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INVESTIGATING THE RELATIONSHIP BETWEEN THE CONSTRUCTION SAFETY PLAN, KNOWLEDGE MANAGEMENT, AUDIT PROCESS, INFORMATION SYSTEM, WEB, AND BIM WITH CONSTRUCTION SAFETY PERFORMANCE

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ABSTRACT

The rapid growth of high-rise building construction in Indonesia has led to a significant increase in accidents, necessitating a robust audit process for construction safety. This research investigates the relationship between construction safety plans (CSPs), audit processes, knowledge management (KM), information systems, the web, and BIM on construction safety performance, aiming to develop a BIM-based KM audit process. To analyze the significance level of various indicators for each variable considerable importance, a mixed-methods approach was employed, combining qualitative insights from expert interviews with quantitative analysis using Structural Equation Modeling (SEM) via SmartPLS. The findings in the study reveal that the studied variables have a Cronbach's Alpha value above 0.7, and the retained variables have a significant value greater than or equal to 0.7. In this study, the confidence level is 95%, where there is a relationship between variables that meet the t-table, which is > 1.96, it can be concluded that the relationship between each variable has a significant value. This study provides a framework for integrating these elements to enhance construction safety performance, offering valuable guidelines for industry stakeholders to improve safety practices in construction projects.

Keywords: Construction Safety Plan, Audit Process, Knowledge Management, Information System, Web Integration, BIM, Safety Performance

1. INTRODUCTION

Indonesia has experienced significant growth in the construction of high-rise buildings, with numerous structures exceeding a height of 200 meters. Construction projects involve extensive manual labor, hence increasing the likelihood of work-related accidents. An efficient construction safety management system is necessary to mitigate the greater accident rate that is associated with increased complexity of construction. For a project to be considered successful, it must prioritize the health and safety of its workers, regardless of whether it is completed on time and under budget (Lim, 2019). The objective of implementing occupational safety and health (OSH) is to safeguard workers, company resources, the surrounding community, and the natural surroundings, as required by Law No. 1 of 1970.

The data from the Employment Social Security Institution accident insurance program in 2022 indicates an increasing yearly rise in both work accidents and occupational diseases. The number of reported accident cases in 2021 amounted to 234,370, reflecting a 5.7% rise compared to the preceding year. This data emphasizes the immediate necessity to give priority to Occupational

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Safety and Health (OSH) in the workplace to ensure the welfare of workers and the overall success of construction projects.

The implementation of construction work safety is carried out due to the risk of workplace accidents, considering the applicable standards based on the audit process regulations in the Indonesian Minister of Public Works and Public Housing No. 10 of 2021 concerning Guidelines for Construction Safety Management Systems and applicable Occupational Health and Safety (OHS) provisions. Therefore, research is needed on high-rise building projects to apply construction safety in the workplace. Implementing the construction safety management system according to regulations involves an internal audit system within construction companies to assess the level of implementation, identify influential factors, and respond with corrective actions to fulfill the Occupational Health and Safety Management System (OHSMS) and prevent work accidents (Ibrahim, 2020).

Audits are a critical component of the OHSMS, providing a means to directly and comprehensively monitor the implementation and effectiveness of the company's OHSMS (Robson, 2010). Safety audits should be conducted by personnel independent of the contractor, while safety reviews can be conducted by internal project team members. Safety audits provide fundamental proactive feedback to safety professionals and operations staff regarding deficiencies in safety management schemes (Karanikas, 2017).

To overcome safety challenges, management systems must adapt to change by effectively capturing, storing, and disseminating new injury prevention strategies. This can be achieved through the development, implementation, and maintenance of effective safety Knowledge Management (KM) processes (Hallowell, 2012). Expert auditor judgments are more accurate and demonstrate a higher level of professional scepticism in knowledge transfer and information seeking (Rodgers., et al 2017).

Safety should focus on technologies that allow construction site operators to share their knowledge and experience with planners to use BIM as a knowledge base for construction site design (John et al., 2015). Technological developments are expected to support construction applications by providing added value to each project. BIM offers efficient and optimizing benefits to the management of construction companies. Building Information Modeling (BIM) is a sophisticated technology applied in developed countries to support efficiency and effectiveness in construction company management. BIM is expected to help minimize the accident rate, especially in the construction industry (Lim, 2019).

In this research, previous studies are expanded upon with the main concept of implementing KM with an audit process integrated with BIM. Structural Equation Modelling (SEM) is a second-generation multivariate data analysis method frequently employed in research due to its ability to test theoretically supported linear and additive causal models (Haenlein & Kaplan, 2004). Analyzing the relationship between indicators can be done in several ways, including multiple regression, path analysis, factor analysis, and SEM.

SEM is a multivariate method for investigating the relationship between exogenous (independent) and endogenous (dependent) latent variables in a model simultaneously (Kline, 1998). SEM provides validity and reliability of the observed variables in the measurement model and shows the relationship between observed quantitative variables and unobserved (latent) variables (Barclay et al., 1995). Model assessment through SEM is used as a quantitative study to determine the hypothesized relationship and significance between constructs and indicators for implementation and continuation in construction. The resulting model in this study provides an objective and measurable assessment of how much construction safety performance needs to be improved throughout the project life cycle.

2. LITERATURE STUDY

In this research, the variables affecting construction safety performance are classified into six categories: construction safety plan (CSP), audit process, KM, information system, web, and Building Information Modeling (BIM). Based on this conceptualization, the following research establishes hypotheses supported by the literature to construct a Partial Least Squares-Structural Equation Modelling (PLS-SEM) model, aiming to enhance construction safety performance by integrating each influencing factor.

H1. BIM affects information systems: The use of BIM for safety in construction has the potential to increase practitioners' understanding of their site, thereby reducing the likelihood of accidents (John et al., 2015). BIM is widely seen as an enabling technology with the potential to improve communication between stakeholders, enhance the quality of information available for decision-making, improve the quality of services provided, and reduce time and costs at every stage of the construction cycle (John et al., 2015).

H2. BIM affects web: Web-based communication systems can contain safety information that can be accessed at any time, including BIM that can visualize projects and facilitate real-time communication between stakeholders, thus improving safety performance (Zou et al., 2017).

H3. KM affects information systems: KM is the process of sharing information and knowledge in the form of necessary data/documents that are always updated and accessible with information technology. Mechanisms or tools within an organization promote knowledge sharing, enabling members to improve their skills and knowledge (García-Fernández, 2015).

H4. The audit process affects KM: Developing an audit process KM information system, such as a website, assists auditors and auditees in carrying out the audit process, thereby reducing disputes in the design and build integrated contract system (Tussadiyah, 2021).

H5. The audit process affects the information system: Obtaining information related to the audit process within the organizational scope of safety performance in high-rise buildings with design contracts supports information such as rules applicable to case studies in the safety performance audit process (Dyah et al., 2023). Information systems benefit from collecting, processing, storing, analyzing, and disseminating data and information for specific purposes (Turban et al., 2008).

H6. The audit process affects the web: An audit website can provide dynamic and continuously updated information on dominant risks in the audit process, enabling wide dissemination of updated information (Tussadiyah, 2021).

H7. CSP affects BIM: Simulating safety during construction projects, the Work Breakdown Structure (WBS) can be integrated with the schedule of work implementation, including the resources used, thus providing input information to BIM (Hu & Zhang, 2011). The use of BIM for health and safety in construction can increase practitioners' understanding of their sites, reducing the likelihood of accidents (John et al., 2015). The integration of BIM and the Safety Plan should be applied throughout the project life cycle (Putra Lim & Latief, 2020).

H8. CSP affect KM: Implementing KM in buildings can improve control over critical variables related to security and safety in high-rise building projects. The knowledge map will be structured according to the specific conditions of the company and its experiences (Argiolas et al., 2022).

H9. The CSP affects the audit process: Risk control, along with safety goals and programs, are validated and can be used as a standard for developing safety goals and programs in the CSP of integrated construction work to design and build high-rise buildings. Developing standards for the SMKK audit process involves identifying the stages of the audit process, audit activities/elements, audit objectives, and potential audit risks (Akram, 2023).

H10. In the implementation of SMK3L, information systems collaborating with web applications can improve safety performance (Yufrizal, 2022). In addition to improving safety performance, using information systems can impact organizational behavior and culture, increase public collaboration, disseminate information more efficiently, and assist in decision making (Lu et al., 2014).

H11. Web affects construction safety performance: Web-based communication systems can increase involvement in construction activities by facilitating information exchange, communication links, and activities affecting safety performance indicators (Aguilar & Hewage, 2013).

The research hypotheses, shown in Figure 1, are based on the relationships between the variables of CSP, audit process, KM, information system, web, and BIM, aimed at improving construction safety performance. This is showed in the path connectivity diagram of the proposed structural relationship model to enhance construction safety performance.

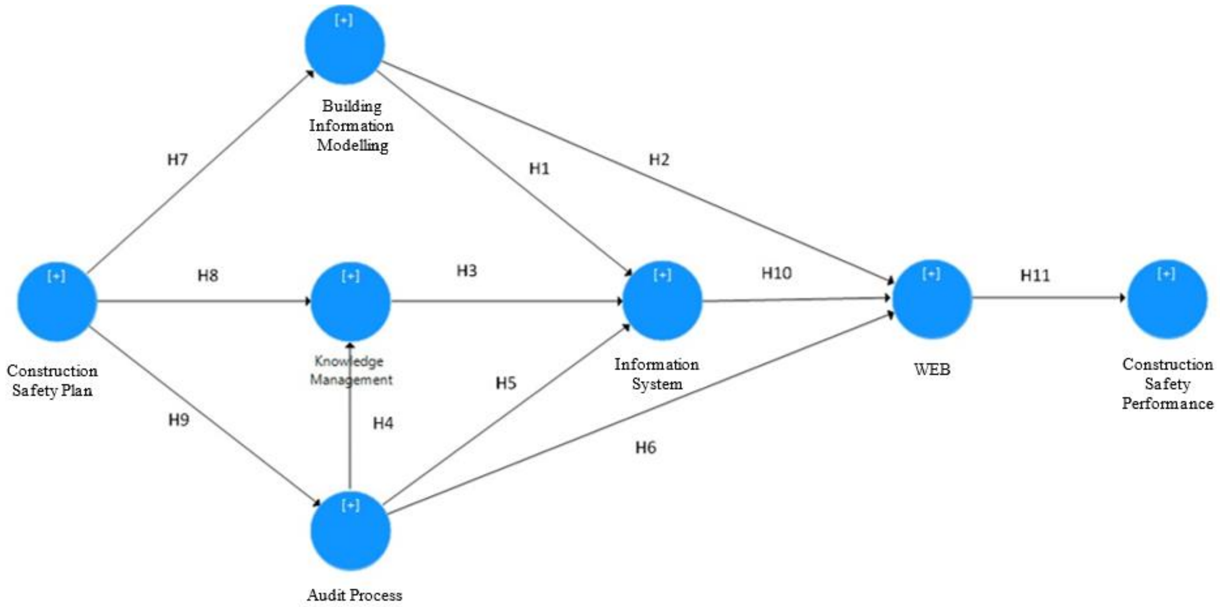

Figure 1 Research Hypothesis

3. METHODS

This study employs a mixed-method approach, integrating both quantitative and qualitative techniques to provide a comprehensive analysis of the factors influencing construction safety performance. Quantitative data were gathered through questionnaire distribution, while qualitative insights from experts were utilized to ensure a profound understanding of the presented variables. This methodological approach aims to bolster the validity and reliability of the research outcomes.

Questionnaires were distributed to experts to validate and solicit feedback from them. Expert knowledge was based on qualifications from academia or practitioners, including contractors, consultants, and government officials. Inputs from these experts were then synthesized and utilized as input for composing the questionnaire, as depicted in Table 1, which lists items considered significant to construction safety performance.

Table 1 Items Considered Significant to Construction Safety Performance

Code	Variable	Code	Variable
X1	Construction Safety Plan (CSP)	X5	Web
X1.1	Work Breakdown Structure	X5.1	WEB Content
X1.2	Hazard Identification, Risk and Opportunity Assessment	X5.2	Accuracy
		X5.3	Format
X1.3	Action Plan (Goal and Programme)	X5.4	Timeliness
X2	Audit Process	X5.5	Ease of Use
X2.1	Audit Programme Management	X5.6	Security and Privacy
X2.2	Audit Implementation	X5.7	Response and Privacy
X2.3	Audit Criteria	X6	BIM
X3	Knowledge Management (KM)	X6.1	Data Properties
X3.1	Knowledge Create	X6.2	Relationship
X3.2	Knowledge Sharing	X6.3	Utilities
X3.3	Knowledge Application	X6.4	Information Criteria
X4	Information System	X6.5	Function Criteria
X4.1	Database Planning	X6.6	Technical Criteria
X4.2	Technology Integration	X6.7	Organizational/Legal Criteria
X4.3	Technical System Integration	Y1	Construction Safety Performance
X4.4	Process Data	Y1.1	Leading Indicator
		Y1.2	Lagging Indicator

Based on the literature review, this study evaluated the relationship between CSPs, audit processes, KM, information systems, web, BIM, and construction safety performance. This evaluation involved content and construct validation of identified variables to assess the accuracy of variables, indicators, and statements. Surveys were conducted by distributing questionnaires to 63 respondents, with statistical data processed using IBM SPSS for descriptive analysis of respondent homogeneity. A data adequacy test was performed to determine significance values between variable relationships, modeling these relationships with SmartPLS 3.3.3. During data management, eight outliers were identified and excluded, resulting in 55 respondents' data being used to produce a significant relationship between variables. The stages conducted in this study which are briefly described in Figure 2.

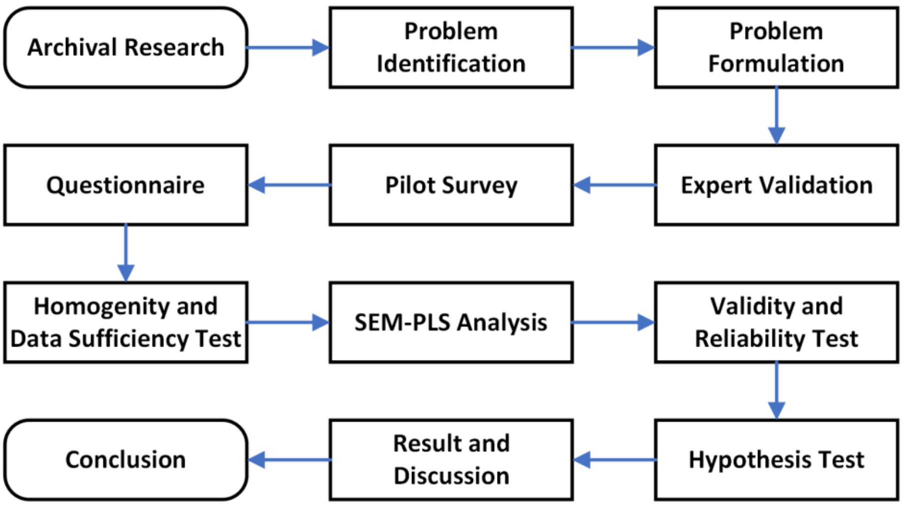

Figure 2 Research Flow

3.1. Homogeneity Test with SPSS

This study consists of seven variables with a total of 206 indicators. The homogeneity test intends to determine the level of difference in understanding the results of the questionnaire by respondents, who are influenced by several factors such as work experience, latest education, and the institution where the respondent works. The homogeneity test is a non-parametric analysis where the data variables used are nominal scales. In this study, the Kruskal-Wallis test was employed using SPSS software. The test results are considered homogeneous if the Asymp. Sig (2-tailed) is greater than the level of significance (α) 0.05 and the Kruskal-Wallis H value <0.05 (df) according to the degree of freedom value. The grouping results can be seen in Table 2.

Table 2 Respondent Grouping

No		Grouping	Number of Respondent
1	Instance	Contractor	41
		Consultant	8
		Government	4
		Academics and Practitioners	2
2	Education	Bachelor	42
		Master	12
		Doctoral	1
3	Work Experience	< 5 Years	19
		5- 10 Years	22
		> 10 Years	14

Based on the results of the homogeneity test, all indicators support the null hypothesis (H0), indicating no significant differences in respondents' perceptions based on their institution, education, and work experience. The analysis results using SPSS showed that Asymp. Sig values are greater than the level of significance, confirming the homogeneity of the data.

3.2. Data Sufficiency Test

The data sufficiency test is conducted to determine whether the data collected is sufficient based on the required number of observations (N'). Data can be considered sufficient if the number of observations made (N) is greater than the number of observations required (N'). The formula for testing the adequacy of research data is as follows:

$$N' = \left(\frac{\frac{k}{s}\sqrt{N\Sigma x^2 - (\Sigma X)^2}}{\Sigma x} \right) \quad (1)$$

If the data N' is smaller than N (i.e., 55), then the data obtained is declared sufficient. The data sufficiency test was carried out using Microsoft Excel software, and the results indicated that the data was sufficient for further data management.

3.3. PLS-SEM Analysis

SEM is a statistical technique that seeks to explain the covariance among a set of variables. SEM can be defined as a system of equations that specifies the structure of relationships between observed and unobserved (latent) quantitative variables (McQuitty and Wolf, 2013). In measurement using SEM, there are two approaches: evaluating each variable separately and testing all variables simultaneously with structural modeling.

4. RESULTS AND DISCUSSION

Relationship analysis using Smart-PLS software was conducted to estimate the causal-predictive relationships between the variables of CSP, KM, Audit Process, Information System, Web, and BIM on construction safety performance. The hypothetical model was described according to the framework shown in Figure 3.

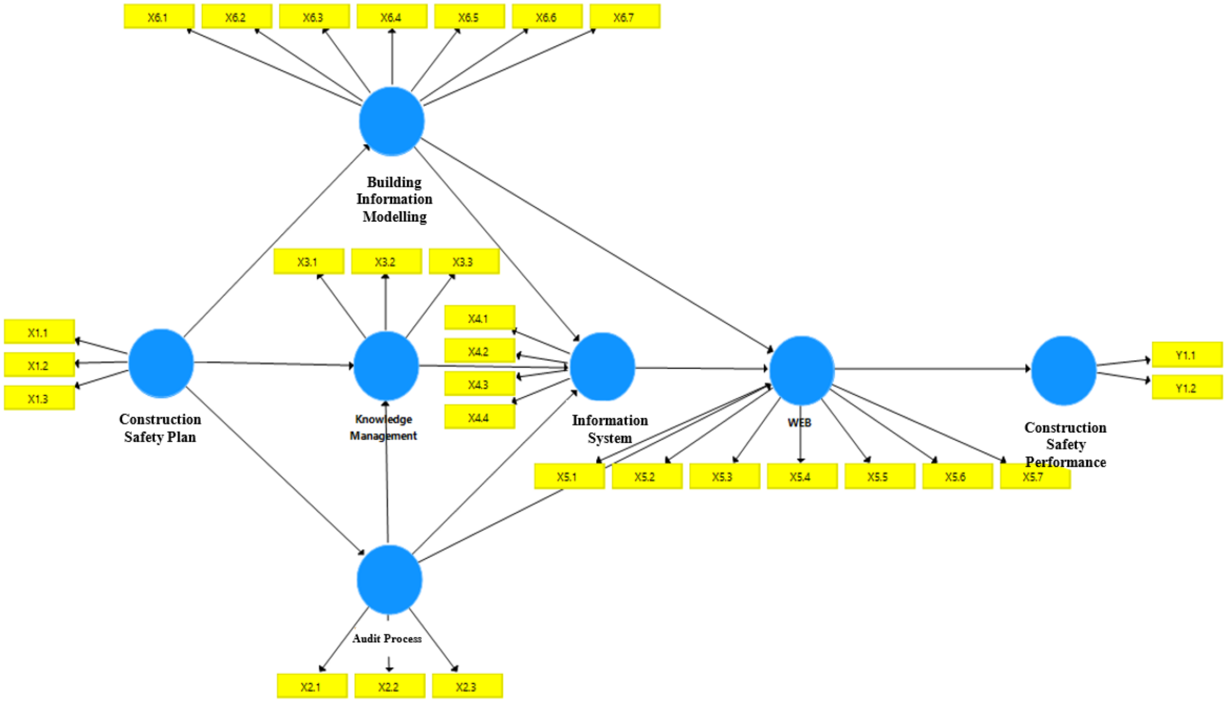

Figure 3 Research Model in Smart-PLS

4.1. Validity and Reliability Test

The validity test, based on Average Variance Extracted (AVE), aims to assess construct variables for sufficient discriminant validity and convergent validity. The standardized loading factor is a method of comparing the correlation of indicators of a construct with the correlation of indicators of other constructs. AVE is conducted as a validity test, where a variable is considered valid if the AVE value is greater than the squared correlation between the variables. A variable will be deemed valid if the AVE value is greater than 0.50 (McQuitty & Wolf, 2013).

4.1.1 Validaty Test

The loading factor value is considered to have discriminant validity if it is greater than 0.7 (Hair et al., 2013). It is necessary to check whether the AVE value of any indicator is less than 0.7, in which case it should be eliminated or retained. The AVE value of outer loadings that meet the requirement is greater than 0.7, as shown in Table 3. The validity test is performed by analyzing convergent validity according to the requirements in McQuitty & Wolf (2013) and discriminant validity according to the requirements in Hair et al. (2013). Figure 4 shows the results of the PLS algorithm calculation to determine the AVE value using SmartPLS 3.0.

Table 3 AVE Value of Outer Loadings

Variable Indicator	BIM	Construction Safety Performance	KM	Audit Process	CSP	Information System	WEB
X1.1					0,791		
X1.2					0,881		
X1.3					0,875		
X2.1				0,853			
X2.2				0,911			
X2.3				0,894			
X3.1			0,822				
X3.2			0,869				
X3.3			0,875				
X4.1						0,885	
X4.2						0,892	
X4.3						0,907	
X4.4						0,880	
X5.1							0,808
X5.2							0,765
X5.3							0,836
X5.4							0,847
X5.5							0,791
X5.6							0,717
X5.7							0,831
X6.1	0,828						
X6.2	0,832						
X6.3	0,872						
X6.4	0,894						
X6.5	0,765						
X6.6	0,865						
X6.7	0,806						
Y1.1		0,931					
Y1.2		0,914					

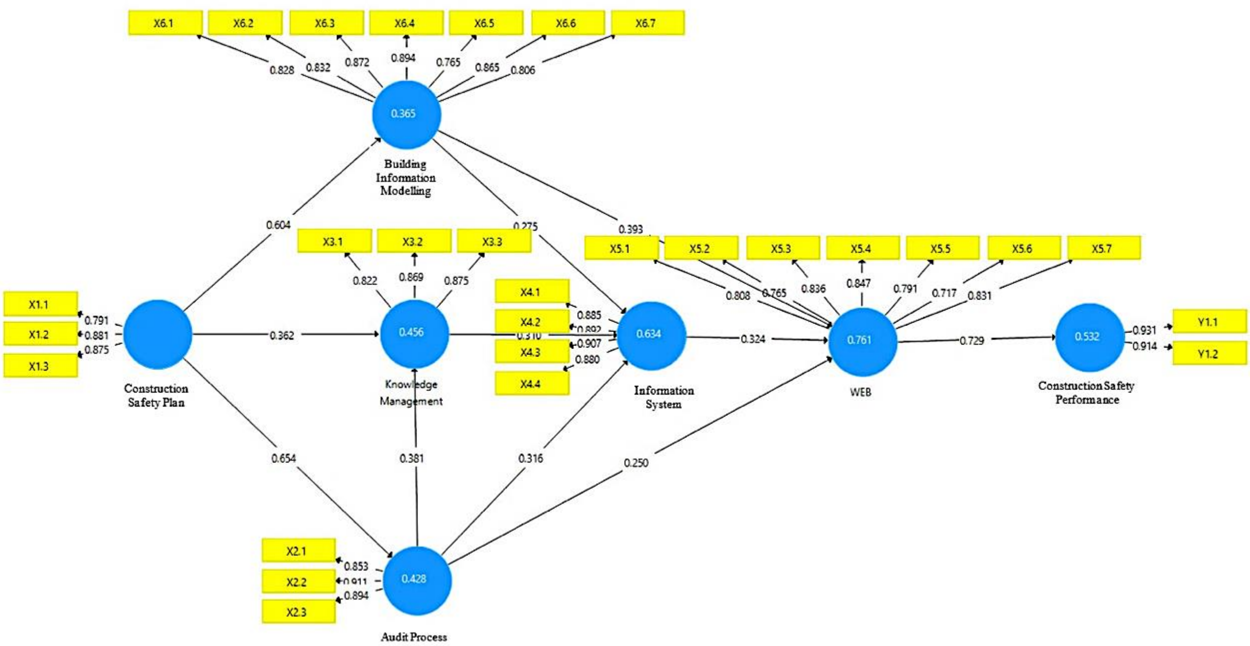

Figure 4 PLS Algorithm Calculation

4.1.2 Reliability Test

The reliability test was carried out to evaluate the outer model by assessing the reliability of the variable construct. The reliability test includes criteria such as Cronbach's alpha and composite reliability. A construct is considered reliable if the Cronbach's alpha value is greater than 0.7 and the composite reliability value is greater than 0.7. These requirements indicate the accuracy, consistency, and precision of a measuring instrument (Neuman, 2006). The composite reliability and Cronbach's alpha values for each factor were greater than 0.70, as shown in Table 4. Therefore, all factors exhibited an AVE value exceeding 0.50, indicating that the items effectively align with their respective constructs. Thus, the convergent validity of the factors is established.

Table 4 Items Considered Significant to Construction Safety Performance

Variable Indicator	Cronbach's Alpha	Composite Reliability	AVE
BIM	0,930	0,943	0,703
KM	0,826	0,920	0,851
KM	0,821	0,891	0,732
Audit Process	0,864	0,917	0,786
CSP	0,809	0,886	0,723
Information System	0,913	0,939	0,793
WEB	0,906	0,926	0,641

The AVE value for each variable exceeds 0.5, indicating that the construct has valid data. Additionally, the Cronbach's alpha value for each construct is greater than 0.7, and the composite reliability value for each construct is also greater than 0.7. Therefore, it can be concluded that all constructs are both valid and reliable.

4.2. Hypothesis Test

Hypothesis testing is conducted by examining the path coefficient value, which indicates the parameter coefficient and the t-statistic value. If the t-statistic value is greater than the t-table value, then the hypothesis is accepted. In this study, the confidence level is 95%, so the t-table value for the one-tailed hypothesis is 1.96. For example, the relationship between the CSP and the Audit Process has a t-statistic value of 3.305. This means that the t-statistic is greater than the t-table value (3.305 > 1.96), indicating that the relationship between the CSP and the Audit Process is significant. The path coefficient results are shown in Figure 5 and Table 5.

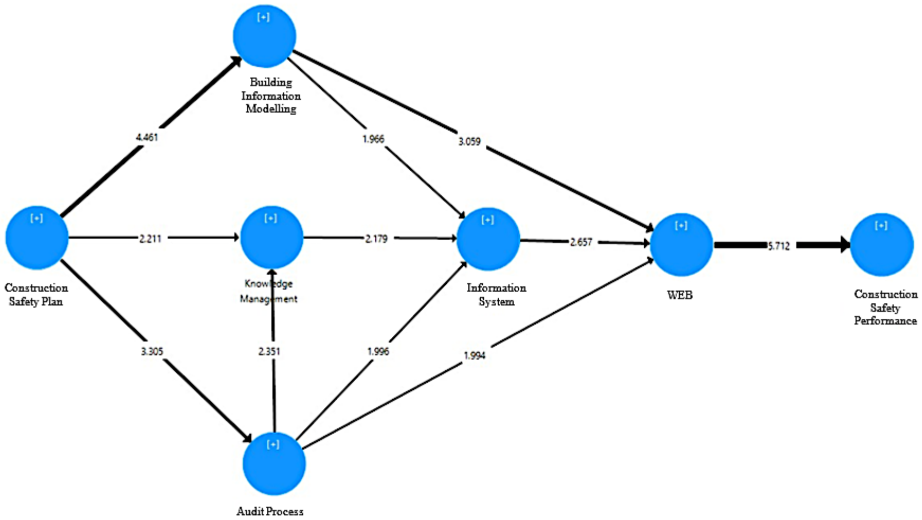

Figure 5 Effect of Relationship between Variables

Table 5 shows that there is a relationship between variables that meet the t-table criteria for significance, namely where the t-statistic value is greater than the t-table value.

Table 5 Path Coefficient Results

Relationship between Variables	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
BIM → Information System	0,275	0,278	0,140	1,966	0,025
BIM → Web	0,393	0,389	0,128	3,059	0,001
KM → Information Systems	0,310	0,313	0,142	2,179	0,015
Audit Process → KM	0,381	0,360	0,162	2,351	0,010
Audit Process → Information System	0,316	0,301	0,159	1,996	0,023
Audit Process → Web	0,250	0,264	0,125	1,994	0,023
CSP → BIM	0,604	0,594	0,135	4,461	0,000
CSP → KM	0,362	0,367	0,164	2,211	0,014
CSP → Audit Process	0,654	0,608	0,198	3,305	0,001
Information System → WEB	0,324	0,310	0,122	2,657	0,004
Web → Construction Safety Performance	0,729	0,714	0,128	5,712	0,000

Path modeling in PLS-SEM first examines the direct effects between variables. Subsequent analysis determines the indirect effects mediated by other variables (Shanmugapriya & Subramanian, 2016). The total effect is then calculated by summing the direct and indirect effects, providing a comprehensive understanding of the model structure relationships (Nitzl et al., 2016). The results of the total effect analysis using PLS-SEM are presented in Table 6.

Table 6 Total Effect Results

Relationship between Variables	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
BIM → Construction Safety Performance	0,351	0,341	0,109	3,224	0,001
BIM → Information System	0,275	0,278	0,140	1,966	0,025
BIM → Web	0,482	0,478	0,124	3,896	0,000
KM → Construction Safety Performance	0,073	0,069	0,047	1,558	0,060
KM→ Information Systems	0,310	0,313	0,142	2,179	0,015
KM → Web	0,100	0,094	0,057	1,751	0,040
Audit Process → Construction Safety Performance	0,285	0,281	0,111	2,569	0,005
Audit Process → KM	0,381	0,360	0,162	2,351	0,010
Audit Process → Information System	0,434	0,415	0,149	2,921	0,002
Audit Process → Web	0,391	0,392	0,135	2,895	0,002
CSP → BIM	0,604	0,594	0,135	4,461	0,000
CSP → Construction Safety Performance	0,425	0,418	0,161	2,643	0,004
CSP → KM	0,611	0,595	0,162	3,770	0,000
CSP → Audit Process	0,654	0,608	0,198	3,305	0,001
CSP → Information System	0,562	0,556	0,158	3,549	0,000
CSP → Web	0,583	0,567	0,154	3,791	0,000
Information System → Construction Safety Performance	0,236	0,225	0,104	2,275	0,012
Information System → Web	0,324	0,310	0,122	2,657	0,004
WEB -> Construction Safety Performance	0,729	0,714	0,128	5,712	0,000

The results presented in Table 6 demonstrate that the path coefficient and total effect values meet the criterion of a t-statistic value greater than 1.96, indicating positive and significant influences between the variables. Path analysis of the resulting model reveals two primary paths encompassing all variables:

1. CSP →Audit Process → KM → Information System → Web → Construction Safety Performance (Y1 = 0.654X1 + 0.381X2 + 0.310X3 + 0.324X4 + 0.729X5)
2. CSP → BIM → Information System → Web → Construction Safety Performance (Y2 = 0.604X1 + 0.275X6 + 0.324X4 + 0.236X5)

The regression equations Y1 and Y2 illustrate the relationships between the dependent variables (Y1 and Y2) and the independent variables. The coefficients indicate how a one-unit change in an independent variable affects the dependent variable, assuming other variables remain constant. For example, a one-unit increase in X1 leads to a 0.654 unit increase in Y1, while a one-unit increase in X5 results in a 0.729 unit increase in Y1. Similarly, a one-unit increase in X1 leads to a 0.604 unit increase in Y2, while a one-unit increase in X5 results in a 0.236 unit increase in Y2. These equations enable the prediction of Y1 and Y2 values based on the independent variable values, providing insights into the relationships among variables within the regression model.

In addition to identifying dominant indicators, the results of data analysis produce a relationship model between variables. The coefficient value affects the predictive nature of the independent variable on the dependent variable, as seen in the original sample column (O). It is interpreted that the CSP influences construction safety performance based on previous literature. The development of risk control standards, along with safety goals and programs in the CSP, identification of work activities at the WBS level, potential hazards and risks, and risk control can improve construction safety performance, as referenced in the regulation of the Minister of Public Works and Public Housing No. 10 of 2021 (Akram, 2023).

This research employed a questionnaire methodology to acquire data, with the questionnaire distributed based on predefined criteria. These criteria included the institution, years of experience, and the highest level of education attained. The study demonstrates that web integration stands out as the most significant factor in enhancing construction safety performance. Additionally, five other factors, including CSP, audit processes, KM, information systems, and BIM, exert considerable influence on improving construction safety performance. The factors affecting safety performance were assessed through PLS-SEM, with the resulting values falling within parameter boundaries. Therefore, the hypotheses generated in this study have been proven.

Referring to the t-statistic values and p-values from the PLS-SEM results, the variable "web" demonstrates the highest level of significance in influence. The cross-loading results on the outer loading indicators also show a positive impact on the "web" variable. Therefore, this study recommends that auditors implement and enhance construction safety performance by integrating the web as the information system platform containing an open database of variables for exchange and phased realization transmission online, as well as for the observation and control of audit activities, with other variables serving as support, as all presented variables are interconnected.

The results of experts' validation are synergistically supported by previous research emphasizing the importance of developing CSPs to enhance construction safety performance. Improving construction safety performance can be attained through the incorporation of risk management measures, identification of root causes, and establishment of objectives and programs within the CSP. Integrating these elements with an information system aligns with the guidelines outlined in the Minister of Public Works and Public Housing Regulation Number 10 of 2021 (Rahma, 2023). The audit process is an important element of the OHS management system because audit activities are carried out to review and evaluate the performance and effectiveness of the applicable OHS management system (Robson, 2010). The application of KM in buildings can improve control over critical variables in security and safety in high-rise building projects. The knowledge map will be structured according to the specific conditions of the company according to the experience that the company has gone through (Argiolas et al., 2022). Information systems facilitate tracking records of incidents, conditions, and dangerous behavior, processing data into various forms of needed information, and allowing direct access by interested parties to improve construction safety (Yufrizal, 2022). Web-based information systems can increase involvement in construction activities by facilitating information exchange, communication links, and activities that affect safety performance indicators (Aguilar & Hewage, 2013). The use of Building Information Modelling (BIM) for health and safety on construction sites has the potential to increase practitioners' understanding of their sites, thus reducing the likelihood of accidents (John et al., 2015).

From the relationship analysis results, a new theory is derived in this study. Theory is a collection of concepts, definitions, propositions, and variables that are systematically related and have been generalized to explain and predict certain phenomena (Cooper & Emory, 1995). The new theory derived from the relationship model explains the equations of Y1 and Y2 values based on the independent variable values and provides an understanding of the relationships among the variables within the regression model. The implementation of BIM in the occupational safety management system can elevate the level of workplace safety and pinpoint potential hazards that may arise during the initial planning, construction, and maintenance stages of construction projects (Lim, 2019).

5. CONCLUSION

This study identifies key factors influencing the audit process to enhance construction safety performance. The dependent variables Y1 and Y2 are influenced by multiple independent variables. For Y1, CSPs, audit processes, KM, information systems, and the web significantly contribute to its outcome, with the web demonstrating the highest impact. Conversely, for Y2, CSPs, information systems, the web, and BIM play notable roles. These results underscore the intricate relationships between the independent variables and the dependent variables Y1 and Y2.

Such insights are essential for understanding the underlying dynamics of the phenomena under investigation and can offer valuable guidance for decision-making processes in relevant domains. Specifically, BIM significantly impacts the evaluation of construction safety implementation. Therefore, auditees are advised to focus on these factors when implementing the audited process, which has been validated by experts in this study.

Recommended strategies include implementing CSPs and integrating them with BIM modeling, supported by a web-based information system for quick online adoption and access, to enhance construction safety performance. Further research should aim to identify additional factors that can improve construction safety performance.

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