Exploring the Potential of Building Information Modeling (BIM) in Material Management: Enhancing Efficiency, Waste Reduction, and Stakeholder Communication

Dante L. Silva [1], Eisen Joshua A. Jucal [2], Laurenz Gean A. Ramat [3], Alesandra Alia S. Torres [4]
[1, 2, 3, 4] School of Civil, Environmental and Geological Engineering,
Mapua University, Manila, Philippines
Email: [2] ejajucal@mymail.mapua.edu.ph, [3] lgaramat@mymail.mapua.edu.ph, [4] atorres@mymail.mapua.edu.ph

Abstract—**This study explores how Building Information Modeling (BIM) might revolutionize material management in the construction sector by increasing productivity, reducing waste, and promoting smooth stakeholder communication. Conventional material management techniques frequently encounter difficulties with inefficiency, communication breakdowns, and waste problems, which raise project costs and cause delays. BIM shows potential in addressing these challenges through its models of construction projects facilitating improved teamwork clash identification, visual representation and cost forecasting. This study investigates the specific use of BIM in material management, addressing a crucial gap in existing research. By thoroughly analyzing current BIM technologies and their practical applications, the research evaluates their effectiveness in reducing material waste and boosting overall efficiency in material management. The study also examines various case studies and real-world examples to illustrate successful BIM applications, and the measurable benefits observed in diverse construction projects. Furthermore, the study explores the aspects of influence on BIM adoption including training reluctance to change and the necessity for staff. It offers in-depth suggestions for implementing BIM. The results aim to serve as a guide for professionals in the construction industry, policymakers and scholars by highlighting how BIM can revolutionize material handling and support greener and productive construction methods.**

Keywords—Building Information Modeling (BIM), Material Management, Enhancing Efficiency, Waste Reduction, Stakeholder Communication, Cost Estimation, BIM Adoption, Construction Industry, Project Management, and Human Factors in BIM.

I. INTRODUCTION

Material management is crucial in construction, ensuring resource availability, minimizing waste, and optimizing schedules [1]. Traditional methods often face challenges of inefficiency, poor communication, and high waste generation, prompting interest in Building Information Modeling (BIM) as a potential solution. BIM supports efficient collaboration, cost estimation, and visualization by creating digital building models, though research specifically linking BIM to material management remains limited [2]. This study addresses that gap, exploring BIM's potential to improve efficiency, reduce waste, and enhance stakeholder communication. Key aspects of material management include procurement, inventory control, and waste management, with improved practices essential to reducing delays, costs, and environmental impacts [3] [4]. As BIM adoption grows worldwide, its benefits in project success and cost control make it increasingly standard in construction [5] The research focuses on several key challenges in BIM implementation for material management. These include limited analysis of current BIM technologies, the need for evaluating BIM's effectiveness in waste reduction, insufficient understanding of its impact on efficiency, and the influence of human factors on BIM adoption [6], [7], [8]. . Additionally, there is a lack of comprehensive guidelines for integrating BIM, addressing technical and organizational barriers faced by stakeholders [9], [10].

The study's objectives are to investigate and understand BIM's effectiveness in material management, specifically in reducing waste, improving efficiency, and facilitating stakeholder communication. By analyzing current BIM technologies, assessing waste reduction potential, examining efficiency impacts, identifying human factors, and proposing implementation recommendations, this research offers actionable insights for successful BIM adoption. BIM's significance spans multiple areas. For engineers, it provides tools to optimize material use and reduce waste. Environmentally, it promotes sustainable practices, while students in construction engineering can gain practical insights. Government agencies and future researchers may also find the findings beneficial for policy and further study. Focusing on the Philippine construction sector, this research will gather data from key stakeholders to determine BIM's potential benefits and challenges in material management. Limitations include technical constraints, generalizability issues, and time restrictions. Nevertheless, this study aims to deepen understanding of BIM's role in optimizing material

Received: 12-12-2024
Revised: 20-6-2025
Published: 30-6-2025

management, contributing to improved project outcomes and sustainability in the construction industry.

II. METHODOLOGY

A. Conceptual Framework

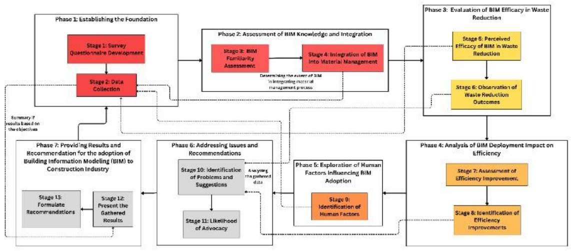

Fig. 1. Conceptual Framework

PHASE 1: Establishing the Foundation

Stage 1: Survey Questionnaire Development

At this stage, a detailed survey questionnaire will be designed to collect data from the questionnaire respondents representing the different stakeholders in the construction industry: project manager, architect, engineer, and contractor. The questionnaire will focus on the group's familiarity with BIM, current material management practices, and perceived benefits and problems of BIM implementation. That means that questions will be designed to obtain quantitative and qualitative data. It should be comprehensive enough to cover critical areas, which include material management practices that exist at present, perceived problems, and any benefits that BIM integration can bring. Conducting a pilot survey refines questions to be clear and relevant in the main distribution.

Stage 2: Data Collection

Questionnaires are administered to the targeted respondents, whose views are then collated. This step may further involve interviews and focus group sessions to elicit a better understanding of the issues at hand. This forms an empirical basis for giving meaning to the analysis of the current state of material management and the potential impact of BIM. The data collection process is carefully planned to obtain a representative sample of the construction industry, covering various projects and company sizes at geographical locations. The collected data are organized systematically, stored, and maintained with confidentiality in high regard and compliance with ethics. Additional nuanced views are added to the research and permit a more in-depth examination of the issues concerned with BIM adoption and material management practices through interviews and focus group discussions.

PHASE 2: Assessment of BIM Knowledge and Integration

Stage 3: BIM Familiarity Assessment

At this stage, an analysis of the data gathered through the questionnaire will be done to establish the level of familiarity and knowledge of the different stakeholders using BIM. This will entail establishing the degree of understanding of the respondents' BIM principles, tools, and practices and their experience in applying BIM in past projects. Descriptive statistical methods will be used to summarize data collected, describing an overview of the knowledge of BIM by various respondents and their current practice regarding material management, together with the benefits and problems perceived. Charts, graphs, and tables are used to visualize the data, which makes it easier to recognize significant trends and draw preliminary conclusions on the current situation regarding BIM knowledge in the industry.

Stage 4: Integration of BIM into Material Management

This stage shall also review how BIM has been employed up to the present in material management practices within the construction industry. It involves assessing how far BIM tools and techniques are used in the planning, tracking, and managing of construction materials, together with the perceived impact of BIM integration on the efficiency of material management. The survey and interview data give insight into how BIM is used on different projects, showing best practices and common challenges. Case studies of successful BIM implementations review the practical examples and identification of critical factors leading to effective BIM integration. This stage shall also review how BIM has been employed up to the present in material management practices within the construction industry. It involves the assessment of how far BIM tools and techniques are used in the planning, tracking, and management of construction materials, together with the perceived impact of BIM integration on the efficiency in material management. The data from the surveys and interviews give insight into how BIM is being used on different projects, showing best practice and common challenges. Case studies of successful BIM implementations review the practical examples and identification of key factors leading to effective BIM integration.

PHASE 3: Evaluation of BIM Efficacy in Waste Reduction

Stage 5: Perceived Efficacy of BIM in Waste Reduction

This stage shall involve analyzing stakeholders' perceptions of how practical BIM has reduced material wastage at construction sites. In evaluating the impact of BIM as perceived to have reduced waste, the respondents will give their views on how BIM has helped reduce waste and improve the efficiency of material management at building sites. On this count, descriptive and inferential statistical methods may be used to quantify the perceived benefits of BIM for reducing waste by identifying trends or correlations relating BIM usage with waste reduction.

Stage 6: Observation of Waste Reduction Outcomes

In this phase, construction projects using BIM are analyzed for real-life data to establish an actual outcome regarding waste reduction. Project records, material usage logs, and data related to waste disposal present a quantified impact of BIM on reducing material waste. Case studies of completed projects implementing BIM provide practical examples and offer empirical evidence of the effectiveness of BIM in reducing waste. Preliminary findings from this phase will provide a sound foundation for assessing the actual impact of BIM on waste reduction and defining best practices in maximizing its benefits. In this phase, actual construction projects using BIM are analyzed with respect to real-life data in order to establish an actual outcome regarding waste reduction. Project records, material usage logs, and data related to waste disposal present a quantified impact of BIM on reducing material waste. Case studies of successfully completed projects that have implemented BIM provide practical examples and offer empirical evidence on how effective BIM is at reducing waste. Preliminary findings from this phase will provide a sound foundation for assessing the actual impact of BIM on waste reduction and defining best practices in the maximization of its benefits.

PHASE 4: Analysis of BIM Deployment Impact on Efficiency

Stage 7: Assessment of Efficiency Improvement

This is the assessment stage for how the implementation of BIM would impact overall project efficiency in terms of time and cost savings, better coordination of projects, and increased productivity. Analyses include assessments of the survey and interview data to see the stakeholders' perceptions on efficiency improvements arising from the implementation of BIM. Key metrics of completion times of projects, adherence to budgets, and utilizations of resources are analyzed to quantify efficiency gains resulting from BIM. Descriptive and inferential statistics methodologies identify the major trends and correlations of BIM usage with efficiency improvements.

Stage 8: Identification of Efficiency Improvements

Identification in this stage relates to areas where BIM has brought about high-efficiency improvements in construction projects. This investigates the detailed records of the projects; it examines case projects enabled by BIM compared to traditional projects to determine critical factors contributing to efficiency gains. Case studies of successful BIM implementations give practical examples of how BIM improved project efficiency through best practices and lessons learned. These results provide recommendations on actionable insights toward maximizing the efficiency benefits of BIM in future projects.

PHASE 5: Exploration of Human Factors Influencing BIM Adoption

Stage 9: Identification of Human Factors

This is where human factors impacting BIM adoption and effective use within the construction industry have been explored. In this respect, it will involve checking data from the surveys and interviews to realize such vital elements as training and education, organizational culture, resistance to change, and stakeholder collaboration. The findings are a detailed explanation of the problems and opportunities of the BIM adoption process from a human point of view, emphasizing the need to consider these factors so that the application of BIM would be successful. To this end, the analysis also includes identifying strategies to overcome the barriers and developing a culture of innovation and collaboration within construction organizations.

PHASE 6: Addressing Issues and Recommendations

Stage 10: Identification of Problems and Suggestions

At this stage, the problems and challenges encountered while implementing BIM are analyzed, and practical suggestions are given to rectify such issues. The survey, interviews, and case studies summarize common barriers with actionable recommendations for overcoming such obstacles. This analysis also examines technical difficulties, lack of standardization, and problems associated with data management and interoperability. The suggestions provided are toward the improvement of the overall effectiveness of BIM implementation, intended to ensure that construction organizations will be able to capture all the benefits that BIM has to offer.

Stage 11: Likelihood of Advocacy

It is the willingness of the stakeholders to recommend BIM adoption in their organizations and the broader construction industry. This analysis uses data from a survey and interviews conducted for the study, where the perceptions of stakeholders on BIM adoption were assessed regarding its benefits and how readily they would be willing to encourage the broader adoption of the technology. The results provide insight into the factors affecting the stakeholders' advocacy of BIM, mainly driven by perceived value, ease of use, and organizational support. The analysis also identifies strategies for advocacy that will encourage broad adoption of BIM, ensuring that benefits are recognized and embraced across the industry.

PHASE 7: Providing Results and Recommendations for the Adaptation of Building Information Modeling (BIM) to the Construction Industry

Stage 12: Present the Gathered Results

It would be the stage at which the study's results are communicated efficiently and comprehensively to the recipients through detailed reports, visualizations, and presentations. The results will be communicated to construction professionals, industry associations, and the policy framer to make them aware of the advantages and challenges of adopting BIM. The presentation of results involves highlighting key findings, practical examples, and BIM's possible impact on material management, efficiency, waste reduction, and communication. This helps increase awareness and empowers informed decisions about adopting BIM.

Stage 13: Formulate Recommendations

The final step is to make reasonable and constructive recommendations for adopting BIM in the construction industry. These recommendations are based on the findings of this study aimed at solving the identified challenges to improve the benefits associated with BIM. In this regard, strategies include improving BIM adoption, enhancing its training and education, collaboration, and technical and organizational barriers. This would provide construction organizations and stakeholders with a clear, usable roadmap for the effective implementation and exploitation of BIM, realizing its full benefits to the overall advancement of the construction industry.

B. Research Design

This quantitative research study seeks to investigate and explore the potential of Building Information Modeling (BIM) in material management, specifically focusing on enhancing efficiency, waste reduction, and stakeholder communication within the construction industry. The research design will employ a cross-sectional approach, collecting data at a specific point in time by administering a structured survey questionnaire to a representative sample comprising construction industry professionals, BIM practitioners, and project managers. Quantitative data analysis techniques, including descriptive statistics and inferential statistics such as correlation and regression analysis, will be utilized to examine the relationship between the implementation of BIM and the dependent variables of efficiency enhancement, waste reduction, and stakeholder communication. The research will adhere to rigorous ethical considerations to ensure participant confidentiality and informed consent. The outcomes of this research endeavor are anticipated to provide valuable insights into the potential benefits of integrating BIM into material management practices within the construction industry, thereby contributing to the existing body of knowledge in this domain.

C. Research Setting and Respondents

This study focuses on the Philippine construction industry, analyzing the adoption of Building Information Modeling (BIM) for material management within this specific context. The literature review draws on local sources to understand BIM's role and current material management practices in the Philippines. Data collection was conducted exclusively among Philippine construction stakeholders, including project managers, architects, engineers, contractors, and suppliers, through BIM-focused Facebook groups. By focusing on professionals with hands-on experience, the research aims to capture insights that reflect the unique challenges and opportunities of BIM adoption in the Philippines.

D. Data Gathering Procedure and Instruments

Data was gathered using a structured survey questionnaire, designed to align with the study's objectives, covering BIM's potential impact on efficiency, waste reduction, and communication within material management. Closed- and open-ended questions allowed for both quantitative data and in-depth insights. Surveys were distributed digitally, maximizing reach and response rates across various regions. Collected data were then analyzed using descriptive statistics to identify trends and summarize BIM's role in material management within the Philippine construction sector. The findings were interpreted to draw conclusions and formulate recommendations, aiming to support BIM adoption for improved material management practices.

E. Statistical Treatment

The following statistical treatments will be employed to explore the potential of Building Information Modeling (BIM) in material management and its impact on efficiency, waste reduction, and stakeholder communication. Descriptive statistics will summarize and present the collected data, including mean, median, mode, standard deviation, and range measures. Correlation analysis will examine relationships between variables using Pearson's correlation coefficient. These statistical treatments aim to provide empirical evidence of the benefits of BIM in material management, specifically in enhancing efficiency, waste reduction, and stakeholder communication.

III. RESULTS AND DISCUSSION

Table 1. Familiarity and Opinion of the Respondents towards BIM

STATEMENTS	n	Mean	Interpretation	Median	Mode	STD
How familiar are you with building information modeling (BIM) technologies?	212	4.028436	Very familiar (4)	4	4	0.73623684
In your opinion, how important are BIM technologies in improving material management in construction projects	212	4.1800948	4	4	4	0.644228583
Overall		4.1042654	4	4		0.690232712

Table .1 shows the participants' knowledge of Building Information Modeling (BIM) technologies and their perceived value in better material management within building projects. On average, subjects reported a high understanding of BIM tools, with a mean score of 4.03 out of 5. This suggests that most people are familiar with BIM tools. Similarly, participants scored relatively high on the value of BIM tools in better material handling, with a mean score of 4.18 out of 5. This shows that respondents usually consider BIM technologies essential in improving material management processes within building projects.

The results show a strong agreement among the participants regarding the value of BIM technologies in material management, as suggested by both the high mean scores and the lack of significant variation in answers. The high knowledge of BIM technologies suggests that the building industry has widely accepted these tools, realizing their potential to address material management issues successfully. This agreement between perceived importance and knowledge underscores the industry's understanding of the value proposition offered by BIM technologies in better material management practices. The mode and median scores consistent with the mean further support the conclusion that most participants share a similar view on the importance of BIM technologies in material management.

These findings indicate a solid basis for leveraging BIM technologies to improve material management practices within building projects. The high awareness among industry pros suggests that there is already a sizable base of knowledge and skills available for applying BIM-driven material management solutions. Moreover, the agreement on the importance of BIM technologies highlights the potential for broad acceptance and integration into industry practices.

Table 2. Effectiveness of Building Information Modeling (BIM) in Material Waste Reduction

STATEMENTS	n	Mean	Interpretation	Median	Mode	STD
Effectiveness of Building Information Modeling (BIM) in reducing material waste through accurate quantity estimation	212	4.014150943	Very familiar (4)	4	4	0.6493071
Optimizing material usage in construction projects	212	4.235849057	4	4	4	0.6391921
Overall		4.125	4	4		0.6442496

Table 2 shows the perceived usefulness of Building Information Modeling (BIM) in two key areas: (1) lowering material waste through accurate amount estimate and (2) improving material usage in building projects. The mean scores show that respondents view BIM as highly successful in both areas, with a mean score of 4.01 for lowering material waste and 4.24 for improving material usage. Additionally, the median and mode scores are consistent with the mean scores, suggesting a general agreement among respondents regarding the usefulness of BIM in these areas. The standard deviations show relatively low variability in answers, further backing the uniformity of views across individuals.

The results indicate a general belief among industry workers in the effectiveness of BIM technologies in reducing material waste and improving material usage within building projects. The high mean scores suggest a strong agreement regarding the perceived usefulness of BIM in handling these issues. The similarity between the mean, median, and mode scores indicates that most respondents share a similar view, supporting the fact that BIM is widely regarded as a valuable tool in material management practices. The relatively low standard deviations indicate little difference in opinions among respondents, further emphasizing the unity of beliefs about BIM's usefulness in material waste reduction and material usage efficiency. These findings have important implications for the acceptance and application of BIM tools in building projects. The general belief in the usefulness of BIM in reducing material loss and improving material usage suggests a solid basis for leveraging these technologies to improve sustainability and efficiency within the building industry.

Table 3. Impact of Building Information Modeling (BIM) Implementation

STATEMENTS	n	Mean	Interpretation	Median	Mode	STD
Impact of implementing Building Information Modeling (BIM)	212	3.424528	Significant improvement (4)	3	3	0.575126
Improving efficiency in material management processes within construction projects	212	4.183962	4	4	4	0.645162
Overall		3.804245	4	4		0.610144

Table 3 shows the effect of adopting Building Information Modeling (BIM) on material management processes within building projects. The mean number for the effect of BIM adoption is 3.42, showing that respondents usually sense a significant gain, albeit not overwhelmingly so. Respondents ranked BIM adoption highly for the specific feature of improving speed in material management processes, with a mean score of 4.18, showing that it is viewed as very effective in this regard. The total mean score of 3.80 shows a good view of BIM adoption's effect on material management efficiency. The median and mode numbers show a constant impression among respondents, with the majority describing the effect as a significant improvement and efficiency gain, respectively. The standard deviations show relatively low diversity in answers, suggesting a degree of agreement among individuals.

The results suggest a complex view of the effect of BIM adoption on material management efficiency within building projects. While respondents generally admit a significant change, the mean score indicates that views are somewhat split, with some respondents possibly having less marked benefits. However, the high mean score for improving speed in material management processes shows a strong belief in the usefulness of BIM in this specific area. The similarity between the median and mode scores further supports the conclusion that most respondents view BIM adoption as leading to significant improvements in material management efficiency, matching the overall goal of improving building processes. These findings implied that while there is generally a good attitude toward BIM adoption's impact on material management efficiency, stakeholders may have different experiences and views. This shows the value of considering external factors and unique project processes when judging the usefulness of BIM in material management.

Table 4. Factors Influencing the Impact of Building Information Modeling (BIM)

STATEMENTS	n	Mean	Median	Mode	STD
How has the implementation of BIM impacted the efficiency of material management processes in construction projects?	212	3.424528	3	3	0.575126
Lack of knowledge	212	0.636792	1	1	0.4820622
Lack of skills	212	0.650943	0	0	0.9393196
Resistance to change	212	2.646226	3	3	0.9698463
Cost considerations	212	3.471698	4	4	1.3574966
Technological barriers	212	3.396226	5	5	2.3393572
Overall	212	2.371069			1.1105347

Table 4 shows data on different factors influencing the efficiency of material management processes in building projects following the adoption of Building Information Modeling (BIM). The mean numbers represent the perceived effect of BIM adoption on efficiency and the amount to which individual factors add to difficulties or roadblocks. Respondents ranked the impact of BIM adoption on material management efficiency with a mean score of 3.42, showing a modest view of its usefulness. Additionally, respondents listed several vital factors affecting the efficiency of material management processes: lack of understanding (mean = 0.64), lack of skills (mean = 0.65), unwillingness to change (mean = 2.65), cost considerations (mean = 3.47), and technology barriers (mean = 3.40). The total mean number for all factors is 2.37, indicating a modest amount of worry or challenge across the listed factors. Median and mode numbers provide further insight into the primary trends of answers, while standard deviations show differences in views among respondents.

The results show a complicated set of factors affecting the impact of BIM adoption on material management efficiency. While respondents usually sense a modest improvement in efficiency following BIM introduction, several difficulties are noted. Lack of information and skills are considered relatively minor hurdles, suggesting that respondents feel sufficiently informed and able to utilize BIM technologies. However, reluctance to change appears to be a significant worry, showing possible cultural or organizational hurdles to adopting BIM-driven material management practices. Cost factors and technological hurdles also present notable challenges, showing the financial and technical complexities of implementing BIM solutions. The overall mean score indicates that respondents perceive a modest level of difficulty or worry across all identified factors, showing the multiple challenges facing the successful application of BIM in material management processes within building projects. The findings underscore the importance of handling a range of factors beyond technical skills to improve the effect of BIM on material management efficiency. While BIM technologies offer potential solutions, beating resistance to change, handling cost limits, and managing technological hurdles are essential for successful adoption.

Table 5. Impact of Building Information Modeling (BIM) on Material Management Efficiency

STATEMENTS	n	Mean	Median	Mode	STD
How has the implementation of BIM impacted the efficiency of material management processes in construction projects?	212	4.67	-	-	-
Lack of knowledge	212	0.905660377	1	1	0.292992467
Lack of skills	212	1.320754717	2	2	0.949404102
Resistance to change	212	2.264150943	3	3	1.293819701
Cost considerations	212	2.358490566	4	4	1.9722659
Technological barriers	212	0.023584906	0	0	0.34340141
Overall	212	1.924528302			0.89938647

Table 5 shows data on the observed effect of Building Information Modeling (BIM) implementation on the speed of material management processes in building projects and the difficulties involved with this implementation. The mean score for the effect of BIM adoption on material management performance is exceptionally high at 4.67, showing a strong positive impact. In contrast, respondents noted several challenges, including lack of knowledge (mean = 0.91), lack of skills (mean = 1.32), resistance to change (mean = 2.26), cost considerations (mean = 2.36), and technological barriers (mean = 0.02). The total mean number for all factors is 1.92, showing a usually low amount of observed challenge or difficulty. Median and mode numbers provide extra insights into central trends, while the standard deviations show diversity in answers.

The results show a significant positive view of the effect of BIM adoption on material management efficiency within building projects. Respondents widely view BIM as highly successful in improving efficiency, as demonstrated by the high mean number and the mode and median being 5. However, responders also note several problems involved with BIM adoption. However, lack of information and skills are considered relatively small hurdles, and reluctance to change and cost considerations appear as more significant issues. Resistance to change may represent cultural or organizational hurdles to accepting new technologies, while cost factors show the financial difficulties of implementing BIM solutions. Surprisingly, technological hurdles receive the lowest mean score, showing that respondent's sense minimal challenges. These findings show that BIM implementation has a considerable positive impact on material management efficiency in building projects, but there are still challenges to solve. Stakeholders should highlight strategies to beat reluctance to change and address cost limits to maximize the benefits of BIM.

Table 6. Relationship between familiarity with Building Information Modeling (BIM) technologies and its perceived importance in improving material management

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.640115	0.2217617	11.9052	3E-25	2.202951	3.07727929	2.2029506	3.0772793
How familiar are you with Building Information Modeling (BIM) technologies?	0.383699	0.0542155	7.0773	2E-11	0.276823	0.4905759	0.276823	0.4905759
There is a significant positive relationship between familiarize of BIM and importance of BIM in improving material management in construction projects, r(209) = 0.43, p< 0.00000000002.								

Table 6 shows the relationship between familiarity with Building Information Modeling (BIM) technologies and their perceived importance in improving material management in construction projects. The results indicate a significant positive relationship between familiarity with BIM technologies and the perceived importance of BIM in improving material management in construction projects. The intercept coefficient of 2.64 suggests that when familiarity with BIM is zero, the perceived importance of BIM in material management improvement is estimated to be 2.64. The coefficient for familiarity with BIM (0.38) indicates that for every one-unit increase in familiarity with BIM, the perceived importance of BIM in material management improvement increases by 0.38 units. The t-statistic (7.08) and extremely low p-value ($p < 0.00000000002$) demonstrate the statistical significance of this relationship. These findings suggest that individuals have become more familiar with BIM technologies; they are more likely to perceive BIM as necessary for improving material management in construction projects. This highlights the importance of promoting awareness and understanding of BIM technologies among industry professionals to enhance their appreciation of its potential benefits.

Table 4.7 shows the relationship between the effectiveness of Building Information Modeling (BIM) in accurately estimating quantities of materials needed for construction projects and its impact on optimizing material usage. The results show a significant positive link between the usefulness of BIM in correctly estimating the number of materials needed for building projects and its impact on improving material usage. The intercept value of 1.92 shows that when the usefulness of BIM in material estimates is zero, the improvement of material usage is predicted to be 1.92.

Table 7. Effectiveness of Building Information Modeling (BIM) in Material Estimation and its Impact on Material Usage Optimization

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.9213108	0.223876	8.582017	2E-15	1.48	2.3626438	1.47997776	2.362644
How effective do you think BIM is in accurately estimating quantities of materials needed for construction projects?	0.5765947	0.055059	10.47221	6E-21	0.4681	0.6851349	0.4680546	0.685135

There is a significant positive relationship between the effectiveness of Building Information Modeling (BIM) in reducing material waste through accurate quantity estimation and optimizing material usage in construction projects, r(209) = 0.58, p< 0.000000000000000000006

The measure for the effectiveness of BIM in material estimate (0.58) shows that for every one-unit increase in the effectiveness of BIM, the improvement of material usage grows by 0.58 units. The t-statistic (10.47) and extremely low p-value ($p < 0.000000000000000000006$) show the statistical significance of this connection.

These findings show that as the usefulness of BIM in correctly predicting amounts of materials improves, there is a related rise in the optimization of material usage in building projects. This shows the critical role of accurate material estimates supported by BIM in improving total material management efficiency.

Stakeholders should highlight efforts to improve the efficiency of BIM tools and processes for material estimates, as this can lead to significant benefits in lowering waste and improving resource usage. Additionally, the statistical significance of the relationship offers factual support for the value of harnessing BIM for material management efficiency, showing its ability to drive positive outcomes in building projects.

Table 8. Impact of Building Information Modeling (BIM) Implementation on Material Management Efficiency

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.788	0.250422	11.1345	6.24E-23	2.294659	3.281983	2.29466	3.28198
How has the implementation of BIM impacted the efficiency of material management processes in construction projects?	0.408	0.072121	5.65085	5.16E-08	0.265369	0.549716	0.26537	0.54972

There is a significant positive relationship between impact of implementing Building Information Modeling (BIM) and improving efficiency in material management processes within construction projects, r(209) = 0.36, p< 0.00000005.

Table 8 shows the relationship between the impact of implementing Building Information Modeling (BIM) and improving the efficiency of material management processes in construction projects. The intercept coefficient indicates the predicted value of the dependent variable (effectiveness of material management) when the impact of BIM adoption is zero. The results show a significant positive relationship between adopting Building Information Modeling (BIM) and improving the efficiency of material management processes in building projects. The intercept value of 2.788 shows that when the effect of BIM adoption is zero, material management efficiency is considered 2.788. The coefficient for the impact of BIM implementation (0.408) shows that for every one-unit increase in the effects of BIM implementation, the efficiency of material management grows by 0.408 units. The t-statistic (5.65) and extremely low p-value ($p < 0.00000005$) show the statistical significance of this connection.

These findings show that as the effect of adopting Building Information Modeling (BIM) grows, there is a related improvement in the efficiency of material management processes in building projects. This shows the importance of successfully adopting BIM to drive good results in material management. Stakeholders should highlight tactics to improve the effect of BIM adoption, such as spending on training and resources, pushing organizational buy-in, and creating a culture of innovation and teamwork.

Table 9. Key Factors Influencing the Adoption of Building Information Modeling (BIM)

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	3.56	0.11	32.27678	2E-82	3.3425	3.7775	3.3425	3.77745
Lack of knowledge	-0.04545	0.2	-0.23196	0.817	-0.432	0.3409	-0.432	0.34089
Lack of skills	0.01548	0.05	0.326081	0.745	-0.078	0.1091	-0.078	0.10908
Resistance to change	0.14667	0.11	1.305794	0.193	-0.075	0.3681	-0.075	0.36811
Cost considerations	-0.06875	0.08	-0.83303	0.406	-0.231	0.094	-0.231	0.09396
Technological barriers	-0.07833	0.04	-1.92504	0.056	-0.159	0.0019	-0.159	0.00189

There is a significant positive relationship between implementation of BIM impacted the efficiency of material management processes in construction projects andkey factors influencing the adoption of BIM in the construction industry, r(206) = 0.31, p< 0.0004.

Table 9 presents the coefficients, standard errors, t-statistics, p-values, and confidence intervals for a regression analysis examining the relationship between the impact of implementing Building Information Modeling (BIM) on the efficiency of material management processes in construction projects and key factors influencing the adoption of BIM in the construction industry. The results show a significant positive link between the effect of adopting Building Information Modeling (BIM) on the efficiency of material management processes in construction projects and critical factors affecting the acceptance of BIM in the construction industry. The slope value of 3.56 shows that when all vital factors are zero, the material handling efficiency is considered 3.56. However, none of the coefficients for the key factors (lack of information, lack of skills, reluctance to change, cost considerations, and technological barriers) are statistically significant, as suggested by their p-values being above 0.05. The index for technological barriers has the lowest p-value (0.056), suggesting a modest level of importance.

These findings suggest that while there is a relationship between the impact of BIM implementation on material management efficiency and critical factors influencing BIM adoption in the construction industry, the individual factors examined in this analysis do not significantly contribute to explaining the variation in material management efficiency. This means that other unknown factors may play a more substantial role in influencing the acceptance of BIM and its impact on material management efficiency.

Table 10. Organizational and Technical Challenges in Building Information Modeling (BIM) Implementation and Material Management Efficiency

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.65	0.1203	38.66	2E-96	4.412858	4.887142154	4.412858	4.887142
Organizational challenges	0.13	0.1533	0.856	0.393	-0.17105	0.433548118	-0.17105	0.433548
Technical challenges	0.13	0.0919	1.361	0.1751	-0.05612	0.306120312	-0.05612	0.30612
Training requirements	-0.01	0.0511	-0.2	0.8387	-0.11118	0.090349373	-0.11118	0.090349
Potential barriers faced by stakeholders	-0.1	0.0368	-2.74	0.0066	-0.17329	-0.02832703	-0.17329	-0.02833
Other	0.08	0.108	0.747	0.4562	-0.13231	0.293605102	-0.13231	0.293605

There is a weak positive relationship between the implementation of BIM and the efficiency of material management processes, but it is not statistically significant at the 0.05 significance level., $r(206) = 0.21$, $p < 0.07$.

Table 10 examines the relationship between organizational and technical challenges in Building Information Modeling (BIM) implementation and the efficiency of material management processes. The standard errors measure the range of the coefficient numbers, while the t-statistics and p-values rate the statistical significance of the coefficients. The confidence intervals show the range within which the valid population values will likely fall. The regression analysis shows a weak positive link between BIM usage and material management processes' performance, but it is not statistically significant at the 0.05 significance level. The slope value of 4.65 says that when all organizational and technology problems are zero, the efficiency of material management is estimated to be 4.

IV. Conclusion

In conclusion, the study highlights the evolving potential of Building Information Modeling (BIM) in the construction industry's material management. Using a quantitative research approach, the study examined the opinions, attitudes, and value of adopting BIM in improving partner communication, reducing waste, and boosting efficiency.

1- Conduct a thorough analysis of existing Building Information Modeling (BIM) technologies and their potential in material management.

This study's thorough examination highlights the substantial potential of current BIM technology to revolutionize material management procedures in the building sector. Better control over material quantities, usage, and waste is made possible by BIM's provision of comprehensive data and insights. Because BIM enables construction professionals to make better decisions based on precise, real-time information, this capacity is essential for maximizing resource allocation and eliminating waste. The promise of BIM, then, goes beyond simple material tracking and may be used to promote a more effective, sustainable, and regulated method of material management in building projects.

1. Analyze the effectiveness of Building Information Modeling (BIM) in reducing material waste through accurate quantity estimation and optimization material usage in construction project.

Through improved quantity estimation accuracy and material utilization optimization, BIM technologies have demonstrated efficacy in significantly decreasing material waste in construction projects. These technologies aid in more accurate resource allocation and planning, which lowers waste and unnecessary material orders. Since cutting waste immediately advances environmental objectives and lowers expenses related to excess resources, BIM's beneficial effects on material efficiency are consistent with industry aims for sustainable practices. Overall, the results show how BIM's ability to accurately estimate quantities and optimize materials greatly improves the sustainability and efficiency of building processes.

2- Investigate the impact of implementing Building Information Modeling (BIM) on improving efficiency in material management processes within construction projects.

It has been demonstrated that using BIM improves the effectiveness of material management procedures in building projects. According to the study, industry professionals strongly agreed that BIM is useful for improving operational efficiency and simplifying processes. BIM streamlines resource tracking and coordination across the project lifecycle by centralizing material data and promoting improved communication between project teams. Reduced project schedules, cost savings, and increased project predictability are all results of this efficiency gain, and they all improve overall project outcomes and customer satisfaction.

3- Identify the key human factors that influence the adoption and implementation of Building Information Modeling (BIM) in the construction industry, including factors related to knowledge, skills, and resistance to change.

For BIM to be adopted and used effectively in the construction sector, human aspects are essential. The study highlights a number of human factors-related issues, such as industry professionals' lack of expertise, reluctance to alter long-standing procedures, and ignorance of BIM's potential. These elements pose serious challenges to utilizing BIM's full potential. To overcome these obstacles, organizations must make a determined effort to raise awareness, enhance training, and promote a change in perspective. Unlocking the full potential of BIM in promoting effective and sustainable material management practices requires addressing these human elements.

4- Propose comprehensive recommendations and guidelines for the successful adoption and implementation of Building Information Modeling (BIM) in material management within the construction industry, addressing organizational and technical challenges, training requirements and potential barriers faced by stakeholders.

Construction companies must solve organizational and technical issues if they want BIM to be successfully embraced and included in material management procedures. To give industry experts the skills and knowledge they need, the report suggests making focused expenditures in training and development. Furthermore, establishing a culture that values creativity and teamwork can lessen opposition to change and facilitate the smooth integration of
BIM. Stakeholders may optimize the transformative potential of BIM by giving priority to these methods and taking proactive measures to address any potential obstacles. In the end, putting these suggestions into practice will improve project results, encourage sustainability, and boost material management effectiveness in the building sector.

References

[1] Jusoh, Z. M. & Kasim, N. (2017). A Review on Implication of Material Management to Project Performance. MATEC Web of Conferences. 87.01012.10.1051/matecconf/20178701012.

[2] Rodriguez L. V., Bagcal, O. R., Baccay, M. A., & Barbier, B. M. (2019). Adoption of Building Information Modeling (BIM) in the Philippines' AEC Industry: Prospects, Issues, and Challenges. Journal of Construction Engineering, Technology and Management. 9(2). 8- 20p. doi.org/10.3759/jocetm.v9i2.2547

[3] Mall, A. (2019, March). Reducing Material Waste with The Application Of Building Information Modelling(Bim). [PDF]. https://openscholar.dut.ac.za/bitstream/10321/3253/1/MALL_2019.pdf

[4] Damini (n.d.). What is Material Management? (Definition, Types, and Objectives) https://www.deskera.com/blog/material-management/#:~:text=The%20critical%20components%20of%20 material,plan%20to%2 0acquire%20those%20materials.

[5] Vasudevan, G. (2019). Study on Adoption of Building Information Modelling in Reducing Construction Waste in Malaysia. IOP Publishing. doi:10.1088/1755-1315/358/4/

[6] Ajirotutu, Rasheed O., et al. "Exploring the intersection of Building Information Modeling (BIM) and artificial intelligence in modern infrastructure projects." *Journal of Advanced Infrastructure Studies* 2 (2024).

[7] Abuhussain, M. A., Waqar, A., Khan, A. M., Othman, I., Alotaibi, B. S., Althoey, F., & Abuhussain, M. (2024, February). Integrating Building Information Modeling (BIM) for optimal lifecycle management of complex structures. In *Structures* (Vol. 60, p. 105831). Elsevier.

[8] Adeyemi, A. B., Ohakawa, T. C., Okwandu, A. C., Iwuanyanwu, O., & Ifechukwu, G. O. (2024). Advanced Building Information Modeling (BIM) for affordable housing projects: Enhancing design efficiency and cost management. *J. Build. Inf. Model*, *12*, 45-60.

[9] Fadlalla, A. A. (2024). Modal Analysis of Beams Using Finite Element Methods. *Journal of Civil and Construction Engineering Research (JCCER)*, *1*(1).

[10] Radwan, M. M., Mousa, A., & Zahran, E. M. M. (2024). Enhancing pavement sustainability: prediction of the pavement condition index in arid urban climates using the international roughness index. *Sustainability*, *16*(8), 3158.