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Adoption of Emerging Building Construction Materials and Its Implications for Rural Construction Workforce Management

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ABSTRACT

This study examined rural construction workers' perceptions of emerging building construction materials and their implications for job security, employment displacement, adaptability, and workforce management. A descriptive–correlational research design was employed involving 50 rural construction workers who completed a structured survey questionnaire. Data were analyzed using descriptive statistics and one-way analysis of variance (ANOVA). Findings revealed high perceived job security (WM = 3.8), adaptability and support (WM = 4.1), and economic and social impacts (WM = 3.9), while employment displacement concerns remained moderate (WM = 3.3). Respondents expressed strong agreement regarding workforce development recommendations (WM = 4.8). No significant differences emerged across age, education, residence, or occupational position. However, work experience significantly differentiated perceptions of economic and social impacts ($p = 0.020$) and worker sentiment ($p = 0.024$), with experienced workers reporting more favorable assessments. The findings indicate that rural workers generally perceive construction innovation positively, with occupational experience representing an important factor in workforce perceptions. Structured competency-based training, workplace mentoring, and coordinated institutional support are recommended to strengthen workforce preparedness. The study's limited sample and reliance on self-reported perceptions constrain broader generalizability. Nevertheless, the findings provide empirical insights for inclusive rural construction management and support Sustainable Development Goals 8, 9, and 12 by informing workforce development, responsible technological innovation, and the human-resource requirements of sustainable construction practices.

Keywords: *Construction Innovation, Emerging Building Materials, Employment Displacement, Rural Construction Workers, Sustainable Construction, Work Experience, Workforce Adaptability*

1. INTRODUCTION

The construction industry is undergoing significant transformation through the introduction of emerging building materials, digital technologies, and sustainable construction practices. These innovations offer opportunities to improve project efficiency, resource utilization, and environmental performance while changing traditional construction processes and workforce requirements. However, successful implementation depends on workers' technical competencies, organizational readiness, and access to appropriate training. Siddiqui et al. (2023) emphasized the increasing importance of construction-related skills in technological transformation, while Hajirasouli et al. (2025) highlighted the implications of Construction 4.0 for workforce development, employment structures, and labor adaptation. The adoption of emerging construction materials also requires consideration of economic, technical, and institutional barriers. Poorisat et al. (2024) identified implementation costs and other practical constraints affecting sustainable building practices, while Yap et al. (2024) emphasized the importance of organizational commitment, expertise, and stakeholder awareness. These challenges are particularly relevant when considering rural construction workers, whose capacity to adjust to innovations may depend on existing skills, occupational experience, and opportunities for professional development. Against this background, the present study examines rural construction workers' perceptions of emerging building construction materials, particularly their implications for job security, potential displacement, adaptability, economic and social outcomes, and workforce management. The study seeks to provide empirical evidence that can inform inclusive workforce development and sustainable construction management practices.

Research Problem

The increasing adoption of emerging building construction materials presents opportunities for improving construction practices but also raises concerns regarding workforce preparedness, employment security, and adaptability. Technological changes can transform job requirements and create demand for new competencies, potentially affecting workers with limited access to training and institutional support. Hajirasouli et al. (2025) identified workforce transformation, skills shortages, and employment-related challenges as important consequences of construction innovation. Similarly, Siddiqui et al. (2023) emphasized the need to evaluate construction workers' evolving competencies to support technological adoption. Although existing research has examined construction innovation and sustainable building practices, the experiences and perceptions of rural construction workers require greater empirical attention. Studies on sustainable construction have identified financial, knowledge-related, organizational, and technical barriers that may influence innovation adoption (Oliveira & Melo, 2024; Yap et al., 2024). However, these findings do not fully explain how rural workers perceive the employment and socioeconomic implications of emerging construction materials. Consequently, the central research problem concerns the extent to which rural construction workers perceive emerging building materials as opportunities or challenges to their employment and working conditions. Specifically, the study examines perceptions of job security, displacement factors, adaptation and support mechanisms, economic and social impacts, worker sentiment, recommended interventions, and adoption barriers, including whether these perceptions differ according to demographic and occupational characteristics.

Assumptions of the Study

This study is guided by the assumption that the adoption of emerging building construction materials may influence rural construction workers' perceptions of employment security, workforce adaptability, and socioeconomic conditions. It assumes that workers' responses to innovation may be associated with their educational attainment, occupational experience, job

position, and access to workforce development opportunities. Recent construction research recognizes skills development and workforce preparedness as important considerations in technological transformation (Siddiqui et al., 2023; Hajirasouli et al., 2025). The study further assumes that effective workforce adaptation requires appropriate training, organizational support, and opportunities for knowledge development. Sustainable construction research has identified stakeholder awareness, professional expertise, and institutional commitment as relevant factors affecting implementation (Poorisat et al., 2024; Yap et al., 2024). These assumptions provide the basis for investigating rural workers' perceptions and possible differences across profile variables. They are treated as guiding propositions rather than predetermined research findings.

Objectives of the Study

The primary objective of this study is to examine the adoption-related perceptions of emerging building construction materials and their implications for rural construction workforce management. Specifically, it aims to describe respondents' demographic and occupational characteristics in terms of age, sex, educational attainment, work experience, place of residence, and job position; assess their perceptions of job security, displacement factors, adaptation and support mechanisms, economic and social impacts, worker sentiment, recommendations and future directions, and perceived barriers; and determine whether significant differences exist in these perceptions when respondents are grouped according to their profile characteristics. Furthermore, the study seeks to identify implications for workforce development, training initiatives, and construction management strategies that may support inclusive adaptation to emerging building materials. These objectives are consistent with contemporary discussions emphasizing the integration of skills development, organizational readiness, and socially responsible innovation in construction (Siddiqui et al., 2023; Hajirasouli et al., 2025).

Conceptual and Theoretical Framework

The study is anchored in a contemporary workforce-readiness and innovation-adoption perspective, emphasizing the relationships among worker characteristics, perceived consequences of construction innovation, and adaptive capacity. Siddiqui et al. (2023) demonstrated that construction transformation requires diverse competencies and systematic approaches to workforce skills development. Complementing this perspective, Hajirasouli et al. (2025) explained that construction innovation affects workforce structures, skills requirements, employment arrangements, and opportunities for professional development. The conceptual basis also incorporates organizational and institutional factors influencing sustainable construction adoption. Oliveira and Melo (2024) identified educational, economic, organizational, and regulatory considerations affecting sustainable construction practices, while Yap et al. (2024) highlighted the importance of expertise, awareness, and management commitment in overcoming implementation barriers. Within this framework, demographic and occupational characteristics—particularly age, educational attainment, work experience, residence, and job position—serve as respondent grouping variables. Workers' perceptions of job security, displacement factors, adaptation and support, economic and social impacts, sentiment, future recommendations, and barriers constitute the primary assessment dimensions. The framework assumes that workforce adaptation involves interactions among individual experience, perceived opportunities and risks, and available institutional support. It guides the study's descriptive and comparative analyses without presuming causal relationships.

The study primarily aligns with SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), and SDG 12 (Responsible Consumption and Production). SDG 8 is reflected in the study's examination of job security, potential worker displacement, workforce adaptation, and employment-related consequences of construction innovation. By identifying perceived workforce challenges and support needs, the research may inform training and workforce management strategies that promote inclusive employment opportunities and decent working conditions. This direction is consistent with the emphasis of Hajirasouli et al. (2025) on addressing the social and employment dimensions of construction transformation. SDG 9 is supported by the study's focus on emerging building construction materials and the capacity of rural workers to adapt to innovations in construction practices. Understanding workforce readiness and implementation barriers may assist construction managers and other stakeholders in developing more accessible and inclusive approaches to technological advancement. Siddiqui et al. (2023) highlighted the significance of workforce competencies in facilitating industry transformation. SDG 12 is relevant because emerging and sustainable building materials may contribute to improved resource efficiency and more responsible construction practices when appropriately selected and implemented. Poorisat et al. (2024) discussed sustainable building practices and their potential benefits, while Oliveira and Melo (2024) examined factors that support or constrain sustainable construction adoption. Although the present study does not directly measure material consumption, waste reduction, or environmental performance, its findings may help identify workforce-management requirements for implementing more sustainable construction practices. Overall, the research contributes primarily to socioeconomic, technological, workforce, and institutional sustainability by examining how rural construction workers respond to emerging construction materials and what forms of support may facilitate inclusive innovation adoption.

2. METHODOLOGY

Research Design

The study employed a descriptive–correlational research design to examine rural construction workers' perceptions of emerging building construction materials and the relationships among relevant workforce variables. The descriptive component assessed respondents' characteristics and perceptions, while the correlational component examined relationships among the variables. Statistical comparisons were also conducted to determine differences in perceptions across demographic groups.

Research Locale or Study Setting

The study was conducted in rural construction settings, focusing on workers engaged in construction activities within rural communities. These settings provided the context for examining workforce adaptation to emerging building materials, particularly in construction environments characterized by labor-intensive practices.

Participants or Data Sources

The study involved 50 rural construction workers with varying demographic and occupational characteristics. Respondents were classified according to age, sex, educational attainment, work experience, place of residence, and occupational position. Their responses served as the primary data for assessing perceptions of emerging construction materials and associated workforce implications.

Research Instruments or Materials

A structured survey questionnaire served as the primary data collection instrument. It gathered information on respondents' demographic characteristics, awareness of emerging building

construction materials, perceived adaptability, job security, displacement factors, adaptation and support mechanisms, economic and social impacts, worker sentiment, recommendations, and perceived barriers to innovation adoption.

Data Gathering Procedure

Data were collected through the administration of a structured questionnaire to 50 rural construction workers. The instrument obtained respondents' demographic information and assessments of emerging construction materials and their implications for employment and workforce adaptation. Responses were compiled for statistical analysis to identify prevailing perceptions and differences across respondent groups.

Data Analysis

Data were analyzed using descriptive and inferential statistics. Descriptive measures, including frequencies, percentages, weighted means, and standard deviations, were used to summarize respondents' demographic profiles and perceptions. Correlation analysis was employed to examine relationships among variables, while one-way analysis of variance (ANOVA) was used to determine significant differences in perceptions when respondents were grouped according to their demographic characteristics. Statistical significance was evaluated at the 0.05 level.

Ethical Considerations

Ethical considerations were observed throughout the study, particularly informed consent and confidentiality. These measures were implemented to protect respondents' information and ensure ethical treatment during data collection and analysis.

3. RESULTS AND DISCUSSION

3.1 Respondents' Demographic Characteristics

3.1.1 Demographic and Occupational Profile

The study involved 50 rural construction workers, of whom 50% were aged 46 years and above, followed by 32% aged 36–45 years. Most respondents were male (98%), while 48% had more than ten years of construction experience. Regarding educational attainment, 54% were high school graduates, and 12% had completed college education. Most respondents resided in barangay-level rural communities (70%), and 80% were employed as laborers. These findings indicate that the surveyed workforce was predominantly male, relatively mature, and experienced, with educational attainment concentrated at the secondary level. The gender distribution reflects a broader concern regarding women's participation in construction occupations, as discussed by Holdsworth et al. (2023) and Ghanbaripour et al. (2023). Furthermore, the concentration of experienced workers and relatively limited tertiary education highlights the relevance of accessible, practice-oriented workforce development. Siddiqui et al. (2023) emphasized the growing importance of construction-related competencies, while McPhee et al. (2026) identified the need for educational and workplace training approaches that address emerging technological requirements. These studies provide a basis for considering workforce development strategies suited to the occupational characteristics of the respondents.

3.2 Perceptions of Emerging Building Construction Materials

3.2.1 Job Security and Employment Displacement

Respondents reported a high level of perceived job security, with a weighted mean (WM) of 3.8 (SD = 1.12). Factors contributing to employment displacement received a moderate rating (WM = 3.3, SD = 1.04), indicating awareness of potential employment risks associated with emerging construction materials without strong displacement concerns. The findings suggest that

respondents generally viewed emerging construction materials as manageable occupational changes rather than immediate threats to employment. However, favorable job security perceptions do not eliminate the possibility of workforce restructuring as construction practices evolve. Hajirasouli et al. (2025) identified changing occupational requirements, skills shortages, and potential displacement as important workforce implications of Construction 4.0. Similarly, van der Heijden (2023) emphasized the need to consider the social and organizational consequences of construction innovation alongside its technical benefits. These perspectives support proactive workforce planning, particularly through competency development and employment transition support, to address potential adjustments associated with emerging construction materials.

3.2.2 Workforce Adaptability and Support Mechanisms

Adaptation and support mechanisms received a high overall rating (WM = 4.1, SD = 1.02), indicating respondents' favorable perceptions of their capacity and willingness to adjust to emerging construction materials when adequate training and support are available. This finding suggests that rural construction workers are receptive to innovation when appropriate capacity-building opportunities and managerial assistance are provided. Siddiqui et al. (2023) emphasized the importance of developing competencies required by evolving construction technologies, while McPhee et al. (2026) highlighted the role of education, workplace training, and mentoring in strengthening technological readiness. Furthermore, Jaiswal et al. (2024) identified skills development and implementation readiness as important considerations for Construction 4.0 adoption in developing countries. These findings reinforce the relevance of structured training, practical demonstrations, and workplace support in improving workforce preparedness for changes in construction materials and practices.

3.2.3 Economic and Social Impacts

The perceived economic and social impacts of emerging construction materials received a high rating (WM = 3.9, SD = 1.04), reflecting respondents' generally favorable assessment of the broader implications of material innovation for rural construction activities. These findings suggest that respondents recognize potential economic and social opportunities associated with emerging construction materials. Hajirasouli et al. (2025) explained that technological transformation in construction can create opportunities for productivity improvement and workforce development while also introducing employment-related challenges. Similarly, Poorisat et al. (2024) identified economic, environmental, and social considerations relevant to sustainable building practices, while Oliveira and Melo (2024) highlighted the importance of institutional and organizational conditions in sustainable construction implementation. These studies indicate that the potential benefits of emerging materials should be considered alongside workforce readiness and implementation requirements. Integrating these considerations into construction management may support more inclusive approaches to innovation in rural settings.

3.2.4 Worker Sentiment Toward Emerging Materials

Worker sentiment toward emerging construction materials received a moderately positive rating (WM = 3.7, SD = 1.14), indicating generally favorable attitudes toward innovation despite potential adjustments in existing work practices. The findings indicate that respondents were not strongly resistant to emerging construction materials, although their acceptance may be influenced by available training and organizational support. Fasasi et al. (2024) identified technological expertise, management commitment, and awareness as important considerations in construction technology adoption. Likewise, Jaiswal et al. (2024) discussed organizational and workforce-related challenges affecting the implementation of Construction

4.0 in developing countries. These perspectives suggest that favorable worker attitudes should be supported through effective communication, opportunities for participation, and accessible skills development. Such measures may help construction managers maintain workforce confidence and address uncertainties associated with changing construction practices.

3.2.5 Recommendations, Future Directions, and Perceived Barriers

Respondents expressed very strong agreement with recommendations and future directions for workforce development (WM = 4.8, SD = 0.49), emphasizing the importance of structured training, policy support, and managerial interventions. Meanwhile, perceived barriers received a relatively low rating (WM = 2.41, SD = 0.28), indicating that existing challenges were not considered insurmountable. The findings highlight respondents' strong expectations for coordinated institutional and managerial assistance in adapting to emerging construction materials. Yap et al. (2024) identified limited expertise, insufficient regulatory support, management commitment, and stakeholder awareness as barriers to sustainable construction practices. Similarly, Oliveira and Melo (2024) emphasized the relevance of educational, organizational, economic, and regulatory considerations in addressing sustainable construction challenges. McPhee et al. (2026) further highlighted the importance of strengthening formal and workplace-based training opportunities to address emerging technological competencies. These findings support coordinated capacity-building initiatives involving contractors, training institutions, and policymakers. Although respondents reported relatively low perceived barriers, continued workforce assessment and institutional support remain important for addressing implementation challenges.

3.3 Differences in Perceptions Across Respondent Profiles

3.3.1 Differences According to Age, Education, Residence, and Position

One-way analysis of variance (ANOVA) revealed no statistically significant differences in respondents' perceptions when grouped according to age, educational attainment, residence, and occupational position ($p > 0.05$). This finding applied across job security, displacement factors, adaptation and support, economic and social impacts, worker sentiment, recommendations, and perceived barriers. The absence of statistically significant differences suggests relatively consistent perceptions across the demographic and occupational groups examined. Shared work practices, exposure to similar construction conditions, and common employment experiences may help explain this pattern, although these possible explanations were not directly tested. Siddiqui et al. (2023) highlighted the importance of developing competencies across different construction roles, while McPhee et al. (2026) emphasized accessible educational and workplace training opportunities. These perspectives support considering broad-based awareness and training initiatives for rural construction workers. However, the nonsignificant findings should not be interpreted as proof that demographic characteristics have no influence, particularly given the study's sample size.

3.3.2 Differences According to Work Experience

Work experience produced statistically significant differences in perceptions of economic and social impacts ($F = 3.610$, $p = 0.020$) and worker sentiment ($F = 3.445$, $p = 0.024$). Respondents with more than ten years of construction experience generally reported more favorable perceptions in these dimensions. However, no significant differences were observed across experience groups regarding job security, displacement factors, adaptation and support, recommendations, and perceived barriers ($p > 0.05$). These findings indicate that occupational experience was associated with differences in selected perceptions of emerging construction materials. Workers with longer construction experience may draw on accumulated practical knowledge when evaluating technological changes and their potential implications. Hajirasouli

et al. (2025) emphasized the importance of workforce competencies and skill development in responding to construction innovation, while Siddiqui et al. (2023) highlighted the diverse competencies required for technological transformation. McPhee et al. (2026) also discussed workplace mentoring and practice-based learning as approaches to strengthening emerging technological capabilities. These perspectives provide a contemporary basis for interpreting the relevance of occupational experience without establishing a causal relationship. Experienced workers may therefore be engaged in mentoring and knowledge-sharing activities to support less experienced colleagues during construction innovation.

4. CONCLUSIONS AND RECOMMENDATIONS

This study examined rural construction workers' perceptions of emerging building construction materials, particularly their implications for job security, employment displacement, workforce adaptability, and construction management. Findings revealed generally positive perceptions of emerging materials, characterized by favorable assessments of job security, adaptability, and economic and social impacts, alongside moderate concerns regarding employment displacement. Workers expressed strong support for structured training and institutional assistance, suggesting their willingness to adapt to changing construction practices. Demographic characteristics, including age, educational attainment, residence, and occupational position, did not significantly differentiate respondents' perceptions. However, work experience significantly influenced perceived economic and social impacts and worker sentiment, with more experienced workers reporting more favorable views. Collectively, these findings highlight the importance of practical experience, workforce readiness, and managerial support in facilitating innovation adoption. The study contributes to rural construction management by identifying workforce considerations relevant to inclusive and sustainable technological transitions.

Construction managers and contractors should prioritize structured training and skills development initiatives that prepare rural construction workers to handle emerging building materials effectively. Training activities should emphasize practical demonstrations, workplace-based learning, and continuous competency enhancement to strengthen adaptability and minimize employment displacement concerns. Experienced construction workers may be engaged as mentors to facilitate knowledge transfer and support less experienced colleagues during technological transitions. Training institutions should collaborate with construction organizations to develop accessible, competency-based programs responsive to rural workforce conditions. Policymakers and relevant government agencies should strengthen institutional support for workforce development through appropriate training opportunities and coordinated capacity-building initiatives. Construction managers should also maintain effective communication with workers regarding technological changes, employment implications, and available support mechanisms. Regular assessments of workforce perceptions, training needs, and adaptation challenges are recommended to inform management decisions. These measures may promote workforce preparedness, inclusive participation, and more effective adoption of emerging construction materials in rural communities.

This study employed a descriptive–correlational design involving 50 rural construction workers, which limits the generalizability of findings to broader construction workforce populations. Data were obtained through a structured questionnaire measuring respondents' perceptions, rather than directly observing material adoption practices or workforce performance. Consequently, the findings reflect self-reported assessments and do not establish causal relationships between demographic characteristics and workforce perceptions. The study also focused on rural construction settings, limiting direct applicability to urban or large-scale construction

environments. Future research may involve larger and more diverse samples, incorporate direct assessments of workforce adaptation, and examine emerging material adoption across different construction contexts.

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