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Analysis of Supporting and Hindering Factors in the Implementation of Construction Safety Management Systems

I Putu Artama Wiguna[1], Indradjaja Manopol[2], and Zetta Rasullia Kamandang[3]
[1] Associate Professor, Civil Engineering Department, Institut Teknologi Sepuluh Nopember, Jl. Raya ITS, Sukolilo Surabaya 60111, Indonesia, E-mail: artama.wiguna@gmail.com (corresponding author).
[2] Senior Construction Practitioner, Director of Professional Association, Indonesia, E-mail: ijmanopol@gmail.com
[3] Doctoral Researcher, Civil Engineering Department, Institut Teknologi Sepuluh Nopember, Indonesia, E-mail: zerasullia.ts@upnjatim.ac.id

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Abstract: The construction industry is characterized by a high risk of accidents due to multiple hazards, dynamic work environments, weather, tight schedules, and a large workforce, all of which challenge the consistent enforcement of safety measures. Despite the issuance of Ministerial Regulation No. 10/2021 concerning the Construction Safety Management System (CSMS), its implementation in Indonesia remains suboptimal, as evidenced by the high frequency of workplace accidents recorded between 2018 and 2020. This study aims to identify the key factors supporting and hindering the successful implementation of CSMS in construction projects. A descriptive quantitative approach was used, involving a two-stage survey: a preliminary questionnaire for expert validation and a main questionnaire distributed to 147 respondents working on road and bridge projects managed by state-owned enterprises. Factor analysis was applied to simplify complex variable relationships and identify latent constructs. The results revealed five supporting factors: (1) strong management commitment to safety. (2) The availability of safety procedures, policies, and resources. (3) Organizational competence and effective managerial implementation. (4) A strong safety culture, and (5) comprehensive safety training for supervisors and workers. Conversely, three primary hindering factors were identified: (1) weak safety culture, (2) management shows deficiency in commitment and capability, and (3) low worker competence. These findings offer practical insights to help Indonesian construction companies to strengthen their safety culture and managerial commitment. They also provide government policy aimed at improving the monitoring and enforcing CSMS implementation.

Keywords: Construction safety management system, factor analysis, occupational safety, safety culture, construction projects.

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1. Introduction

Construction projects are inherently complex and physically demanding, both in their planning and execution. The nature of the work involves constantly changing environments, multiple locations, exposure to external conditions such as weather, tight project schedules, and the coordination of large and diverse teams. These factors place the construction industry among the sectors with the highest occupational risks. According to the International Labour Organization (2021), construction remains among the most hazardous sectors, with an estimated 60,000 fatal accidents occurring globally each year or roughly one death every ten minutes. Furthermore, construction workers are three to four times more likely to suffer a fatal accidents than employees in other industries. This trend is also prevalent in Indonesia. Despite numerous regulations addressing occupational safety, construction-related accidents remain frequent, especially between 2017 and 2020.

In response to these ongoing challenges, the Ministry of Public Works and Public Housing (PUPR) introduced Ministerial Regulation No. 10/2021, Guidelines of the Construction Safety Management System (CSMS). This regulation aims to ensure technical safety throughout the construction process, protect workers' health, minimize environmental impacts, and maintain public safety. Recent studies confirm that the implementation of safety management systems in Indonesia remains inconsistent. Kadir et al. (2022) found that although construction workers recognize the importance of

safety, management shows only a limited degree of commitment, and safety is rarely prioritized in practice. Similarly, Bria et al. (2024) analyzed 150 court rulings on construction accidents between 2010 and 2022 and found that incidents remained frequent, particularly in toll road projects, even after the enactment of PUPR Ministerial Regulation No. 21/2019, which highlights the persistent gap between regulation and practice. Most existing literature tends to attribute construction accidents to individual worker behavior, emphasizing unsafe actions and a lack of attention from site managers. However, construction accidents should not be viewed solely as the fault of individual workers but must be assessed holistically as failures at the organizational level. Endroyo et al. (2017) highlighted that safety outcomes at the project level are shaped not just by site personnel's behavior but also by the role of project management. Similarly, Winge et al. (2019) argued that construction accidents stem from a range of causes, including factors such as worker behavior, hazard mitigation, direct oversight, material or equipment usability, contextual site hazards, worker competence, and managerial oversight. Li et al. (2015) further noted that in many developing countries, construction safety continues to be a persistent problem due to weak safety regulations, poor enforcement, insufficient compensation for accident victims, and other institutional barriers that limit the effectiveness of safety management systems.

This issue is especially critical for state-owned construction enterprises, which are often tasked with delivering large-scale infrastructure projects and are expected to model high standards of regulatory compliance and occupational safety. The CSMS framework addresses not only occupational safety and health of workers but also the safety of the broader network of stakeholders involved in construction activities. However, the practical implementation remains far from ideal. Awareness of CSMS among project stakeholders remains low, a situation compounded by weak regulatory enforcement, limited competence in safety management, and the absence of clear incentives for compliance. A well-implemented CSMS has the potential to improve construction quality, deliver social benefits, and reduce losses caused by accidents, health issues, and project disruptions. This study addresses the following research questions: (1) What are the key supporting factors for successful implementation of CSMS in Indonesia? and (2) What are the key hindering factors? The findings are expected to provide practical recommendations to enhance safety practices and reduce the incidence of construction-related accidents in the national infrastructure sector.

2. Material and Methods

This study adopted a descriptive quantitative approach to examine the factors influencing the successful implementation of the CSMS's. The research process was divided into four main stages: conceptual development, instrument preparation, data collection and analysis, and interpretation of findings and recommendations. The overall framework is presented in Fig. 1.

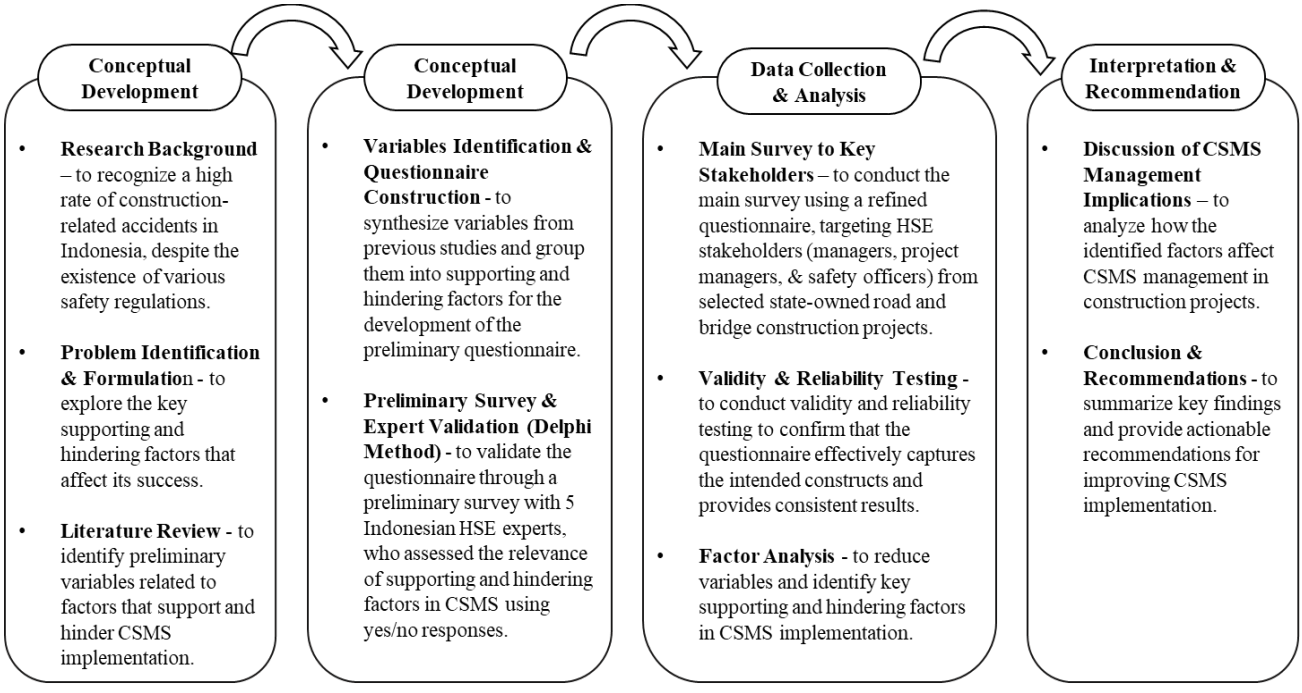

Fig. 1. Research methodology

The first stage, conceptual development, began with the identification of persistent construction-related accidents in Indonesia despite existing regulatory frameworks. This observation led to the formulation of research problems aimed at identifying key supporting and hindering factors affecting CSMC implementation. A comprehensive literature review was conducted to extract relevant variables from prior empirical studies. These variables formed the foundation for the research instrument.

In the second stage, instrument preparation, the identified variables were classified into two categories: supporting and hindering factors. Each variable was used to formulate a questionnaire. The rationale for adopting the questionnaire was grounded in both regulatory requirements and theoretical perspectives on construction safety management, including OSHA (2022) and the CSMS guidelines under Ministerial Regulation No. 21/2019. Supporting factors were adapted from works such as Hinze et al. (2013), Bavafa et al. (2018), and Mohammadi et al. (2018), while hindering factors were drawn from studies such as Buniya et al. (2021), Yiu et al. (2019) and Durdyev (2017). These studies consistently emphasize such issues as weak managerial commitment, limited workforce competence, and lack of enforcement as key barriers, while highlighting management commitment, availability of procedures, competence, safety culture, and training as key enablers. Thus, the questionnaire items represent theoretically and empirically validated variables that capture both supporting and hindering aspects of CSMS implementation. A preliminary questionnaire was then validated using the Delphi technique, involving Health, Safety, and Environment (HSE) experts in Indonesia. These experts evaluated the relevance of each item using binary (yes/no) responses to ensure content validity.

The third stage involved data collection and statistical analysis. The final questionnaire was distributed to key personnel from selected state-owned enterprises engaged in road and bridge construction projects. Target respondents included QHSE general managers, project managers, site safety officers, and other relevant stakeholders directly involved in CSMS implementation, both at the corporate and project levels. A minimum of 30 valid responses was targeted, with actual participation exceeding this threshold across multiple large-scale state-owned construction enterprises (SOEs). In this survey, each item was assessed using a five-point Likert scale, ranging from 1 ("very low influence/very unlikely to hinder or support") to 5 ("very high influence/highly hindering or supporting"). To ensure data quality, construct validity was assessed using Pearson's correlation. Items were considered valid if their correlation coefficient exceeded the critical r-table value at a 5% significance level. Reliability was assessed using Cronbach's Alpha, with a minimum threshold of 0.60, in line with Van Griethuijsen et al. (2015) and Hair (2010), who suggested that values above 0.60 indicate acceptable internal consistency for exploratory studies. Items meeting both criteria were retained for further analysis. Factor extraction was performed using Principal Component Analysis (PCA) with Varimax rotation. Sampling adequacy was assessed with the Kaiser-Meyer-Olkin (KMO) test, with values above 0.50 deemed acceptable (Kaiser, 1960). The suitability of data was further confirmed through Bartlett's Test of Sphericity, which must be significant ($p < 0.05$) to indicate adequate correlations among items. Only factors with eigenvalues greater than 1.0 were retained, following the Kaiser criterion (Hair, 2010).

The fourth stage focused on interpretation and recommendations, where the extracted factors were analyzed to explain their implications for CSMS implementation. This stage contextualized the statistical findings into practical managerial and institutional insights and concluded with actionable recommendations to improve CSMS practices in Indonesian construction projects.

3. Results

3.1. Identification of Supporting and Hindering Variables

3.1.1. Respondent profile

The preliminary questionnaire was distributed to five experts in the field of Construction Safety Management Systems (CSMS). These experts were selected based on their extensive professional experience spanning government, contracting, consulting, and industry associations. Among the respondents, four were males and one female. Their educational backgrounds ranged from bachelor's degrees to doctoral degrees, with work experience varying from 20 to 31 years. Specifically, respondent A, a male with a doctoral degree, has 27 years of experience and works at the Ministry of Public Works. Respondent B is a male contractor with a master's degree and 31 years of experience. Respondent C is a female consultant holding a master's degree with 25 years of experience. Respondent D, a male with a bachelor's degree, represents an HSE association and has 28 years of experience. Lastly, respondent E is a male contractor with a Masters in Science and 20 years of experience.

3.1.2. Results of questionnaire analysis

This preliminary survey applied the Delphi method, in which five selected HSE experts assessed the relevance of each proposed supporting and hindering factor using binary "Yes" or "No" responses. A factor was considered relevant if at least three out of five experts (≥75%) responded "Yes," in line with the minimum consensus threshold commonly applied in Delphi-based evaluations (Chu and Hwang, 2008; Murry and Hammons, 1995).

For the supporting factors, all five experts unanimously confirmed that the initial 30 proposed items were relevant for CSMS implementation. Additionally, one expert suggested five more supporting factors for potential inclusion in the main questionnaire: (1) external partnerships with related stakeholders. (2) Digitalization of HSE control systems (e.g., permits, reporting). (3) the establishment of a K4 Training Center, mock-up exhibition, and safety and quality induction rooms. (4) Implementation of the 12 Golden Safety Rules. (5) Availability of a Learning Management System (LMS) for HSE capacity-building. Of these, three suggestions were incorporated in the questionnaire, external stakeholder partnerships, digitalization of HSE controls, and the K4 Training Center, as they introduced new dimensions not yet fully captured by existing items. The remaining two suggestions were not included, as their content was already implicitly reflected in previously listed factors. As a result, the final set of supporting factors included in the questionnaire increased from 30 to 33.

For the hindering factors, most experts agreed that all 17 proposed items were relevant. However, four factors received at least one "No" response, namely: tight project schedule (marked "No" by two respondents), absence of safety policies and regulations (by one respondent), lack of top management awareness (by one respondent), and unsafe project conditions (by one respondent). Despite these minority responses, all four factors still met the minimum agreement threshold (≥3 experts responded "Yes") and were thus retained for inclusion in the questionnaire.

3.2. Analysis of Supporting and Hindering Factors

3.2.1. Respondent profile

Respondents for the second-phase questionnaire were selected based on their direct or indirect professional experience in construction safety. A total of 160 questionnaires were distributed across seven SOEs and one subsidiary company, resulting in 147 valid responses and a high response rate of 91.87%.

The sample was predominantly male (97.28%), with female participation at 2.72%, reflecting the gender imbalance typical of the construction industry. Overall, 95.24% of respondents (140 individuals) were from SOEs, while 4.76% were from the subsidiary. Regarding project types, the majority of respondents were involved in road and bridge construction, including road projects (14.79%), toll roads (35.21%), bridges (14.08%), and combined road-and-bridge projects (23.94%). Other project types accounted for 11.97%. In total, 88.03% of respondents were engaged in road and bridge projects, indicating strong relevance to the research context.

In terms of education, most respondents held a bachelor's degree (81.63%), followed by diploma-level education (9.52%) and master's degrees (8.84%). Respondents also held a range of professional positions: Director (0.68%), General Manager (6.12%), Project Manager (24.49%), Manager and Senior Manager (51.70%), and Staff (17.01%). This shows that 82.99% of the respondents occupied managerial-level roles or higher. Regarding work experience, 82.31% had more than 20 years of experience, while smaller proportions fell into the categories of 1–5 years (6.80%), 11–15 years (4.76%), and 16–20 years (0.24%). Given the predominance of highly experienced professionals with long tenure in road and bridge projects (88.03%), employment in SOEs (95.24%), high-level positions (82.99%), and undergraduate or higher education (90.47%), the respondent group can be considered well-qualified and competent to provide informed insights for this research.

3.2.2. Supporting factors analysis

3.2.2.1. Validity and reliability test of supporting factors

The supporting factors comprised 33 variables evaluated through a questionnaire. To ensure instrument validity, a Pearson correlation analysis was conducted. With a sample size (N) of 33, the critical r-table value was 0.344. As a result, all 33 items yielded correlation coefficients higher than 0.344, indicating that all supporting variables were valid. Furthermore, the reliability of the instrument was tested using Cronbach's Alpha, resulting in 0.970 as the value (Table 1), which exceeds the minimum acceptable threshold of 0.60. Therefore, the questionnaire is highly reliable and suitable for further analysis.

Table 1. Reliability test result of supporting factors

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Item
.970	.971	33

3.2.2.2. Factor analysis of supporting factors

The Kaiser-Meyer-Olkin (KMO) test produced a value of 0.932, and Bartlett's Test of Sphericity was statistically significant ($p = 0.000$), confirming the suitability of the dataset for factor analysis. All 33 variables met the minimum communality requirement (> 0.50) and were retained for factor extraction. Based on the Initial eigenvalues output, five components with eigenvalues greater than 1 were extracted, accounting for a combined 71.102% of the total variance. Factor 1 20.521%, Factor 2 17.267%, Factor 3 15.313%, Factor 4 12.545%, and Factor 5 5.456%. Once the five components structure was confirmed, a Varimax rotation was applied to enhance interpretability (see Table 2, Rotated Component Matrix). This rotation clarified the grouping of strongly related variables within each factor, allowing for thematic interpretation.

The rotated component matrix in Table 2 shows the factor loadings for each variable. Each variable was assigned to the factor with the highest loading, which helped interpret and label the five extracted factors. Furthermore, as shown in Table 3 below, the results of factor analysis grouped the supporting variables into five latent constructs. Factor 1, labeled as Strong Management Commitment to Safety, comprises eleven key variables. These include the availability of a construction safety manual (loading 0.663), availability of construction safety program (loading 0.528), existence of post-project site lockout policy (loading 0.565), existence of project helmet use policy (loading 0.810), existence of work stoppage policy (loading 0.718), control of hazardous substances and drugs (loading 0.650), management commitment (loading 0.688), worker involvement in safety practices (loading 0.537), continuous safety evaluation (loading 0.547), commitment and responsibility toward safety (loading 0.655), and external partnerships with relevant stakeholders (loading 0.615). These items consistently reflect visible and integrated efforts by management to prioritize and institutionalize safety

in the construction environment. These items consistently reflect visible and integrated efforts by management to prioritize and institutionalize safety in the construction environment.

Table 2. Rotated component matrix of supporting factors

Code	Factors	Component				
		1	2	3	4	5
X1	Availability of Construction Safety Manual	0,663	0,262	0,367	0,297	-0,147
X2	Availability of Construction Safety Program	0,528	0,408	0,449	0,316	-0,200
X14	Existence of post-project site lockout policy	0,565	0,173	0,242	0,374	0,177
X15	Existence of project helmet use policy	0,810	0,140	0,258	0,160	0,107
X16	Existence of work stoppage policy	0,718	0,171	0,233	-0,150	0,240
X22	Control of hazardous substances and drugs	0,650	0,154	0,282	0,315	0,000

Table 2. Rotated component matrix of supporting factors (continued)

Code	Factors	Component				
		1	2	3	4	5
X23	Management commitment	0,688	0,293	0,344	0,313	-0,049
X24	Worker involvement in safety practices	0,537	0,280	0,183	0,483	0,036
X25	Continuous safety evaluation	0,547	0,200	0,423	0,451	0,097
X28	Commitment and responsibility toward safety	0,655	0,383	0,114	0,288	0,220
X31	External partnership with relevant stakeholders	0,615	0,286	0,165	0,350	0,325
X3	Availability of CSMS documents	0,490	0,549	0,346	0,052	-0,050
X4	Availability of safety objectives and measurement	0,342	0,708	0,104	0,174	0,110
X8	Regular safety meetings and follow-up	0,029	0,767	0,275	0,076	0,052
X12	Safety implementation review	0,344	0,667	0,077	0,066	0,240
X18	Existence of hazard analysis and mitigation plan	0,402	0,541	0,206	0,501	-0,049
X19	Existence of hazard condition analysis and control	0,176	0,703	0,268	0,412	-0,034
X20	Existence of accident investigation procedures	0,531	0,590	0,056	0,225	0,086
X27	Availability of sufficient safety resources	0,033	0,508	0,462	0,301	0,315
X32	Digitalization of safety control (permits, reports, etc.)	0,149	0,677	-0,040	0,170	0,336
X5	Implementation of CSMS training as needed	0,262	0,119	0,778	0,276	0,124
X6	Provision of safety rewards and incentives	0,414	0,154	0,554	0,257	0,201
X7	Scheduling of safety program implementation	0,271	0,558	0,592	-0,026	0,191
X13	Implementation of safety inspections	0,325	0,146	0,705	0,192	0,173
X17	Existence of emergency response plan	0,357	0,336	0,608	0,351	-0,151
X29	Existence of a well-structured safety organization	0,534	0,038	0,649	0,271	0,020
X33	K3 Training Center, Mock-Up, Safety & Quality Rooms	0,125	0,467	0,490	0,438	0,180
X9	Monitoring of safety programs in subcontractors	0,263	0,166	0,296	0,727	0,077
X10	Availability of safety procedures in subcontractors	0,188	0,246	0,215	0,579	0,531
X21	Near-miss incident investigations	0,385	0,130	0,411	0,606	0,078
X26	Good implementation of safety culture	0,358	0,436	0,471	0,479	0,169
X30	Availability of sufficient safety investment and budget	0,236	0,422	0,447	0,506	0,134
X11	Safety training for supervisors and workers	0,116	0,253	0,165	0,068	0,809

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 7 iterations.

Factor 2, interpreted as availability of safety procedures, policies, and resources, consists of nine variables. These are the availability of CSMS documents (loading 0.549), availability of safety objectives and measurement (loading 0.708), regular safety meetings and their follow-up actions (loading 0.767), reviews of safety implementation (loading 0.667), analysis and mitigation of work hazards (loading 0.541), identification and control of hazardous conditions (loading 0.703), existence of accident investigation procedures (loading 0.590), provision of sufficient safety resources (loading 0.508), and

the digitalization of safety control processes (loading 0.677). This factor highlights the importance of operational systems and infrastructure that enable consistent safety performance across projects.

Table 3. Grouped supporting factors

Component	Factor		Variable
1	Strong Management Commitment to Safety	X1	Availability of Construction Safety Manual
		X2	Availability of Construction Safety Program
		X14	Existence of post-project site lockout policy
		X15	Existence of project helmet use policy
		X16	Existence of work stoppage policy

Table 4. Grouped supporting factors (continued)

Component	Factor		Variable
1	Strong Management Commitment to Safety	X22	Control of hazardous substances and drugs
		X23	Management commitment
		X24	Worker involvement in safety practices
		X25	Continuous safety evaluation
		X28	Commitment and responsibility toward safety
		X31	External partnership with relevant stakeholders
2	Availability of Procedures, Policies, and Resources	X3	Availability of CSMS documents
		X4	Availability of safety objectives and measurement
		X8	Regular safety meetings and follow-up
		X12	Safety implementation review
		X18	Existence of hazard analysis and mitigation plan
		X19	Existence of hazard condition analysis and control
		X20	Existence of accident investigation procedures
		X27	Availability of sufficient safety resources
		X32	Digitalization of safety control (permits, reports, etc.)
3	Organizational Competence and Managerial Implementation	X5	Implementation of CSMS training as needed
		X6	Provision of safety rewards and incentives
		X7	Scheduling of safety program implementation
		X13	Implementation of safety inspections
		X17	Existence of emergency response plan
		X29	Existence of a well-structured safety organization
		X33	K3 Training Center, Mock-Up, Safety & Quality Rooms
4	Strong Safety Culture	X9	Monitoring of safety programs in subcontractors
		X10	Availability of safety procedures in subcontractors
		X21	Near-miss incident investigations
		X26	Good implementation of safety culture
		X30	Availability of sufficient safety investment and budget
5	Safety Training for Supervisors and Workers	X11	Safety training for supervisors and workers

Factor 3, labeled as organizational and managerial competence in safety, includes seven variables. These are the implementation of CSMS training as needed (loading 0.778), provision of safety rewards and incentives (loading 0.554), scheduling of safety program implementation (loading 0.592), regular safety inspections (loading 0.705), availability of an emergency response plan (loading 0.608), establishment of a well-structured safety organization (loading 0.649), and availability of dedicated safety training facilities such as training centers, mock-up installations, and safety-quality induction rooms (loading 0.490). Collectively, these elements represent a systematic and capability-based approach to managing safety through skilled personnel and institutional support.

Factor 4, interpreted as a strong safety culture, comprises five variables. These include monitoring of safety program implementation among subcontractors (loading 0.727), availability of safety procedures for subcontractors (loading 0.579), investigation of near-miss incidents (loading 0.606), implementation of a positive safety culture (loading 0.479), and sufficient investment budgets for safety (loading 0.506). This factor underscores the presence of shared values, consistent practices, and budgetary commitment that foster a proactive safety climate throughout the project supply chain.

Lastly, Factor 5 consisted of a single variable, "Safety training for supervisors and workers," which showed a high loading (0.809) and an eigenvalue above 1.0. Although represented by only one item, it was retained because training is widely recognized as a stand-alone determinant of safety outcomes (Hinze et al., 2013; OSHA, 2022). This component reflects a crucial enabler of CSMS implementation, directly shaping field-level behavior and safety awareness, and its presence as an independent factor highlights its strategic importance in supporting other safety-related efforts.

3.2.3. Hindering factors analysis

3.2.3.1. Validity and reliability test of hindering factors

The validity test was conducted to assess whether the questionnaire items accurately measured the hindering factors as perceived by respondents. With 17 variables tested, the critical r-table value at N = 140 and $\alpha = 0.05$ was 0.482. Furthermore, 15 out of 17 items had Pearson correlation coefficients greater than 0.482 and were thus deemed valid. Two items, X3 (Tight project schedule) and X16 (Workers' lack of concern for safety) were below the threshold and subsequently excluded from further analysis. Reliability testing of the 15 remaining items produced a Cronbach's Alpha of 0.924 (Table 4), exceeding the minimum standard of 0.60, confirming that the instrument was highly reliable and suitable for factor analysis.

Table 4. Reliability test result of hindering factors

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Item
.924	.926	15

3.2.3.2. Factor analysis of hindering factors

The Kaiser-Meyer-Olkin (KMO) measure was 0.898, and Bartlett's Test of Sphericity was again significant (p = 0.000), indicating that the dataset was appropriate for factor analysis. Communalities were examined to determine the explanatory power of each variable, with all items meeting the minimum extraction threshold (> 0.50), except for X3 and X16, which had already been excluded during the validity testing phase. As a result, a total of 14 variables proceeded to factor extraction. Based on the Initial eigenvalues output, three components were extracted, where each with eigenvalues greater than 1, accounting for a combined 66.582% of the total variance: Factor 1 explained 50.031%, Factor 2 explained 8.971%, and Factor 3 explained 7.580%. With the hindering factors confirmed to group into three components, a Varimax rotation was applied to enhance interpretability, as shown in the Rotated Component Matrix (Table 5). Each factor clustered variables with the highest loadings, allowing for thematic interpretation.

Table 5. Rotated component matrix of hindering factors

Code	Hindering Factors	Component		
		1	2	3
X5	Safety is not treated as a priority	0.714	0.341	0.090
X10	Top management is unaware	0.759	0.411	0.112
X11	Absence of designated safety officers	0.710	0.094	0.410
X14	Inactive project management in safety	0.804	0.281	0.153
X1	Lack of safety standards	0.356	0.705	0.173
X2	Lack of safety resources	0.205	0.775	0.208
X4	Inadequate commitment to safety	0.317	0.676	0.093
X6	Insufficient safety training	0.053	0.582	0.506
X7	Absence of safety policies and regulations	0.553	0.606	0.194
X8	Safety responsibility assigned solely to safety personnel	0.339	0.656	0.348
X9	Lack of safety inspection	0.444	0.382	0,586
X12	Low worker competence	0.269	0.064	0.797
X15	Unsafe project conditions	0.468	0.156	0.606
X17	Subcontractor-related constraints	–0.059	0.354	0.695

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 10 iterations.

Based on the results of the rotated component matrix shown in Table 5, the 14 hindering variables were grouped into three latent constructs, as summarized in Table 6. To begin with, Factor 1, labeled as low safety culture, includes four key variables. These factors are: not placing treating safety as a priority (loading 0.714), top management is unaware (loading 0.759), no assigned safety officer (loading 0.710), and inactive project management in safety (loading 0.804). These strong factor loadings indicate a consistent pattern of organizational neglect towards safety values and practices.

Table 6. Grouped hindering factors

Component	Factor		Variable
1	Low Safety Culture	X5	Safety is not treated as a priority
		X10	Top management is unaware
		X11	No assigned safety officer
		X14	Inactive project management in safety
2	Low Management Commitment and Capability	X1	Lack of safety standards
		X2	Lack of safety resources
		X4	Inadequate safety commitment
		X6	Insufficient safety training
		X7	Absence of safety policies and regulations
		X8	Safety responsibility assigned solely to HSE personnel
3	Low Worker Competence	X9	Lack of safety inspection
		X12	Low worker competence
		X15	Unsafe project conditions
		X17	Subcontractor-related constraints

Factor 2 represents low management commitment and capability. It comprises six variables: lack of safety standards (loading 0.705), lack of safety resources (loading 0.775), inadequate safety commitment (loading 0.676), insufficient safety training (loading 0.582), absence of safety policies and regulations (loading 0.606), and safety responsibility assigned solely to HSE personnel (loading 0.656). These variables reflect a broader issue of managerial disengagement from safety planning and enforcement.

Finally, Factor 3 is interpreted as low worker competence, containing four variables that highlight field-level execution challenges: lack of safety inspections (loading 0.586), low worker competence (loading 0.797), unsafe project conditions (loading 0.606), and subcontractor-related constraints (loading 0.695). This factor emphasizes the operational risks associated with limited skills, inadequate supervision, and unreliable subcontractor performance. Together, these factors offer a structural understanding of how organizational culture, managerial leadership, and workforce quality intersect to affect safety outcomes in construction projects.

4. Discussion

4.1. Final Supporting and Hindering Factors

This study identified several latent factors that significantly influence the implementation of the CSMS in Indonesian construction projects. Through factor analysis, five key supporting factors and three hindering factors were extracted, each offering valuable insights for both policy development and managerial interventions.

Five key supporting factors emerged as essential enablers of successful CSMS implementation. Foremost is strong management commitment to safety. According to OSHA (2022), management must demonstrate visible commitment through prioritizing safety, allocating sufficient resources, and actively participating in safety activities at all levels. Choudhry and Fang (2008) showed that such commitment correlates with lower incident rates and higher compliance. Yoon et al. (2024) also highlighted the importance of integrating safety planning with risk assessments across various project parameters such as project type, ownership, and budget.

The second supporting factor is the availability of procedures, policies, and safety resources. A safety system is only effective when supported by structured protocols and accessible tools. Hinze et al. (2013) emphasized the importance of having documented procedures, hazard control mechanisms, and emergency preparedness plans to ensure consistency in safety practices. OSHA further recommends conducting regular audits and updates to promote continuous improvement. Mohandes et al. (2023) highlighted that proactive safety protocols are essential throughout all phases of construction. Similarly, Adebiyi and Rasheed (2021) identified project briefings, standard operating procedures, and safety manuals as the most commonly used communication tools for conveying health and safety information. In addition, Nnaji and Karakhan (2020) reported that incorporating technology-based solutions, such as engineering controls, can be more effective than relying solely on traditional administrative training methods.

The third supporting factor is organizational competence in safety management. As suggested by Mohd Kamar et al. (2014) and Mohammadi (2018), safety should be institutionalized through formal organizational structures, clear responsibilities, monitoring systems, and routine audits. Organizational maturity ensures that safety is not left to interpretation but becomes a core element of project execution. Meanwhile, Li et al. (2020) found that safety competency plays a mediating role between structural frameworks and safety behavior. Furthermore, Masrom et al. (2025) emphasized the importance of incorporating mental health, gamified training, and emergency preparedness into safety programs. Le Coze (2019) also advocated for a systems approach to optimize safety structures and reduce accident rates.

The fourth enabler, a strong safety culture, emphasizes that cultural dimensions affect safety outcomes beyond formal compliance. Tang (2025) argued that a culture rooted in trust, mutual accountability, and reinforcement of safe behaviors is essential for sustained improvement. The Construction Management Association of America (CMAA, 2023) reported that projects with mature safety cultures often outperform others in both safety and productivity. Research in behavioral science and cognitive psychology has also emphasized the need to instill safety awareness through organizational emphasis (Bronkhorst, 2015; Fugas et al., 2012; Newaz et al., 2019), thereby strengthening safety culture (Choudhry and Fang, 2008; Seo et al., 2015).

Finally, comprehensive training for supervisors and workers is the fifth supporting factor. Training builds safety competence and awareness across the workforce. Hinze et al. (2013) observed that projects with regular training report fewer incidents and greater rule compliance. OSHA recommends tailoring training to specific roles and adapting content as project risks evolve. In line with this, Kamran et al (2024) emphasize that on-site training plays a critical role in maintaining safety throughout the construction process. Technological advancements are also being used to enhance training. Karakhan et al. (2019) reported positive outcomes from digital learning tools, while Ng and Chan (2017) found that digital signage effectively reminds workers of critical hazards. Meanwhile, Loosemore and Malouf (2019) advocated for more emotionally engaging, responsive, and interactive training to strengthen the importance of safety within individual value systems.

On the other hand, three hindering factors emerged as critical obstacles. The first is the weak safety culture prevalent in many construction organizations. Al-Bayati et al. (2017), states that safety culture should be recognized as a root cause of incidents due to its strong influence on individual safety behavior. It represents the collective values, beliefs, perceptions, skills, and behavioral patterns that influence how strongly an organization prioritizes and upholds health and safety (Hofmann and Stetzer, 1996; Lee and Harrison, 2000). In organizations where safety culture is weak, there is often a reactive approach to safety in which issues are addressed only after incidents occur. Within Indonesian context, Prasetyo and Lestari (2023) reported that many Indonesian state-owned construction companies remain in this reactive phase, with limited proactive initiatives and a lack of shared safety values across organizational levels. This observation aligns with the findings of Lee (2018) and Kalteh et al., (2021), who assert that safety culture plays a crucial role in minimizing accidents, shaping safety behavior, and improving overall performance. Without a strong cultural foundation, even well-structured safety systems fail to deliver their intended outcomes.

The second major hindering factor is insufficient management commitment and capability. Numerous studies have confirmed that leadership engagement is a key driver of safety performance. Choudhry and Fang (2008) demonstrated that effective construction management significantly reduces unsafe behaviors that often lead to accidents. Supporting this, OSHA (2022) underscores the importance of managerial leadership in setting clear safety objectives, allocating adequate resources, and ensuring compliance. When safety is not embedded into strategic decisions, operational safety efforts often become fragmented and under-resourced. Liu et al. (2021) further noted that in high-risk industries like construction, especially in developing regions, organizational support has a weaker influence on employee safety behavior, making consistent implementation more difficult.

The third barrier is low worker competence, a persistent issue in the construction sector. Competency gaps, especially among subcontractors and site laborers, are closely associated with poor safety outcomes. Pourmazaherian and Musonda (2022) found that safety orientation mediates the relationship between worker competence and safety performance, underscoring the need for continuous training. Similarly, OSHA emphasizes the importance of upskilling workers to enhance their ability to recognize and manage workplace hazards. Kukoyi and Adebowale (2021) also confirmed that improvements in health and safety education and training can significantly enhance on-site safety performance. Liang et al. (2019) further stated that higher levels of safety competence directly improve both safety behavior and outcomes. Unfortunately, in fast-paced construction environments, training is often deprioritized due to strict deadlines, compounding safety risks on-site.

In conclusion, the successful implementation of CSMS is shaped by the dynamic interplay of leadership, culture, organizational structure, and workforce competence. Addressing the dominant hindering factors while reinforcing key components is crucial to elevating safety management from a compliance exercise to an embedded organizational practice. This transformation is particularly vital for Indonesia's infrastructure sector, where improving safety outcomes is not only a regulatory expectation but also a moral and strategic imperative.

4.2. Institutional Implications and Current Efforts

Following the issuance of ministerial regulation No. 10/2021 on the CSMS, many SOEs have taken steps to strengthen their internal safety systems. dedicated quality, Health, Safety, and Environment (QHSE) directorates have been established at both the central office and project site levels, staffed by certified professionals with formal training in construction safety. In parallel, the Directorate of Construction Services Management under the Ministry of Public Works and Housing (PUPR) continues to promote technical training and safety awareness, particularly targeting government-funded projects involving project managers, consultants, and on-site personnel. Furthermore, the formation of the National Construction Safety Committee by the Minister of PUPR has played a strategic role. The committee is actively engaged in conducting site audits, issuing technical recommendations, investigating construction-related accidents, and proposing corrective actions to ensure compliance with safety standards and strengthen the national CSMS framework.

However, despite these initiatives, their impact appears limited, as reflected in the ongoing occurrence of construction accidents. Based on the findings of this study, several institutional implications are recommended to enhance the

effectiveness of CSMS implementation across the sector. These include: the reinforcement of national policy related to CSMS. Capacity building programs targeting both managerial and operational levels. The digitalization and standardization of CSMS practices across projects, and the adoption of data-driven monitoring and evaluation mechanisms. These institutional efforts are essential not only to ensure that construction organizations comply with CSMS on paper, but also to ensure that they actively implement safety principles on the ground. The goal is to transition from formal compliance to meaningful practice in daily project operations.

4.3. Managerial Implications

This study has identified three key hindering and five supporting factors that critically influence CSMS implementation. These factors should serve as the foundation for developing practical, sustainable safety programs in the construction sector. Managerial responses are particularly essential to bridge the persistent gap between formal safety policies and their practical application, especially in Indonesia's infrastructure projects, where state-owned enterprises are expected to lead by example.

A key managerial implication is the need to strengthen safety culture across all stakeholders. Improving safety culture should not be limited to contractors alone but must extend to project owners, design and supervision consultants, subcontractors, and vendors. Safety culture refers to a habitual condition that reflects safe thinking and behavior patterns among individuals, supported by leadership that actively promotes accident prevention. To assess and improve this, frameworks like the safety culture maturity model (Hudson, 2007) can be employed, helping organizations identify both strengths and areas needing development in their cultural approach to safety.

Equally important is enhancing management commitment. Strong safety leadership must be evident at all levels, beginning with a formal commitment issued by top management through a Construction Safety Plan that engages all relevant parties. This commitment should be reflected in risk control measures, sufficient allocation of resources and budgets, clear authority to halt unsafe work, open accident investigations, and a consistent system of rewards, sanctions, and evaluations. Project directors play a crucial role by regularly visiting sites, offering feedback, and ensuring all teams understand and align with safety objectives.

Another priority is improving worker competence. Training should be mandatory before workers and foremen are deployed to project sites, ensuring they fully understand the risks and responsibilities associated with their roles. Competence must be evaluated periodically, especially as job complexities and safety risks evolve. This not only helps prevent accidents but also enables workers to contribute to a stronger safety culture within their teams.

Establishing a dedicated safety organization within projects is also vital. A formal safety unit staffed with qualified personnel should be positioned to report directly to the central office, with clear mandates and sufficient authority to enforce safety measures consistently. This structural support ensures that safety is managed systematically rather than informally or inconsistently.

Lastly, developing and effectively socializing safety procedures is critical. Safety-related regulations, manuals, and work procedures must be grounded in hazard control principles and written in accessible language. Procedures should be straightforward, regularly updated, and include clear consequences for non-compliance. By ensuring procedures are well-communicated and easy to follow, organizations can improve compliance and reduce resistance from workers in the field.

5. Conclusion

This study aims to identify and analyze the key factors that support or hinder the successful implementation of the Construction Safety Management System (CSMS) in construction projects. Exploratory factor analysis grouped the 33 supporting variables and were classified into five dominant components: strong management commitment to safety, the availability of safety policies and resources, a capable and well-structured safety management organization, a mature safety culture, and structured training programs for supervisors and workers. Similarly, 15 hindering variables were categorized into three main components: low safety culture, low management commitment and capability, and low worker competence. These findings highlight several key areas that must be prioritized by stakeholders to improve CSMS implementation in construction projects, particularly those managed by Indonesia's state-owned construction enterprises.

Based on these results, several recommendations are proposed at both institutional and managerial levels. At the institutional level, priorities should include the reinforcement of national CSMS-related policies, capacity-building programs targeting both managerial and operational personnel, the digitalization and standardization of CSMS implementation, and the establishment of data-driven monitoring and evaluation mechanisms. At the managerial level, essential actions include strengthening safety culture, enhancing management commitment, improving worker competence, establishing dedicated safety units within project structures, and developing as well as effectively communicating safety procedures to all project stakeholders.

While this study was conducted in the Indonesian context, differences may exist when compared with cases in other countries. However, since the variables used were derived from OSHA guidelines and previous literature, the findings carry broader implications for construction safety management globally. The supporting factors identified, such as management commitment, availability of safety procedures, organizational competence, safety culture, and worker training which represent universal dimensions that are essential for successful safety management regardless of geographic or cultural differences. Similarly, the hindering factors of weak safety culture, limited managerial capability, and low worker competence are challenges shared across many developing and developed economies. Therefore, the results of this research may inform international practitioners and policy-makers by providing a structured framework for diagnosing and

improving CSMS implementation. Future comparative studies across different countries and project types could further validate the generalizability of these factors and highlight context-specific adaptations.

At the same time, this study has several limitations that should be acknowledged. First, the analysis focused exclusively on state-owned construction enterprises (SOEs) in Indonesia, which may limit the generalizability of findings to private contractors and small-to-medium enterprises. Second, most respondents were involved in road and bridge projects, so the results may not represent other project types such as buildings or industrial works. Finally, the study concentrated on organizational and managerial aspects, while external influences such as regulatory enforcement and regional cultural differences were not fully considered. These limitations provide opportunities for future research to broaden the scope across different project types and organizational contexts, including government agencies, private firms, and consulting companies in order to compare perceptions across respondents and apply advanced analytical approaches.

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Author Contributions

I Putu Artama Wiguna contributes to conceptualization, methodology, software, validation, analysis, investigation, data collection, draft preparation, manuscript editing, visualization, supervision, and funding acquisition. Indradjaja Manopol contributes to conceptualization, methodology, software, validation, analysis, investigation, data collection, and project administration. Zetta Rasullia Kamandang contributes to draft preparation, manuscript editing and visualization. All authors have read and agreed with the manuscript before its submission and publication.

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I Putu Artama Wiguna is an associate professor in the Civil Engineering Department at the Institut Teknologi Sepuluh Nopember (ITS), Indonesia. He earned a bachelor's degree in Civil Engineering (Ir.) from ITS Surabaya (1993), a master's degree in Construction Management (MT) from ITS (1997), and a PhD in Construction Management from the University of Newcastle upon Tyne, UK (2006). He also obtained his Insinyur (Ir.) professional title from ITS in 2021. He has held academic leadership roles, including Head of the Postgraduate Study Program in Civil Engineering at ITS (2019–2024) and Head of the Construction Project Management Laboratory at ITS (2016–2020 and 2025-2030). In addition to his academic work, he has been involved in several regional and national construction projects. He is an active member of the Project Management Institute (PMI) and has served as chairperson of the Construction Services Development Board of Indonesia (2016–2020). He also holds various professional certifications in mediation, road engineering, construction management, and senior professional engineering (IPM). His research interests include construction project management, risk management, contract resolution, and infrastructure sustainability.

Indradjaja Manopol is a senior construction professional with over three decades of leadership experience in Indonesia's state-owned construction enterprises. He earned his bachelor's degree in civil engineering in 1984 and a master's degree in 2022, both from Institut Teknologi Sepuluh Nopember (ITS). He previously served as President Director of PT Nindya Karya (2014–2019) and held executive roles at PT Adhi Karya (2001–2011) and PT Hutama Karya (2011–2014). He currently holds positions as a commissioner and director for various construction-related organizations and remains actively involved in professional associations such as GAPENSI and GATENSI. His areas of expertise include construction management, strategic leadership, and infrastructure development.

Zetta Rasullia Kamandang is a doctoral researcher in the Civil Engineering Department at Institut Teknologi Sepuluh Nopember (ITS), Indonesia. She completed her undergraduate studies in civil engineering at Universitas Brawijaya, Indonesia, in 2014. She then pursued a double-degree master's program at Universitas Brawijaya, Indonesia and National Central University, Taiwan (2015–2017). Since 2017, she has been a lecturer and researcher in the Civil Engineering Department at UPN "Veteran" Jawa Timur. Her current research interests include construction sustainability, human resource development, and stakeholders' well-being, including construction workers and surrounding communities.