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Research Article

A Critical Analysis of Enhancing Health and Safety for Productivity in the Construction Industry

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ABSTRACT

The construction sector is among the most dangerous sectors in the world which presents unique risks to occupational health and safety. It faces a wide range of occupational health and safety risks and related threats to worker productivity, which have consistently resulted in a high number of workplace injuries including fatal ones and worker productivity losses along with the ensuing problems with quality, cost, time, etc. As a result, of all industries, the construction sector has the second-highest rate of workplace fatalities The main objective of this study was to provide a framework for leveraging Building Information Modelling (BIM) to create a productivity and safety monitoring system and to critically analyze how using Building Information Modelling (BIM) might help the construction sectors in Singapore become more productive and perform better in terms of safety. The study developed IPASS to manage risk by controlling hazards by considering important safety and productivity factors at the project level, adhering to the conceptual framework. This development was done in five main steps. The first step was a literature review, the second was a review of case studies, the third was questionnaire design, the fourth was data collection analysis and the fifth was the integration of productivity and safety using BIM. These results showed the creation of IPASS, which can analyze data from BIM models to produce productivity and safety rankings for building projects. The study showed how BIM may be used to track safety and productivity as a project develops and improves performance in both areas. It was proposed that IPASS makes it possible for project stakeholders to collaborate since they may base their work on evaluations of safety and productivity performance both before and after projects begin. For the IPASS application, it is recommended that the BIM model that has been provided to the authorities should be utilized for the productivity and safety of construction sites in Singapore.

Keywords: Occupational Health and Safety, IPASS, Building Information Modelling (BIM), workplace fatalities, productivity and safety monitoring system.

INTRODUCTION

The construction business has seen significant changes over the past thirty years about the kind of project that needs to be completed, the technology that is employed, the equipment and design needed for the job, and the methods of communication that are in use. This shift in the construction sector calls for the creation of practical strategies that ensure productivity, particularly in the areas of health management and safety. Productivity is one of the key elements influencing an organization's overall performance which measures how well a business meets its objectives. It is a crucial tool for tracking progress to successfully and economically meet the company's goals. However, the most important aspect of the productivity of a construction company is to maintain its health and safety measures (Abu Aisheh et al., 2022).

Given the typical involvement of numerous actors, agencies, and stakeholders, the construction industry is distinct from other industries due to several distinctive features and inherent challenges. This sector, which is among the most dangerous sectors in the world, presents unique risks to occupational health and safety. It faces a wide range of occupational health and safety risks and related threats to worker productivity, which have consistently resulted in a high number of workplace injuries including fatal ones and worker productivity losses along with the ensuing problems with quality, cost, time, etc. As a result, of all industries, the construction sector has the second-highest rate of workplace fatalities (Goh and Abdul-Rahman, 2013). Therefore, promoting creative approaches that can successfully regulate, mitigate, and even eliminate all significant health and safety hazards and related risks at work is crucial to minimizing these hazards. This will improve worker productivity at all stages of the life cycle in terms of occupational health and safety (Hallowell, 2011)

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This study will specifically focus on investigating creative ways to boost productivity by improving occupational health and safety among all kinds of professionals working in the construction sector in response to the need for productivity by improving occupational health and safety. To address the interrelated problems of occupational safety, occupational health, and worker productivity in the construction industry, this study will attempt to bring together scholars, practitioners, and policymakers to exchange ideas, experiences, and insights.

MATERIALS AND METHODS

The methodology of this study consisted of five essential elements. Literature review, Review of case studies, questionnaire design, data collection and analysis, and integration of safety and productivity using BIM (Teo Ai Lin, 2017).

Step 1: Literature Review

Following the conceptual framework, the study considered important safety and productivity factors at the project level to create IPASS, which controls hazards to manage risk. To create IPASS, the first step was to examine the several approaches that BIM has investigated to enhance safety and productivity in the construction sector both internationally and specifically in Singapore by using literature reviews. This included a study of the industry's potential for, advantages of, and difficulties with BIM deployment. Early in a project, there is the most opportunity to identify and mitigate risks, by risk management concepts. Most of the predictable risks should therefore ideally be "designed out" during the planning and design phases, with the remaining risks being handled throughout the construction and later stages (Zou et al, 2015). Gambatese et al. (2008) emphasized that there is a direct correlation between planning for construction safety and construction site fatalities, meaning that as many hazards as possible should be considered and addressed throughout the design phase. According to Hamidi et al. (2012), the Risk Analysis Process offers a standard analysis loop that advises decision-makers to set up the project context and a productive communication environment, identify risks, evaluate them, take appropriate action to mitigate them, and then appropriately review, document, and report the findings.

Step 2: Review of case studies

Step 2 involved conducting 18 in-depth, in-person interviews with 30 representatives from 12 different companies and organizations between January and December 2014. Establishing a baseline about the productivity and safety improvement practices of the Singaporean construction sector, as well as the use of BIM, was the aim of the interviews. The goal of the interviews was to uncover the most pressing problems and worries regarding BIM, safety, and productivity.

Step 3: Designing of the Questionnaire

In this third step, a questionnaire was then created. It aimed to investigate things including businesses' safety and productivity policies and practices, current techniques for gauging project safety and productivity, businesses' experience with the connection between safety and productivity, and businesses' understanding and integration of BIM.

Step 4: Data Collection and Analysis

Step 4 involved using the questionnaire to gather empirical data. Both consultants and principal contractors participated in the questionnaire-based survey. Companies registered with the BCA under registration heads CW01 (general building) and CW02 (civil engineering), with submitting limits varying from the highest (A1) to the lowest (C3) of the classes, made up the target population for primary contractors. There were 383 contractors found in all. The consultants were chosen from member lists supplied by the corresponding professional associations in Singapore. They included architectural businesses, structural engineering firms, mechanical and electrical (M&E) engineering firms, and quantity surveying firms. 454 consultants in all were chosen. As a result, 837 businesses in total received invitation emails. The questionnaire-based survey received responses from 59 businesses in total. Following the conclusion of the fieldwork, data analysis was done to comprehend the industry's perspectives on productivity and safety, the present state of attempts to improve both, and the industry's use of BIM. The framework of IPASS was the result of numerous rounds of negotiations with the Ministry of Manpower's (MOM) Workplace Safety and Health (WSH) Institute.

Step 5: Integration of safety and productivity using BIM

In step five, productivity and safety were integrated, and BIM was used as the platform for risk management's hazard management. Using BIM, the buildable design idea, and design for safety via ConSASS, which uses the risk management approach, the suggested system (IPASS) seemed to ascertain a building's productivity and safety indices. The buildability score, which described the wall systems, structural systems, along with additional constructed design elements, was the basis for calculating the productivity score. The Code of Practice on Buildability, 2014 Edition (BCA, 2014) is followed in the calculation of the buildability score. The ConSASS evaluation and the dangers found in the wall and structural systems are used to calculate the safety score.

RESULTS

These results showed the creation of IPASS, which can analyze data from BIM models to produce productivity and safety rankings for building projects. The study showed how BIM may be used to track safety and productivity as a project develops and improves performance in both areas. The following is the table showing the results and findings.

Table 1: Key points of the results of interviews

SURVEY	RESULTS
Benefits of BIM (INTERVIEWS)	Communication
	Clash Detection
	Coordination
	Training
	Visualisation
	Safety measures
Challenges of BIM (INTERVIEWS)	Change of mindset
	Technical issues
	Library
	Resources
	Lead time
	Legal framework
	Standarisation
Obstacles to the use of BIM (SURVEY)	Difficulty in finding personnel competent in BIM
	Cost of tm implementation (excluding staff training)
	Cost of staff training
Potentials of BIM in Improving Productivity and Safety (SURVEY)	Pre-project planning
	Clash detection
	Productivity monitoring using actual construction site data
Challenges in using BIM (SURVEY)	The multi-disciplinary approach required in the implementation of BIM
	The time and effort needed to develop extensive libraries
	Shortage of BIM technicians
Factors contributing to low productivity on the construction site (SURVEY)	Site conditions, quality and attitudes of personnel, and management of projects
	Design and procurement
	Subcontracting and productivity practice
	Communication and complexity of project
	Resources and construction method
Factors determining WSH performance level on site (SURVEY)	Site conditions, complexity of project and personnel practices
	Compliance with safety rules and regulations
	Maturity of WSH system
	Availability of safety programmes
Factors impacting on productivity and safety (SURVEY)	Quality and attitudes of workers and project planning
	Resources, weather conditions and accidents
	Subcontracting and construction methods

Table 2: Computation of productivity and safety scores

Productivity Score (B-Score)		Safety Score (S-Score)	
Productivity Systems/ Features	**Labour Saving Index**	**Safety Systems/ Features/ Safety Maturity Level**	**Less Hazardous Index**
Structural systems	45	Structural systems	45

Wall systems	45	Wall systems	45
Other Buildable Design Features	10	ConSASS	10
Maximum	100	Maximum	100

DISCUSSION

The rule-checking features of the proposed IPASS enable it to detect dangers. Unidentified risks may have a stacked effect, increasing the likelihood of hazards, according to Zou et al. (2016). Stop-work orders may therefore cause projects to be delayed, which would hurt site activities and productivity performance. Since Carter and Smith (2006) pointed out that all risk management techniques are useless if any risks cannot be identified before they materialize, IPASS's ability to recognize potential vulnerabilities and minimize risk during the Design Stage is a crucial feature. In the 3D environment, IPASS makes it much simpler to verify any errors and the logic of a design (quality check capabilities). In addition to IPASS's ability to reduce risk on site (by identifying risks virtually before construction), it also has other features that reduce risks by removing hazards because it has built-in safety measures and control rules to address issues brought on by a variety of factors, including design flaws, improper material selection, and more.

Such a feature is crucial for improving safety and productivity because research by Tam et al. (2004) has shown that inadequate risk management commonly results in safety and productivity-related risks. The productivity module and the safety module are the two modules that makeup IPASS, as was previously indicated. BIM served as the integrating platform for the development of the two modules. The BCA's BIM guidelines were consulted to define every property in the BIM model. The BD score of the BCA was taken into consideration when creating the productivity module's productivity index. The wall system (maximum 45 points), structural system (maximum 45 points), and other buildable design elements (maximum 10 points) make up the productivity module. One hundred points is the highest possible productivity score.

The types of dangers, control mechanisms for hazards found in the wall and structural systems, and ConSASS were all taken into consideration while creating the safety module's safety index. Based on hazard prevention and management, the highest possible safety score is 90. The usage of REVIT or another commercial program (like ArchiCAD) in this study is important since it evaluates and verifies the durability of the suggested system and shows its "openness" because it employs the Open BIM methodology. However, to solve some of the persistent issues facing the construction sector that impede its advancement toward excellence, it is critical to disentangle and analyze the variables that affect project performance. To improve efficiency and safety, the article shows how BIM may assist stakeholders in taking these factors into account from the very beginning of the construction process. It outlines a framework for integrating productivity and safety indices with BIM as the platform, resulting in IPASS. IPASS is capable of pinpointing certain high-risk areas during the design stage, enabling hazard mitigation strategies to be applied. At the same time, the productivity of the project, based on the buildability score attained, could be monitored. This intelligent BIM-based system allows the users to identify and control dangerous designs and the potential hazards they pose while keeping an eye on the achievable buildability score. As a result, it enables careful tracking of the increase in productivity and safety both before and throughout the project.

LIMITATIONS

Despite offering insightful information about the connection between productivity and occupational health and safety (OHS) in the construction sector, this study has several drawbacks. Firstly, the study was limited to one region only which was Singapore. Also, the study's limitations were primarily because the industry was still in the process of transitioning to BIM. First, the BIM models that were acquired for system validation only included basic information about the buildings, which prevented IPASS from performing most of the checks that it was designed to perform. Secondly, although it would be ideal for the same BIM models that were submitted to the authorities to be entered into IPASS for productivity and safety monitoring, some manual labor might still be necessary for IPASS to function as efficiently as possible. Depending on the level of detail of the BIM model, the manual effort may involve entering the specifics of building systems and safety as mandated by IPASS. The quality of the BIM models will become more crucial as BIM submittal for projects has become required and BCA is promoting seamless collaboration between participants from all disciplines. Users should be able to fully utilize IPASS. This could be presented to show how the paper bridges the gap between theory and practice, and its consequent impact on society, even though there aren't many consequences for practitioners at this transition period in implementing BIM. Also, to improve the generalizability and dependability of results, future directions of this study can be applied to analyze the relationship between occupational safety and productivity on a wider scale in larger geographic contexts, such as the West Bank and nearby areas, and employ bigger, more representative samples.

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CONCLUSION

In conclusion, this study critically examined the relationship between OHS and raising worker productivity in the construction sector from the perspective of taking Singapore as a case study. The identification of tactics that successfully advance both productivity and safety throughout a building project has been stated as the primary goal to accomplish this goal. According to the study's findings, integrating safety management with productivity enhancement is crucial to implementing the company's plans for construction projects. The suggested system (IPASS) allows practitioners to track their productivity and safety performance during the Design and Construction stages, which is one of the practical contributions. Furthermore, the reports produced by the suggested method can be utilized to submit the required documents to the appropriate authorities. Typically, practitioners must manually determine the buildability score, which takes a lot of time, particularly for intricately designed buildings. The reports include comprehensive information that explains the causes of low productivity and safety ratings and offers potential solutions. Singaporean officials consider the suggested system to be a strong, open system.

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