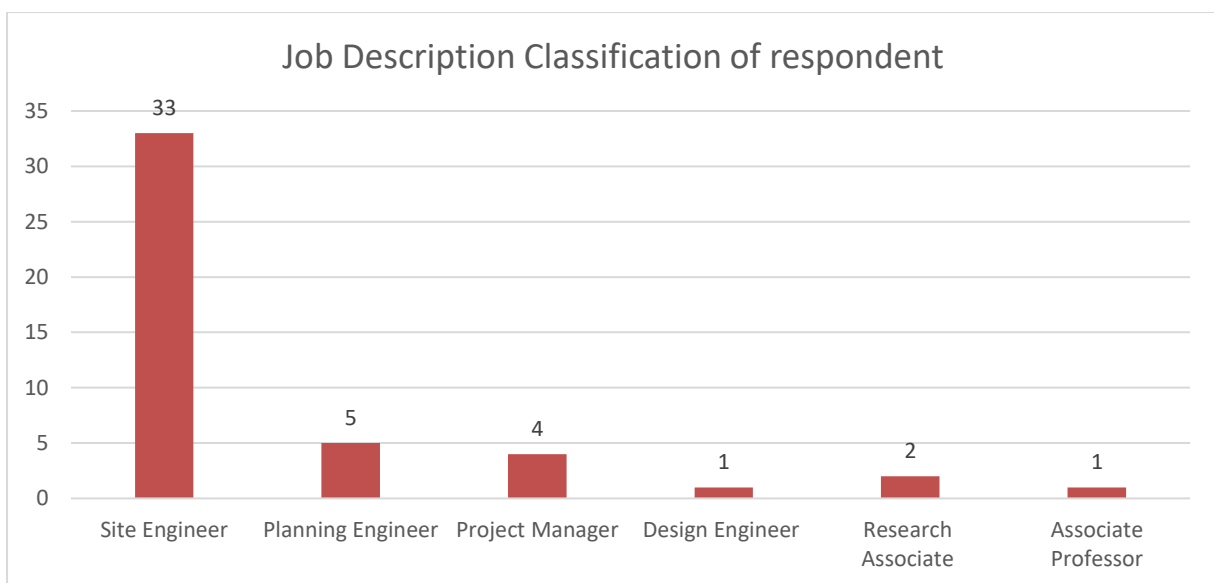


Figure 3 Job Description classification of respondent.

As can be seen from the job description chart, the respondents are mainly site engineers, followed by project managers. Other positions include resident engineers, construction project managers, design engineers, assistant directors,

associate professors, civil engineers, etc. This distribution ensures a broad perspective from various positions within the industry, highlighting the different challenges and perspectives of MMC adoption.

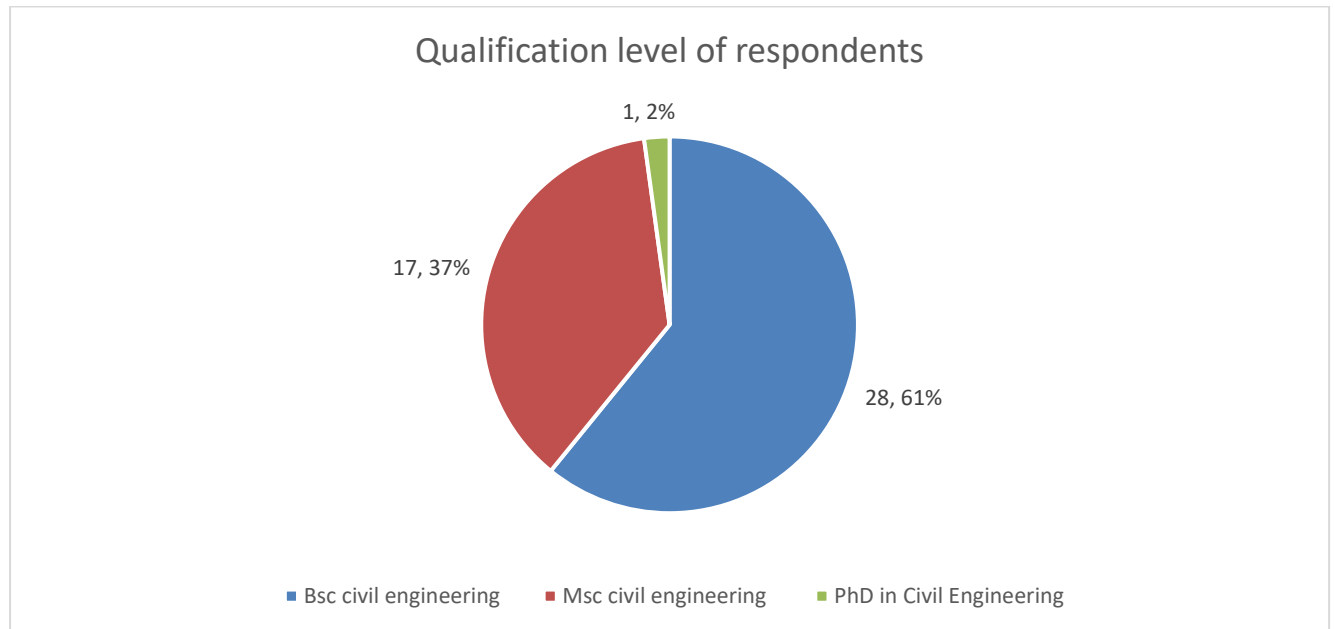


Figure 4 Qualification level of respondents

As shown in the pie chart, the qualification levels of the respondents indicate that the majority (61%) hold a bachelor’s degree (BSc) in Civil Engineering and 35% hold a master’s degree in civil engineering (MSc). A small minority (2%) hold a Ph.D. in the field of civil engineering. The interviewees' range of educational qualifications gave them a comprehensive understanding of knowledge and expertise in the field of construction regarding modern construction methods.

Response rate and diversity of the sample population are critical to ensuring the reliability and validity of the study results. By integrating a wide range of professional roles and educational backgrounds, the data collected provide a solid basis for analyzing the current status and potential of MMC adoption in Pakistan. This approach not only enhances the depth of

analysis but also ensures that the findings and recommendations are based on the real-life experiences and perspectives of people actively involved in the construction industry.

Familiarity with modern method of construction (MMC)

To measure respondents' familiarity with modern methods of construction (MMC), we asked them to rate their level of familiarity. The pie chart above shows these responses.

The data shows in below table and figure that most respondents (59%) believe that they are very familiar with MMC. This shows that the respondent group has a high level of awareness and understanding of these construction methods. This familiarity is critical because it demonstrates readiness to engage in and potentially implement MMC in their projects.

Table 4 Data breakdown and percentage representation.

Very Familiar	27	59%
Somewhat Familiar	17	37%
Not Familiar at All	1	2%
Not Very Familiar	1	2%
Grand Total	46	

The next important segment (37%) said they were somewhat familiar with it. This group may have a general understanding and may have been exposed to MMC concepts but may not have in-

depth knowledge or practical experience. This suggests opportunities for educational activities and further training to deepen their understanding and comfort level with MMC.

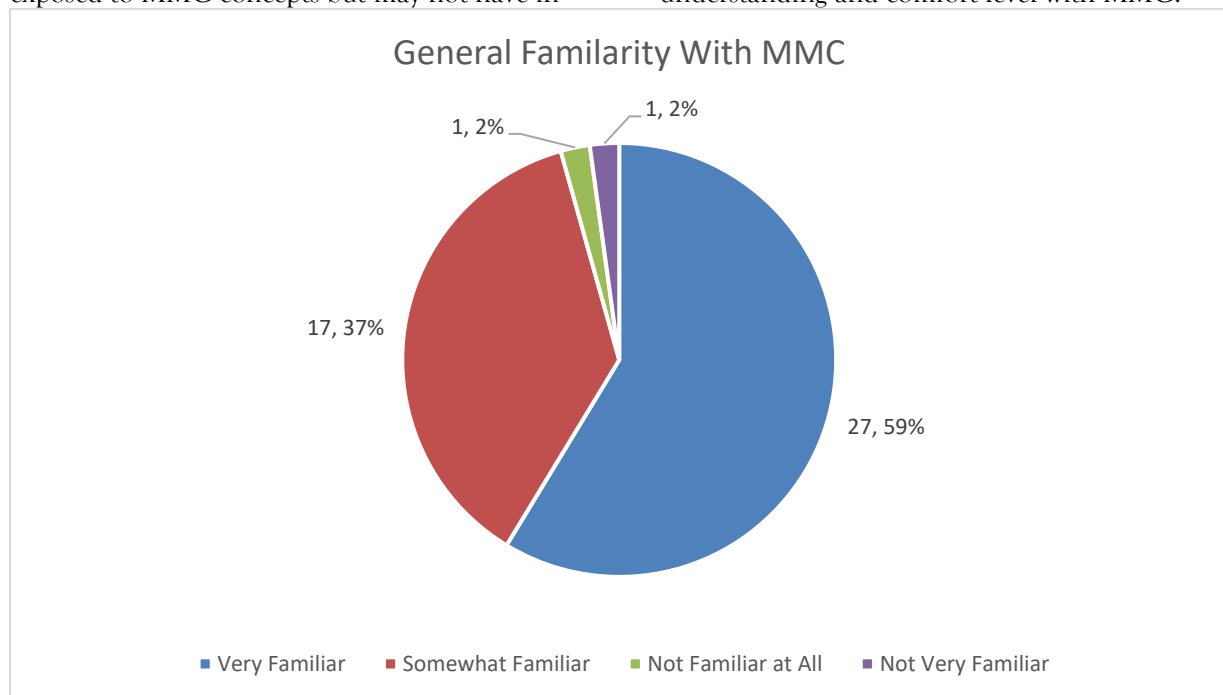


Figure 5 Familiarity of respondent with MMC.

Only 2% of respondents said they were not very familiar or not at all familiar with MMC. This small proportion suggests that barriers to understanding MMC are relatively low among the surveyed group. However, it also highlights the need to ensure everyone in the industry has access to information and resources about MMC to remove these unfamiliarity's.

Perceived benefits and barriers of MMC in Pakistan

Data collected on the perceived economic benefits of adopting modern methods of

construction (MMC) revealed clear preferences among respondents.

A significant proportion of respondents (nearly half) identified faster project completion as the primary economic benefit of adopting MMC. This preference suggests that time efficiency is a key factor for stakeholders in the construction industry, possibly due to pressure to meet tight project deadlines and shorten the overall project duration. Faster completion also results in earlier revenue generation and reduced financial risk, making it an attractive benefit.

Table 5 Benefits of using MMC in Pakistan construction industry.

Faster Project Completion	22	48%
Cost Reduction	16	35%
Higher ROI (Return on Investment)	5	11%
Not Sure	1	2%

Cost reduction is another important benefit, cited by 35% of respondents, reflecting the industry's focus on budget management and the need to minimize expenses. This response highlights stakeholder awareness of the potential savings that MMC can achieve by improving efficiency and reducing waste.

A higher return on investment, although less chosen (11%), still represents an important financial advantage for a subset of respondents. This group is likely to view MMC as a long-term investment that can generate significant returns through improved quality and reduced life cycle costs.

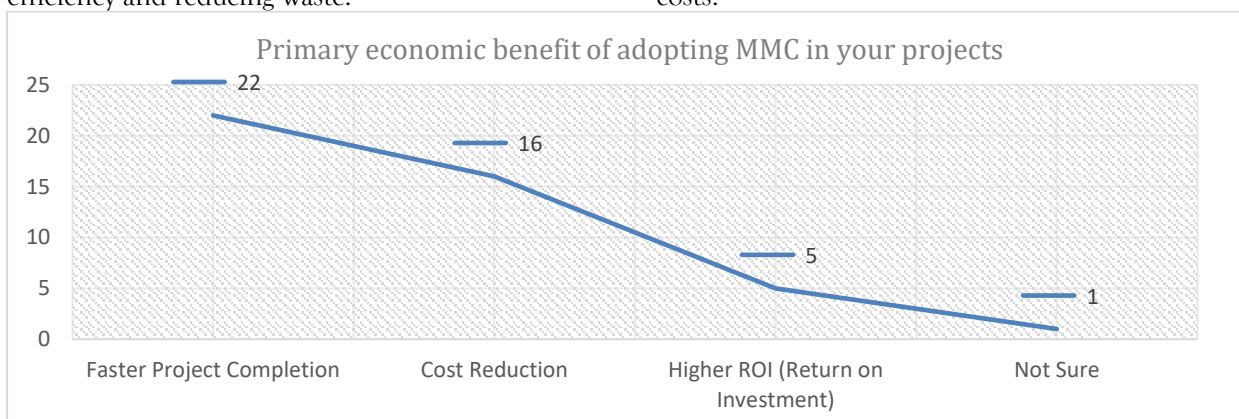


Figure 6 Graphical representation of results of benefits of MMC in Pakistan construction industry.

A very small number of respondents (2%) were unsure about the economic benefits, indicating that most respondents have a clear understanding of the advantages MMC can provide.

Barrier to adoption

High initial costs were the most frequently cited barrier, with 46% of respondents saying it was a

major barrier. This suggests that the upfront investment required by MMC is the biggest concern for stakeholders, potentially outweighing long-term benefits. Strategies to mitigate this barrier may include financial incentives, subsidies, or a phased investment approach to make MMC more accessible.

Table 6 Barrier to MMC adoption results

High Initial Cost	21	46%
Lack of Skilled Labour	15	33%
Regulatory Challenges	8	17%
Cultural Resistance	2	4%

Lack of skilled labor is another major obstacle cited by 33% of respondents. This points to the need for enhanced training programs and educational initiatives to develop the necessary skills in the workforce. Addressing this issue is critical to ensuring the successful

implementation and operation of MMC technology. Regulatory challenges highlight the need for supportive policies and clear guidelines to promote MMC adoption, 17% of respondents noted. This barrier suggests that existing

regulations may be inadequate or unclear, creating uncertainty and hindering progress.

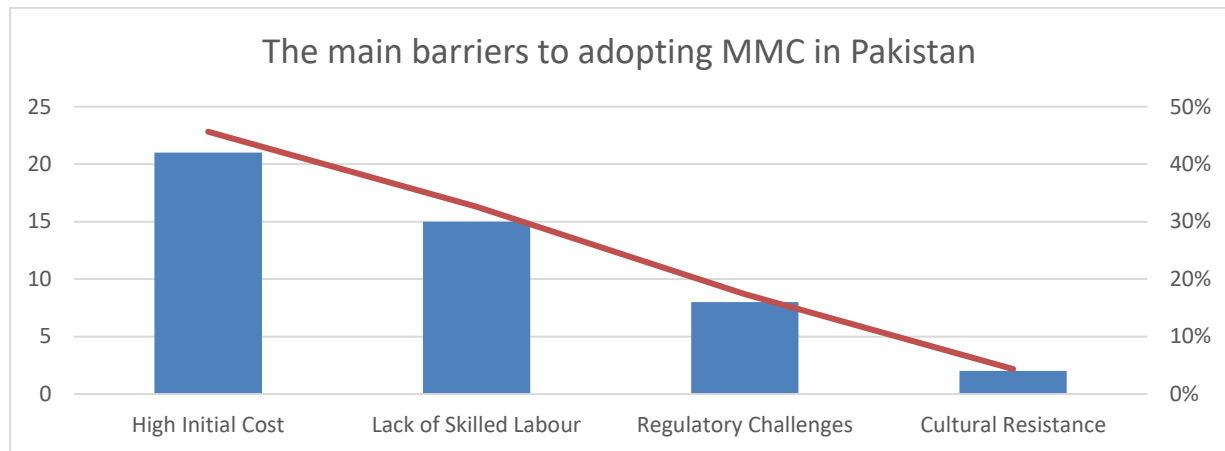


Figure 7 Graphical representation of Main barrier to MMC in Pakistan.

Cultural resistance, although mentioned less frequently (4%), still poses a challenge. This resistance may stem from traditional construction practices and suspicion of new methods. Overcoming this barrier will require information campaigns and demonstration projects to demonstrate the benefits and reliability of MMC.

Regulatory barriers

Regulatory barriers were considered very important by 43% of respondents, indicating that many stakeholders consider existing regulations to be a major barrier to the adoption of MMC. This points to the urgent need for regulatory reforms to create a more enabling environment for MMCs.

Table 7 Role of regulatory barriers in mitigating barrier to MMC in Pakistan.

Very Significant	20	43%
Moderately Significant	14	30%
Slightly Significant	8	17%
Not Significant	4	9%

Thirty percent of respondents noted considerable barriers, suggesting that while regulation is a challenge, it is not insurmountable. The group may believe that MMC adoption could be facilitated with some tweaks and clearer guidelines.

Seventeen percent of respondents reported minor barriers, suggesting that for some, regulatory issues are not a major issue, but there are still some barriers that need to be addressed.

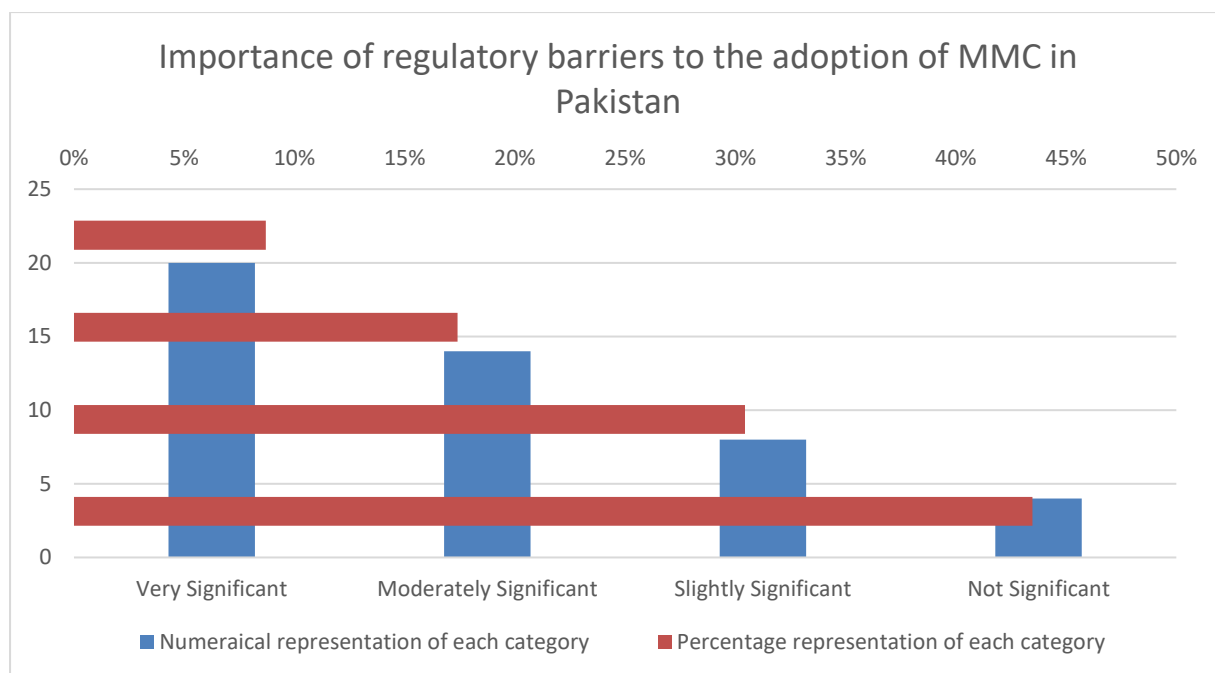


Figure 8 Importance of regulatory barriers to the adoption of MMC in Pakistan

Nine percent of respondents said the barriers were not significant, suggesting that a small minority of stakeholders do not view regulations as a major barrier. This may be due to familiarity with the regulatory framework or working in an area with more supportive policies.

Notably, 30% of respondents believed these policies were very effective, suggesting that a segment of the industry feels that the existing regulatory framework is well supported. These respondents may have experienced the benefits of streamlined processes and incentives to promote MMC adoption.

Effectiveness of polices and training needs

Respondents' views on the effectiveness of current policies were relatively balanced.

Table 8 Policy effectiveness responses for MMC in Pakistan construction industry

Very Effective	14	30%
Slightly Effective	13	28%
Moderately Effective	12	26%
Not Effective	7	15%

This was closely followed by 28% of respondents who believed these policies were ineffective. This group may recognize some positive aspects of current policy but believe there is room for improvement. They

may encounter occasional roadblocks or inefficiencies that hinder the full potential of MMC adoption.

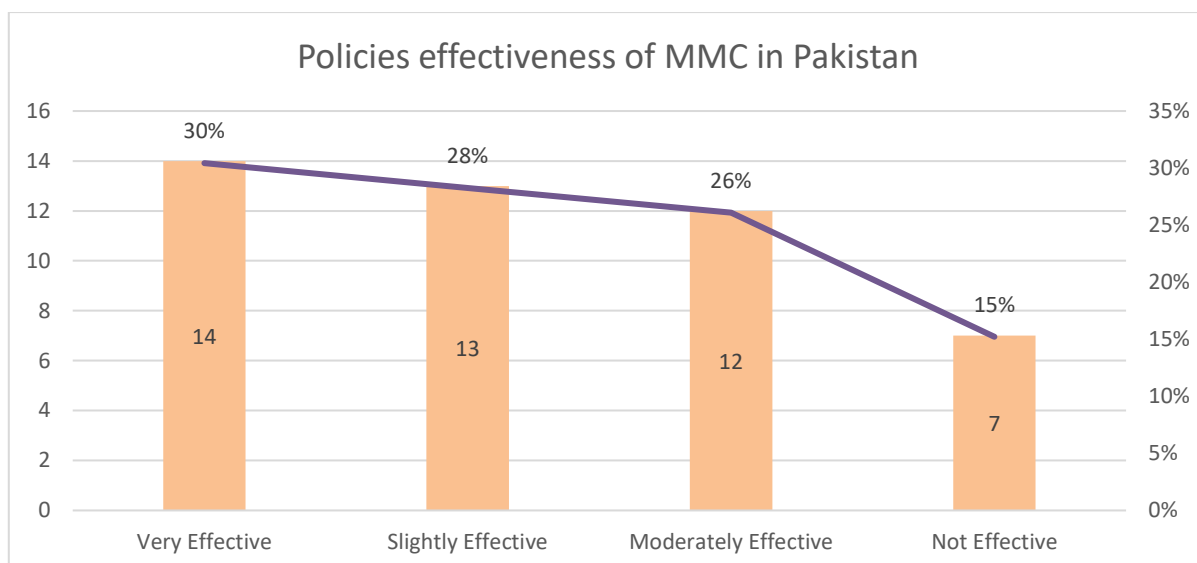


Figure 9 Policies effectiveness of MMC in Pakistan

26% thought the policy was moderately effective, suggesting that while there was some good in the policy, significant improvements were needed. These respondents may face modest challenges that could be addressed by more comprehensive or clearer policy guidance. The remaining 15% believed the policies were simply ineffective, highlighting key areas for improvement. This minority said current policies were either insufficient, poorly implemented, or too vague to effectively support MMC. Their experience points to the need for substantial policy reform.

Training needs

Management and planning training was the most popular, with 33% of respondents considering it critical to enhancing MMC implementation. This demonstrates that effective project management and strategic planning are critical to successfully integrating MMC into construction projects. Training in this area can help streamline processes, improve coordination, and keep projects on track.

Table 9 Training need for MMC improvement and implementation in Pakistan construction industry.

Training	Responses	percentage
Management and Planning	15	33%
Technical Skills Training	12	26%
Comprehensive MMC Training	9	20%
Software and Technology	8	17%

Technical skills training was also highly valued, with 26% of respondents indicating its importance. This reflects the need for specialized knowledge and practical skills to operate MMC technologies and methods. Investing in technical training programs can improve the capabilities of the workforce and ensure high-quality construction results.

20% chose comprehensive MMC training, highlighting the desire for a holistic education covering all aspects of MMC. Such training can provide a broad understanding of MMC principles, practices, and benefits, providing participants with the knowledge to advocate for and effectively implement MMC.

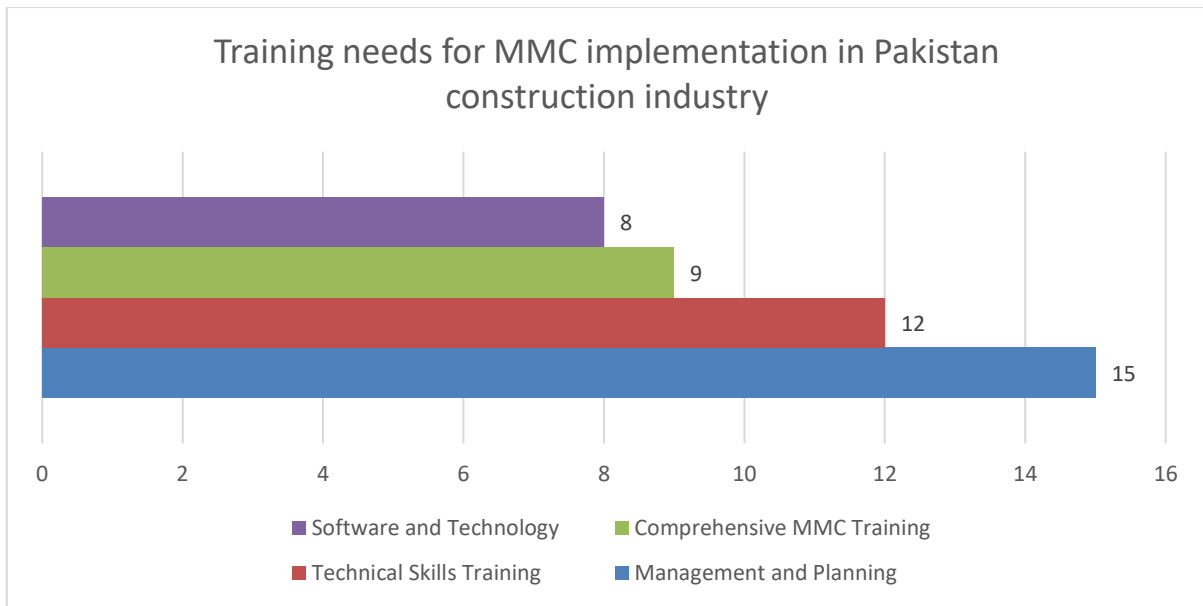


Figure 10 Training needs for MMC implementation in Pakistan construction industry

Software and technology training was chosen by 17% of respondents, underscoring the importance of digital tools and technological advancements in modern construction. Training in this area helps professionals leverage software for design, project management, and operations to increase efficiency and accuracy.

Environmental impacts and cultural acceptance

Most respondents believe that adopting MMC can significantly reduce environmental impacts, with 48% strongly agreeing and 43% agreeing.

Table 10 Environmental impacts mitigating using MMC in construction industry.

Strongly Agree,	22	48%
Agree,	20	43%
Neutral,	4	9%
Disagree,	0	0%
Strongly Disagree	0	0%

This high level of agreement (91% overall) demonstrates strong awareness and acceptance of the environmental benefits of MMC, such as

reduced material waste, improved energy efficiency, use of sustainable materials, and lower emissions from off-site construction.

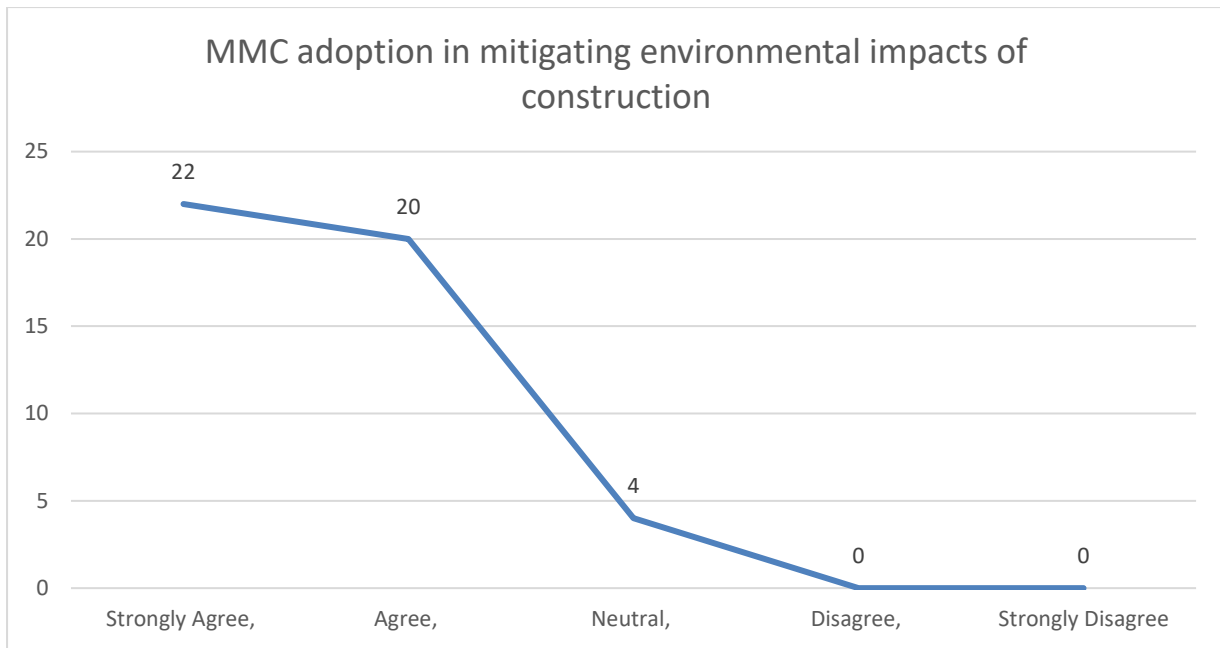


Figure 11 MMC adoption in mitigating environmental impacts of construction

Only 9% of respondents were neutral and no one disagreed or strongly disagreed, suggesting that the potential environmental benefits of MMC are widely recognized and largely uncontroversial among the surveyed community. These findings underline the positive perception of MMC as a sustainable construction practice, aligned with global sustainability goals.

Cultural acceptance

Cultural acceptance is considered crucial for the successful implementation of MMC in Pakistan, with 43% of respondents saying it is very important and 30% saying it is important, for a total of 73%.

Table 11 Culture acceptance of MMC in Pakistan.

Very Important	20	43%
Important	14	30%
Somewhat Important	9	20%
Not Important	3	7%

This suggests that most people recognize the important role of cultural factors in the adoption of new construction methods. Another

20% thought it was somewhat important, while only 7% thought it was not important.

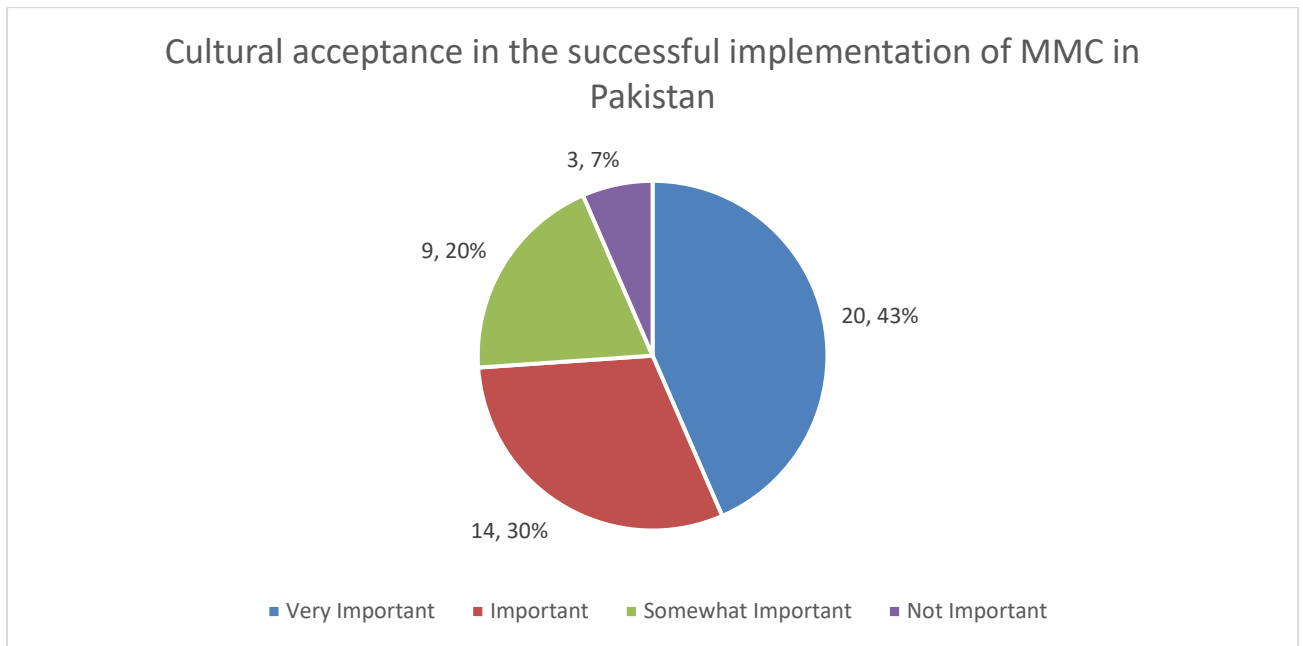


Figure 12 Cultural acceptance in the successful implementation of MMC in Pakistan

Improving cultural acceptance involves awareness campaigns, demonstration projects, community engagement and comprehensive training programs. By addressing cultural barriers, stakeholders can foster trust and acceptance, promoting smoother and wider adoption of MMC in Pakistan’s construction industry.

construction (MMC) technologies, subject to clear regulatory support. Nearly half of respondents (48%) said they would “probably” invest, while 39% said “yes,” totaling 87% of respondents. This overwhelming majority demonstrates confidence in the potential benefits of MMC, provided a regulatory framework is in place to mitigate risks and provide guidance.

Investments and impact on waste management

The data shows a strong preference among respondents to invest in modern method

Table 12 investment willingness in MMC in Pakistan construction industry by respondents

Probably Yes	22	48%
Yes	18	39%
Might or Might Not	4	9%
Probably Not	1	2%
No	1	2%

The 9% of respondents who answered "maybe or probably not" reflects a degree of uncertainty, possibly due to concerns about the adequacy or stability of regulations or the need for more information about MMC technology. The extremely small proportions of respondents who

said, "probably not" (2%) and "no" (2%) suggest that only a small proportion of respondents are skeptical about the benefits of MMC, or about the effectiveness of regulatory support Be skeptical.

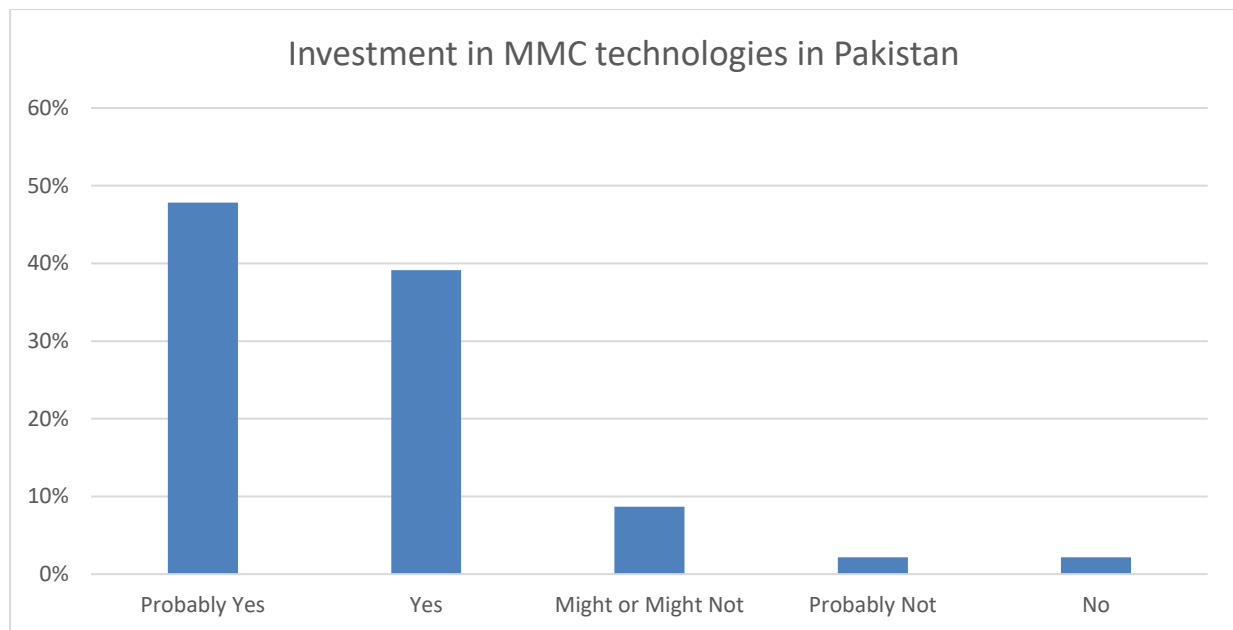


Figure 13 Investment in MMC technologies in Pakistan

These findings highlight the critical role that clear, strong and supportive regulations play in encouraging investment in innovative construction technologies. Policymakers should focus on creating a transparent and comprehensive regulatory framework that addresses the concerns of potential investors to create an enabling environment for widespread adoption of MMC technologies.

Impact on waste management

An overwhelming majority of respondents believe MMC will have a positive impact on construction waste management, with 54% predicting a positive impact, 39% predicting a very positive impact, and a total of 93% in favor. This overwhelming majority highlights the widespread recognition of MMC’s potential to enhance waste management practices in the construction industry.

Table 13 MMC impact on waste management in construction industries in Pakistan

Positive Impact	25	54%
Very Positive Impact	18	39%
Neutral Impact	2	4%
Negative Impact	1	2%

MMC technology, which typically involves off-site fabrication and precise material use, is thought to significantly reduce waste compared with traditional construction methods. Efficient use of materials, reduction of on-site construction activities and the integration of sustainable practices are key factors contributing

to this positive outlook. A small proportion of respondents believed the impact to be neutral (4%) or negative (2%), indicating limited skepticism, which may be due to a lack of familiarity or different experiences with MMC implementation.

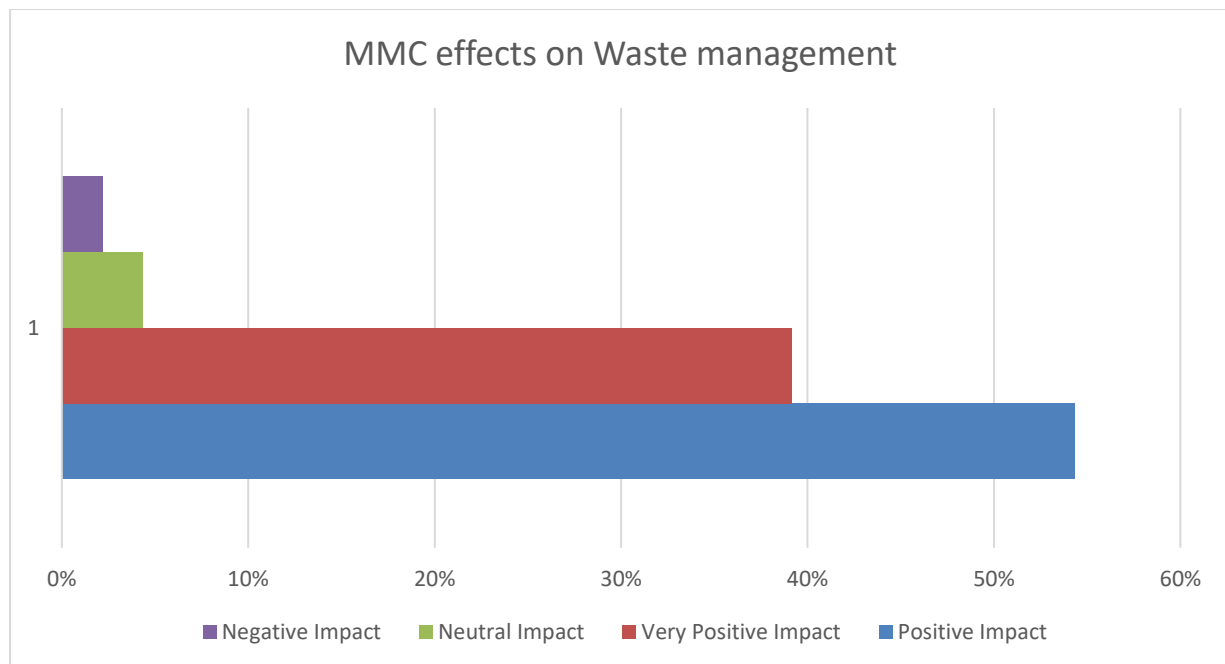


Figure 14 MMC effects on Waste management

Overall, the data demonstrate a clear consensus that MMCs can play a key role in promoting environmental sustainability in the construction industry. The positive awareness of the impact of MMC on waste management highlights the need to continue to promote and demonstrate the environmental benefits of MMC, encourage wider adoption and contribute to more sustainable construction practices.

Discussion

The high level of familiarity with Modern Methods of Construction (MMC) among Pakistani respondents reflects their high level of awareness and readiness for innovative construction practices. This is crucial for the adoption of sustainable and efficient construction techniques, with research highlighting the benefits of prefabrication, which is 84% faster and 13.46% cheaper than traditional methods (Naz et al., 2023). Despite these advances, further training and education are still needed, as 37% of respondents were only somewhat familiar with MMC, highlighting opportunities for deeper knowledge dissemination and practical application (Talpur et al., 2023). This demonstrates that Pakistan is actively but incompletely transitioning to modern construction technologies and requires

ongoing efforts to enhance industry-wide understanding and implementation.

The economic aspects that are primarily associated with the implementation of MMC in Pakistan are centered on timesaving and cost optimization. Time saving was cited by 48% of the respondents in line with other studies which reveal that MMC is 84% faster and 13% cheaper than conventional techniques (Naz et al. 2023). This speed reduces project cycles which mean possible early revenue accumulation and less risk (Khahro et al. 2023). Furthermore, concerning the advantages of MMC, 35% of respondents indicated cost savings; they understood that MMC can lead to reduction the number of expenses and therefore involve better management of budgets (Pervez et al. 2022a). The final 11% perceived a greater return on investment; this is an indication that MMC offers sustainable economic returns by way of enhanced product quality and lowered lifecycle costs.

According to the analysis results, respondents' key concern regarding MMC in Pakistan are the high initial costs as 46% of the respondents shown their concern in this regard. This is in conformity to previous findings indicating that financial factors are one of the key hurdles to the uptake of construction technology (Hussain et al., 2023). To solve this challenge, monetary

incentives might be necessary or phased capital expenses (Iqbal et al. 2021). As many as 33% of respondents mentioned a shortage of skilled labor: organizations should improve the training of employees to increase their productivity (Farooq et al., 2020). Lack of regulatory support (17%) points towards the fact that there is a requirement of definite policy to encourage MMC (Naz et al. 2023). Cultural resistance although, got less attention (4%): calls for informational campaigns to alter conventional perceptions about architecture (Hussain et al. 2023).

When asked to quantify the level of seriousness of Regulatory barriers, 43% of the respondents reported that existing regulations are a major impediment in the adoption of MMCs in Pakistan. This is in line with prior studies showing that legal systems have always acted as a hindrance to embrace innovation technology in construction (Hussain et al., 2023). Among the respondents, 30% deemed these as highly important indicating that enhancements on the part of policymakers in terms of increasing the regulatory clarity and introducing supportive policies could stimulate MMC implementation (Farooq et al., 2020). 17% believed there were only minor barriers which implies that there were some regulatory hurdles but not prohibitive odds and 9% believed there were no major barriers perhaps because existing regulations were very well understood or because local policies were conducive (Pervez et al. 2021). Overcoming the regulation issues by reforms and providing clearer guidance is essential for the adoption of MMC in the broader construction industry.

In this context, the data collected from the respondents of this research has provided an ambiguous perception regarding the applicability, efficiency and effectiveness of the current policy on MMC in the construction industry that prevails in Pakistan. About 30% of the respondents opined that these policies were very effective; in their experience, they have come across quite a few positive things about processes and incentives (Akram et al. 2023). Yet, 28% recognize such policies as being somewhat effective, indicating that while the positives are seen somewhat, more work needs to be done in terms of dealing with occasional

enablers (Tagar et al. 2022). 26 % stated these policies as moderately effective implying that if enhanced could further support MMC (Tagar et al., 2022). The other 15% are of the view that the policy is not effective enough hence requiring significant changes to make the regulatory structure sounder and more comprehensible (Hussain et al., 2023). Taken together, all the findings outlined above indicate that there are strengths and weaknesses with the current MMC policies that need specific enhancing.

About one third of the respondents stressed on the lack of management a planning training needs in the context of construction especially in Pakistan where it has been identified that there are severe lacks in the field of management and planning for successful implementation of MMC. This is in line with other authorities who have advocated for long integrated and transdisciplinary courses in construction projects that will enhance project performance (Irfan et al. 2021). 26% of the respondents said that the training of technical skills proves the professional knowledge and the skills that are needed to run the MMC technology as it enables the professional field experience (Pervez et al. 2022c). 20% preferred overall MMC training meaning that some of them wished to be trained on every aspect of MMC, that would enable wider understanding and application (Hussain et al. 2022). Last but not the least, 17% pointed towards software and technology training which enunciates the use of the technology in increasing the speed and reliability of construction projects according to (Farooq et al. 2020)

Most respondents believe that using modern methods of construction (MMC) can significantly reduce environmental impact, with 91% strongly agreeing or agreeing. This high level of consensus reflects widespread recognition of the benefits of MMC, such as reduced material waste, improved energy efficiency, use of sustainable materials, and lower off-site construction emissions. Studies have shown that MMC can significantly reduce greenhouse gas emissions compared to traditional methods (Pervez et al., 2021). Furthermore, MMC has been associated with reduced waste generation and better resource

utilization, thereby enhancing overall environmental sustainability (Shahid et al., 2022). These findings highlight the strong link between industry perceptions and documented environmental benefits of MMC.

Another barrier in MMC was non-acceptance of culture which if cleared reduce the MMC complexity in Pakistan where the respondent strongly agreed by 73% that culture should be accepted for the proper implementation of MMC in Pakistan. One can speak about the high degree of consistency because the choice of a new form of construction is connected with cultural values. Some of the recommended approaches include: the interaction approach, the intervention approach, the mobilization approach and the management approach. Findings of previous researchers indicate that integration of cultural techniques in construction could help to boost the readiness level to accept and embrace (Wali Shah 2021)(Hamza et al. 2023) They can also enhance stakeholders' perception towards MMC and smoothen the integration of MMC in the construction industry of Pakistan.

It seems that the respondents in the study are highly motivated for investing a MMC technology in Pakistan as 87% of the respondents depicted possible or definite interest in investment. Such a high interest indicates confidence in the opportunities for MMC, or, in other words, the effectiveness of this business model as long as the external risks associated with it are adequately managed at the regulatory level. And studies also agree with this assertion, where regulatory guidance together with support is deemed necessary for investment in sustainable construction technologies (Khan et al. 2021) . Also, the willingness to invest in Innovative construction methods can be complemented by financial incentives and strong policy framework as research depicts (Ifat et al. 2020). Thus, the need for solving the problem of regulation and financing can help to activate the use of MMC.

Approximately all respondents have shown positive views regarding Modern methods of construction (MMC) and its impact on construction waste management in Pakistan. Such consensus supports the extended use of MMC in enhancing the policies on waste

management in construction and reducing wastage of material and care towards the environment by the controlled use of offsite fabrication of the quantity of the material used. Some published evidence highlights that it provides a number of benefits on construction sites reducing, for instance, construction waste by up to 50 % compared to more conventional methods (Shahid et al. 2023)(Khan et al. 2020). They assist in environmental and cost conservation since the practice makes use of sustainable materials in the practice. However, a small percentage (6%) of the respondents were either indifferent or had a negative inclination, this might have resulted from a different level of contact or even the absence of contact with the MMC implementation.

Conclusion

- A strong level of awareness and preparedness for MMC adoption exists among construction professionals, with most respondents indicating familiarity through industry exposure and academic learning, suggesting readiness for transition from traditional methods.
- High familiarity indicates that the industry already understands the core benefits and processes of MMC, which reduces resistance to change and supports smoother implementation of advanced construction technologies.
- Faster project completion emerged as the most significant economic advantage, enabling reduced project durations, earlier revenue generation, and minimized financial risks in a highly time-sensitive construction environment.
- Cost efficiency is another key benefit, driven by reduced material waste, optimized resource utilization, lower energy consumption, and improved operational efficiency compared to traditional construction approaches.
- Despite these benefits, high initial investment costs remain the most critical barrier, limiting adoption among stakeholders and highlighting the need for financial support mechanisms such as subsidies, tax incentives, and grants.
- The shortage of skilled labor presents a major challenge, emphasizing the importance of

structured training programs and education initiatives to develop technical and managerial competencies for MMC implementation.

- Regulatory limitations and unclear policies further hinder adoption, with respondents indicating the need for well-defined frameworks, streamlined approval processes, and dedicated regulatory bodies to support MMC growth.
- Training and capacity building are essential, with strong demand for technical, management, and planning-related programs to ensure effective integration of MMC into existing construction practices and workflows.
- MMC demonstrates significant potential for sustainability by reducing material waste, improving energy efficiency, and promoting environmentally responsible construction practices aligned with global sustainability objectives.
- Cultural resistance and hesitation toward new construction methods remain barriers, requiring awareness campaigns, demonstration projects, and industry engagement to build trust and encourage wider acceptance and investment in MMC technologies.

Recommendations

- Develop clear, consistent and supportive regulatory frameworks for MMC that reduce ambiguity, streamline approval processes, and ensure policies actively encourage adoption while removing unnecessary bureaucratic barriers across construction sector.
- Provide targeted financial incentives including subsidies, grants and tax reliefs to reduce high initial costs of MMC adoption, thereby increasing attractiveness for developers, investors and other key stakeholders involved parties.
- Establish dedicated regulatory bodies responsible for MMC oversight, ensuring standardization, compliance monitoring, and facilitation of approvals while promoting coordinated governance and reducing fragmentation within the construction regulatory system framework overall.
- Implement comprehensive training programs covering management, planning and technical competencies to address skill gaps,

improve workforce capability, and ensure professionals are equipped for effective MMC implementation across industry projects sectors.

- Collaborate with universities and technical institutes to develop specialized MMC courses and curricula, enhancing academic-industry alignment and producing graduates with relevant practical skills for modern construction demands and future needs.
- Conduct awareness campaigns and demonstration projects to showcase MMC benefits, reduce resistance, and improve understanding among stakeholders by highlighting real-world applications and successful implementation case studies across national construction projects.
- Engage stakeholders through participatory mechanisms and feedback systems to enhance collaboration, improve decision-making, and ensure effective communication among professionals, policymakers and community groups involved in MMC construction project delivery process.
- Integrate MMC into national sustainability goals and construction standards while promoting environmentally friendly materials and practices, supported by research and development to enhance long-term environmental performance and adoption across sector.
- Adopt advanced construction technologies such as Building Information Modelling, 3D printing and robotics, supported by reliable digital infrastructure, cloud platforms and real-time data sharing systems to improve efficiency and accuracy.
- Strengthen market development by increasing public awareness, improving supply chain reliability for MMC components, and collaborating with financial institutions to design accessible funding and loan solutions for industry adoption growth.

Future Research:

To continue improving the adoption of MMC in Pakistan future research should target on several key areas. Firstly, it is essential to investigate the specific barriers and drivers of MMC adoption in various regions and construction sector to develop tailored strategies that address local challenges and leverage

opportunities. Additionally, exploring the long-term impacts of MMC on the construction industry and the environment is crucial. This includes studying, how MMC influences project timeline, costs and sustainability metrics over extended periods. Moreover, research should delve into emerging MMC technologies and innovations that could enhance the efficiency, quality and scalability of construction tools, future studies can provide valuable insights that inform industry practices and policy frameworks. Ultimately, ongoing research will be vital for supporting the widespread and effective implementation of MMC in Pakistan's construction industry.

References

- Abt, K. (1987) 'Descriptive data analysis: A concept between confirmatory and exploratory data analysis', *Methods of Information in Medicine*, 26, pp. 77-88. Available at: <https://consensus.app/papers/descriptive-data-analysis-concept-confirmatory-abt/0e78461113b952388525e5d691982fcb/>
- Abuhussain, M. et al. (2024) 'Integrating Building Information Modeling (BIM) for optimal lifecycle management of complex structures', *Structures* [Preprint]. Available at: <https://doi.org/10.1016/j.istruc.2023.105831>
- Akram, N., Zubair, S.S., Asghar, F., Nishtar, Z. and Lodhi, K. (2023) 'Public-private partnerships (PPPs) in construction projects: A study on the utilization, effectiveness, and challenges in Pakistan', *Bulletin of Business and Economics (BBE)*, 12(3), pp. 402-409. Available at: <https://doi.org/10.61506/01.00047>
- Akinradewo, O. et al. (2021) 'Modular method of construction in developing countries: the underlying challenges', *International Journal of Construction Management*, 23, pp. 1344-1354. Available at: <https://doi.org/10.1080/15623599.2021.1970300>
- Ali, A. et al. (2023) 'Identifying and assessing modular construction implementation barriers in developing nations for sustainable building development', *Sustainable Development* [Preprint]. Available at: <https://doi.org/10.1002/sd.2589>
- Ali, A.H. et al. (2024) 'Analysing multifaceted barriers to modular construction in sustainable building projects', *International Journal of Construction Management*, 25, pp. 1-17. Available at: <https://doi.org/10.1080/15623599.2023.2299557>
- Altaf, M. et al. (2021) 'Value analysis in construction projects with BIM implementation: A systematic review', *2021 International Conference on Decision Aid Sciences and Application (DASA)*, pp. 51-56. Available at: <https://doi.org/10.1109/dasa53625.2021.9682253>
- Awan, M.S.I. et al. (2024) 'Examining the effectiveness of current construction methods in Pakistan', *International Journal of Emerging Engineering and Technology* [Preprint]. Available at: <https://doi.org/10.57041/zqbvdw93>
- Azarian, A.A. et al. (2025) 'Barriers and potential solutions to the adoption of modular and offsite construction: A review', *MOC Summit Proceedings* [Preprint]. Available at: <https://doi.org/10.29173/mocs317>
- Baarimah, A. et al. (2021) 'Integration of BIM and value engineering in construction projects', *International Sustainability and Resilience Conference*, pp. 362-367. Available at: <https://doi.org/10.1109/ieecon53624.2021.9668045>
- Baig, M. (2026) *Integration of Risk Management in Development of Restaurant in Coastal Area "Do Darya" Karachi*.
- Bacon-Shone, J. (2014) *Introduction to quantitative research methods*. Available at: <https://doi.org/10.13140/2.1.4466.3040>

- Bello, A. et al. (2023) 'Barriers to modular construction systems implementation in developing countries', *Engineering, Construction and Architectural Management* [Preprint]. Available at: <https://doi.org/10.1108/ecam-10-2022-1001>
- Chen, C., Wang, M. and Chen, S. (2023) 'An efficient data integration scheme', *Biometrics*, 79, pp. 2947-2960. Available at: <https://consensus.app/papers/data-integration-scheme-synthesizing-information-chen/e701e2c978e357b08893b3df4f775c85/>
- Demirdöğen, G. et al. (2021) 'Lean based maturity framework integrating value, BIM and big data analytics', *Sustainability* [Preprint]. Available at: <https://doi.org/10.3390/su131810029>
- Denieffe, S. (2020) 'Commentary: purposive sampling', *Journal of Research in Nursing*, 25, pp. 662-663. Available at: <https://consensus.app/papers/commentary-purposive-sampling-research-case-examples-denieffe/18b41041899f5b39930e239923c09acc/>
- Elsayed, A.M. et al. (2024) 'Framework for integration of value engineering and BIM', *Engineering Research Journal* [Preprint]. Available at: <https://doi.org/10.21608/erj.2024.359250>
- Etikan, İ., Musa, S.A. and Alkassim, R.S. (2016) 'Comparison of sampling techniques', *American Journal of Theoretical and Applied Statistics*. Available at: <https://doi.org/10.11648/j.ajtas.20160501.11>
- Farooq, U. et al. (2020) 'Investigating BIM implementation barriers', *Applied Sciences*, 10(20), p. 7250. Available at: <https://doi.org/10.3390/app10207250>
- Feldmann, F., Birkel, H. and Hartmann, E. (2022) 'Barriers towards modular construction', *Journal of Cleaner Production* [Preprint]. Available at: <https://doi.org/10.1016/j.jclepro.2022.133023>
- Hamza, M. et al. (2023) 'Adoption of prefabricated construction technology', *Sustainability*, 15(10), p. 8281. Available at: <https://doi.org/10.3390/su15108281>
- Hussain, B. et al. (2023) 'Barriers to green building adoption in Pakistan', *International Journal of Management Research and Emerging Sciences*, 13(1). Available at: <https://doi.org/10.56536/ijmres.v13i1.371>
- Hussain, M. et al. (2022) 'BIM in Pakistan construction industry', *Journal of Applied Engineering Sciences*, 12(1), pp. 43-46. Available at: <https://doi.org/10.2478/jaes-2022-0007>
- Ifat, M. et al. (2020) 'Consumer willingness to pay', *LASSIJ*, 4(1), pp. 19-34. Available at: <https://doi.org/10.47264/idea.lassij/4.1.3>
- Iqbal, M. et al. (2021) 'Sustainable construction practices', *Environmental Science and Pollution Research*, 28(26), pp. 34793-34823. Available at: <https://doi.org/10.1007/s11356-021-12917-7>
- Irfan, M. et al. (2021) 'Quality management education in construction', *The TQM Journal*, 33(6), pp. 1100-1122. Available at: <https://doi.org/10.1108/TQM-03-2020-0066>
- Khahro, S.H. et al. (2023) 'Construction project performance in Pakistan', *Sustainability*, 15(3), p. 2469. Available at: <https://doi.org/10.3390/su15032469>
- Khan, A.M., Alaloul, W. and Musarat, M. (2024) 'Digital value engineering in building design', *Environment, Development and Sustainability* [Preprint]. Available at: <https://doi.org/10.1007/s10668-024-05595-1>
- Khan, A.R. et al. (2021) 'Environmental practices for waste management', *Environmental Science and Pollution Research*, 28(41), pp. 58221-58231.

- Available at:
<https://doi.org/10.1007/s11356-021-14739-z>
- Khan, R.A.J. et al. (2020) 'Sustainable housing adoption', *Energy Policy*, 143, p. 111598. Available at:
<https://doi.org/10.1016/j.enpol.2020.111598>
- Li, X.-J., Wang, C. and Alashwal, A. (2021) 'BIM and value engineering integration', *Advances in Civil Engineering* [Preprint]. Available at:
<https://doi.org/10.1155/2021/8849303>
- Merson, L. et al. (2018) 'Secondary data analysis', *The Lancet Global Health*, 6(9). Available at:
<https://consensus.app/papers/analysis-participation-data-source-merson/b044c17e22b5514f8dfee35d0a5cd9c6/>
- Mohamed, A.G. et al. (2024) 'Synergizing BIM and value engineering', *Buildings* [Preprint]. Available at:
<https://doi.org/10.3390/buildings14082515>
- Naz, F. et al. (2023) 'Cost analysis of prefabricated structures', *Jurnal Kejuruteraan*, 35(5), pp. 1135–1143. Available at:
[https://doi.org/10.17576/jkukm-2023-35\(5\)-14](https://doi.org/10.17576/jkukm-2023-35(5)-14)
- Opoku, A., Ahmed, V. and Akotia, J. (2016) 'Choosing research methodology', in *Research methodology in the built environment*, pp. 32–49
- Pervez, H. et al. (2022) 'Risk factors in modular construction', *PLOS ONE*, 17. Available at:
<https://doi.org/10.1371/journal.pone.0272448>
- Pervez, H., Ali, Y. and Petrillo, A. (2021) 'GHG emissions in construction', *Journal of Cleaner Production*, 294, p. 126210. Available at:
<https://doi.org/10.1016/j.jclepro.2021.126210>
- Rahman, M. (2013) 'Barriers of implementing MMC', *Journal of Management in Engineering*, 30, pp. 69–77. Available at:
[https://doi.org/10.1061/\(asce\)me.1943-5479.0000173](https://doi.org/10.1061/(asce)me.1943-5479.0000173)
- Saad, S. et al. (2025) 'Modular construction adoption in developing countries', *Ain Shams Engineering Journal* [Preprint]. Available at:
<https://doi.org/10.1016/j.asej.2024.103228>
- Saeed, A.A. et al. (2025) 'BIM for sustainable AEC projects', *ACADEMIA Journal* [Preprint]. Available at:
<https://doi.org/10.63056/acad.004.04.0982>
- Senthilkumar, D. and Gnanamurthy, R. (2018) *Research methodology*. Available at:
<https://doi.org/10.13140/RG.2.2.28543.10409>
- Shahid, M.U. et al. (2023) 'Construction waste benchmarking', *Engineering, Construction and Architectural Management*, 30(6), pp. 2304–2333. Available at:
<https://doi.org/10.1108/ECAM-07-2019-0375>
- Tagar, H.K. et al. (2022) 'Public policies and industrial growth', *European Scientific Journal*, 18(15), p. 170. Available at:
<https://doi.org/10.19044/esj.2022.v18n15p170>
- Tongco, M.D.C. (2007) 'Purposive sampling', *Ethnobotany Research and Applications*, 5, p. 147. Available at:
<https://doi.org/10.17348/era.5.0.147-158>
- Wali Shah, M. (2021) 'Earthquake resistant structures', *Pakistan Social Sciences Review*, 5(III), pp. 99–109. Available at:
[https://doi.org/10.35484/psr.2021\(5-III\)09](https://doi.org/10.35484/psr.2021(5-III)09)
- Wuni, I. and Shen, G. (2020) 'Barriers to modular construction adoption', *Journal of Cleaner Production*, 249, p. 119347. Available at:
<https://doi.org/10.1016/j.jclepro.2019.119347>