

Development of a Safety Culture Maturity Model for Planning Consultants to Improve Construction Safety Performance

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| Submitted: December 02, 2025 | Revised: June 01, 2026 | Accepted: August 27, 2026 |

| Published: October 23, 2026 |

ABSTRACT

The construction industry continues to record high accident rates, partly due to the limited integration of safety considerations during the design stage. Planning consultants play a strategic role in embedding safety principles early in the project lifecycle; however, prior studies indicate that their safety culture maturity remains low, leading to weak communication practices, inadequate evaluation mechanisms, and insufficient institutionalization of safety values. These conditions create the problem of inconsistent safety performance and unclear linkage between safety-culture variables and project outcomes. Accordingly, the research problem is formulated to identify key safety-culture factors influencing safety and project performance, evaluate maturity levels, and develop a measurable model tailored for planning consultants. This study aims to support accident-prevention efforts and enhance design-stage safety management. This research is limited to nine safety-culture variables evaluated through expert validation and a survey of 125 respondents, operationalized using Structural Equation Modeling–Partial Least Squares (SEM-PLS) to test the measurement and structural models. Findings confirm that all indicators are valid and reliable, and all structural relationships are statistically significant. Safety Evaluation and Learning emerges as the most influential variable in improving Safety Performance, while the model demonstrates strong predictive ability with R^2 values of 0.948 for safety performance and 0.935 for project performance. Safety-maturity assessment further shows that planning consultants remain at the *Compliant* level, with several indicators still *Reactive*, highlighting the need to strengthen cross-disciplinary communication and continuous learning. These results provide a scientifically grounded model for assessing and improving safety-culture maturity to elevate organizational readiness toward *Proactive* and *Resilient* levels.

Keywords: Maturity of Safety Culture, Occupational Health and Safety Management System (SMK3), Civil Engineering Planning Consultants, Construction Safety Performance.

INTRODUCTION

Construction remains one of the most hazardous industries globally, consistently contributing a high proportion of occupational accidents, near misses, and fatalities. International Labour Organization (ILO) reports that the construction sector accounts for approximately 17–30% of global workplace fatalities annually, driven by high-risk activities, dynamic work environments, and fragmented project delivery systems involving multiple stakeholders. [1] In Indonesia, accident trends continue to increase alongside national infrastructure expansion, with major construction failures frequently linked to design issues, coordination failures, and inadequate risk planning during early project stages [2]. The Ministry of Public Works and Housing has therefore mandated the implementation of the *Construction Safety Management System (SMKK)* under regulations PUPR No. 21/2019 and No. 10/2021, emphasizing the need to integrate safety principles starting from the planning and design stages.

Despite this regulatory push, evidence indicates that safety practices among planning consultancy firms—key actors responsible for early hazard identification and risk elimination—remain at low maturity levels. Preliminary findings from the thesis show that various safety culture indicators within planning consultants are still categorized as *Reactive* or *Planned/Compliant*, illustrating insufficient institutionalization of preventive safety behaviours, ineffective communication patterns,

and limited organizational learning mechanisms, organizations with safety practices motivated primarily by compliance tend to demonstrate weak value alignment, inconsistent safety leadership, and vulnerability to recurring incidents. [3] Safety culture quality strongly depends on shared assumptions, leadership commitment, and behavioural reinforcement systems that influence how people perceive and respond to risks. [4] [5]

The safety journey model of UK Coal illustrates five levels of safety maturity as follows: [6]

1. Basic: Minimal or no safety system; lack of awareness regarding the importance of safety.
2. Reactive: Safety actions are taken only after incidents occur; a firefighting-style approach.
3. Planned: Development of formal safety procedures and policies; focus on regulatory compliance.
4. Proactive: A proactive approach to risk management; active involvement at all organizational levels.
5. Resilient: A fully integrated safety culture; continuous improvement and adaptation to change.

]The safety maturity can be shown at figure 1 below

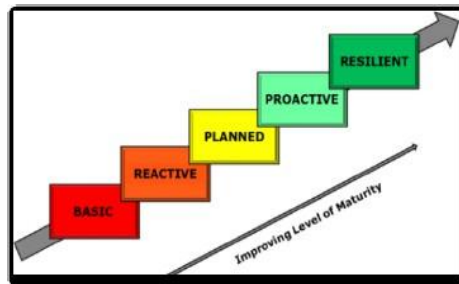


Figure 1. Safety maturity model of UK Coal[6]

Given the inherent ability of the design phase to prevent or eliminate hazards—estimated by several studies to influence 30–50% of accidents at the construction site—designers and planning consultants are strategically positioned to exert substantial control over safety outcomes. [7] Their decisions on technical specifications, design geometry, material selection, and constructability significantly shape downstream project risks. However, the literature on safety in Indonesia predominantly focuses on contractors and field workers rather than planners, creating a critical knowledge gap in understanding how design-stage organizations cultivate safety culture and contribute to overall project performance.

RESEARCH METHODS

Methodology and Research Strategies

The study adopts a structured methodological design aimed at answering four Research Questions (RQ), each supported by a corresponding research strategy. The multi-stage research process follows recommendations, emphasizing quantitative rigor, gradual validation, and systematic refinement of measurement tools. [8]

RQ1 – Identification of Critical Safety Culture Variables.

To identify relevant variables of safety culture maturity among planning consultants, the strategy combines a literature review, expert panel evaluation, and early-stage indicator refinement. This aligns with exploratory phases recommended by Creswell [9], ensuring that all latent constructs are theoretically grounded and contextually valid.

RQ2 – Measurement Model Development and Pilot Testing.

RQ2 focuses on building and validating the initial measurement model. A pilot survey was conducted among a small group of respondents to test reliability, clarity, and indicator behaviour,

followed by normality assessments, common method bias testing, and refinement based on expert feedback.

RQ3 – Full SEM-PLS Structural Testing.

The third research question evaluates the structural relationships among nine safety-culture constructs and two outcome variables—Safety Performance and Project Performance. This phase uses full-scale surveys supported by Structural Equation Modelling–Partial Least Squares (SEM-PLS), consistent with recommendations for theory development and prediction-oriented modelling. [10]

RQ4 – Final Expert Validation and Model Consolidation.

The last research question validates the final model using the Delphi method, expert workshops, and triangulation. This ensures the resulting safety-culture maturity model is both theoretically robust and practically applicable to design consultancy environments.

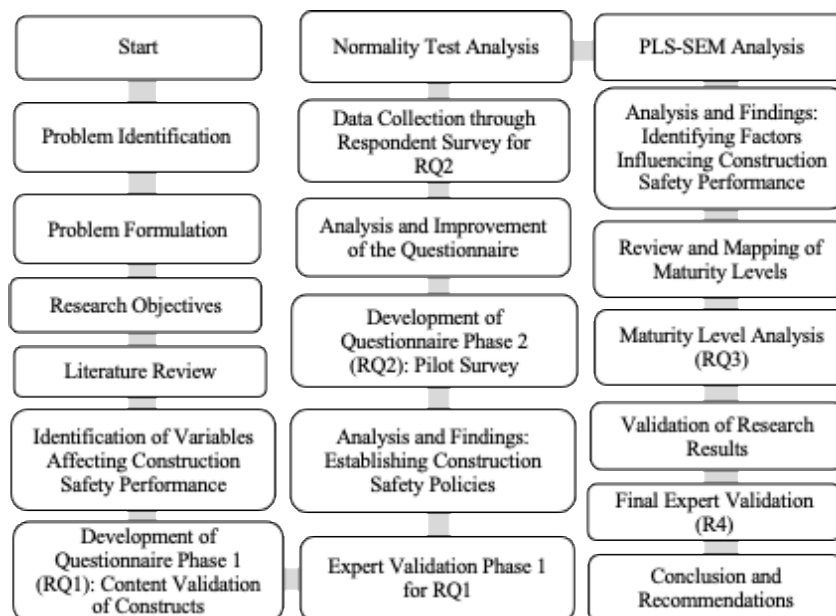


Figure 2. Research Methods

Data Acquisition Method

Stage 1 – Expert Validation of Variables (RQ1).

Initial variables and indicators were screened through expert judgment involving senior planners, safety auditors, and construction project specialists. Experts assessed indicator relevance, clarity, and contextual alignment with Indonesian regulations such as PUPR Regulation No. 10/2021. Insights gained from this stage formed the foundation of the revised survey instrument.

Stage 2 – Pilot Survey (RQ2).

A pilot survey was administered to a small sample of respondents to evaluate indicator behaviour, check reliability consistency, and perform early statistical diagnostics. Respondents were selected based on their experience in planning, design coordination, or risk assessment, ensuring data quality.

Stage 3 – Main Survey (RQ3).

The main dataset was collected through a comprehensive survey involving 125 respondents, representing professionals in civil engineering design consultancy firms across Indonesia. Criteria included: minimum 3 years of experience, involvement in design review processes, and familiarity with safety or risk management procedures.

Stage 4 – Delphi and Expert Revalidation (RQ4).

A multi-round Delphi process was conducted to validate model relevance and indicator interpretation. Experts refined constructs, ensured the accuracy of SEM-PLS relationships, and ensured applicability for planning consultant organizations. This multi-phase acquisition method ensured robust triangulation and high validity of the final dataset.

Data Analysis

Data analysis in this study was conducted quantitatively using descriptive statistical techniques and structural modelling through SEM-PLS to evaluate validity, reliability, and the relationships among variables within the safety culture model. Data from the main survey were processed through validity testing (outer loading, AVE), reliability testing (Cronbach's Alpha and Composite Reliability), and structural model evaluation using R^2 values, T-statistics, and predictive relevance. The analysis of safety culture maturity levels was carried out by mapping indicator scores into maturity levels based on the Hudson model, supported by expert validation to ensure the accuracy of interpretation. All analytical results were utilized to test the research hypotheses and systematically address the research questions.

Model Hypothesis

The maturity safety culture hypothesis model is shown in figure

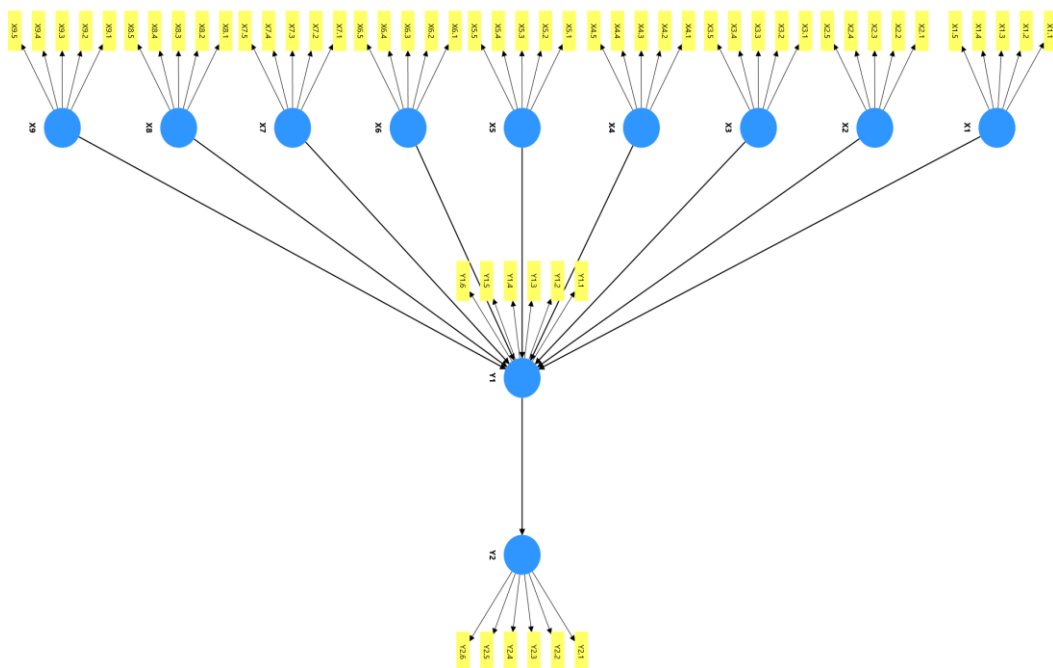


Figure 3. Research Hypothesis

The descriptions of each hypothesis of each effect paths, as follows:

- H1: Safety Leadership has a positive effect on Safety Performance.
- H2: Safety Planning has a positive effect on Safety Performance.
- H3: Safety Resources have a positive effect on Safety Performance.
- H4: Safety Operations have a positive effect on Safety Performance.
- H5: Safety Communication has a positive effect on Safety Performance.
- H6: Managerial Commitment has a positive effect on Safety Performance.
- H7: Safety Behaviour has a positive effect on Safety Performance.
- H9: Safety Culture positively affects Project Performance.

- i) H8: Safety Evaluation & Learning has a significant and the most dominant effect on Safety Performance.
- j) H10: Safety Behaviour mediates the influence of Safety Leadership on Project Performance.
- k) H11: Safety Communication moderates the relationship between Safety Culture and Project Performance.

RESULT AND DISCUSSION

Variables and Indicators

The study evaluates nine safety culture maturity variables, each measured using reflective indicators validated through expert judgment and outer-model assessment. These variables include:

1. Safety Leadership (X1)
2. Safety Planning (X2)
3. Safety Resources (X3)
4. Safety Operations (X4)
5. Regulatory Compliance (X5)
6. Managerial Commitment (X6)
7. Safety Behaviour (X7),
8. Safety Communication (X8), and
9. Safety Evaluation & Learning (X9).

Validation results confirm that all constructs met convergent and discriminant validity thresholds. Outer loading values for indicators exceeded 0.70, AVE values were above 0.50, and Composite Reliability values exceeded 0.90, indicating strong internal consistency. Cronbach's Alpha values were also >0.90 across all constructs, demonstrating excellent reliability. The indicator set for Safety Evaluation & Learning (X9)—including incident review, learning loops, and structured feedback mechanisms—showed the highest contribution to the structural model. Meanwhile, several indicators under Safety Communication (X8)—such as hazard message clarity, cross-disciplinary coordination, and documentation—recorded the lowest scores, consistent with the hypothesis that communication remains the weakest aspect of planning consultant organizations. These validated indicators form the backbone of the safety-culture measurement framework and confirm that the nine-variable model accurately represents organizational safety maturity in design consultancy settings.

Descriptive Analysis

Descriptive analysis reveals that, across all respondents ($n = 125$), the distribution of scores indicates a consistent pattern of moderate safety maturity. Most respondents scored between **2.5 and 3.2**, falling within the *Planned/Compliant* category of the maturity continuum. This pattern aligns with the descriptive trends noted where Indonesian construction organizations often exhibit compliance-oriented safety practices rather than proactive ones. [13] The highest mean scores were observed in **Regulatory Compliance (X5)** and **Managerial Commitment (X6)**, reflecting that planning consultants strongly adhere to regulatory frameworks such as SMK3 and SMKK, but have not yet fully internalized proactive safety values. Conversely, **Safety Communication (X8)** recorded the lowest mean score (below 2.50), indicating limited structured communication among teams—particularly during interdisciplinary meetings and design coordination sessions.

Outer Model Results

The outer model assessment evaluated reliability and validity for all latent constructs. Every indicator surpassed the 0.70 loading factor, confirming strong indicator performance. Average Variance Extracted (AVE) values for all constructs were above 0.50, demonstrating adequate convergent validity. Composite Reliability (CR) and Cronbach's Alpha (CA) values ranged between 0.90 and 0.95, indicating high internal consistency. Discriminant validity was established using Fornell–Larcker criteria and cross-loading matrices, both confirming that indicators loaded more strongly on their respective constructs than on others. This is crucial to ensure that Safety Leadership, Safety Planning, and Safety Operations—though related—represent conceptually

distinct constructs. The outer model assessment also confirmed measurement model fitness using SRMR = 0.044, well below the threshold of 0.08, indicating excellent fit. This supports the argument made by Henseler et al., [14] that SRMR is a reliable goodness-of-fit measure for PLS-SEM models.

Inner Model Results

The inner model (structural) evaluation produced strong and meaningful relationships among all constructs. Using bootstrapping (5,000 subsamples), all path coefficients demonstrated T-statistics > 5.0 and p-values < 0.001, confirming statistically significant relationships among the variables. Safety Evaluation & Learning (X9) recorded the highest path coefficient toward Safety Performance (Y1), indicating that organizations with stronger learning mechanisms tend to exhibit superior safety outcomes. This finding aligns with Reason (1997), who described organizational learning as crucial for continuous improvement of safety. [15] Safety Behaviour (X7) and Safety Leadership (X1) also showed strong positive influence on Safety Performance, consistent with findings that leadership and behaviour are foundational elements of an effective safety system. [11]

Regarding Project Performance (Y2), strong positive relationships were observed from Safety Performance (Y1) and a weaker—but still significant—direct effect from some safety-culture dimensions. This confirms the idea proposed that improvements in safety culture also enhance cost, schedule, and quality outcomes. The high R² values—0.948 (Y1) and 0.935 (Y2)—indicate that the model has excellent explanatory power. Overall, the structural analysis validates the theoretical model and shows that safety culture maturity plays a critical role in enhancing both safety and project performance [16].

Construction work and workplace environmental safety are essential aspects of civil engineering projects to protect workers, the public, and the surrounding environment. Construction activities include site preparation, excavation, foundation installation, structural work, material transportation, and finishing. Each activity presents potential hazards, such as falling objects, machinery accidents, electrical risks, excessive noise, dust, and exposure to hazardous materials. Therefore, implementing an occupational safety and health management system is necessary to identify hazards, assess risks, and establish appropriate control measures. [17]-[18].

Workers must use personal protective equipment, including helmets, safety shoes, gloves, reflective vests, and safety harnesses when required. Construction sites should provide clear warning signs, safe access routes, emergency procedures, and adequate supervision. Environmental protection measures are equally important, including dust suppression, noise control, proper waste management, wastewater treatment, and prevention of soil and water pollution. Regular inspections, safety training, and compliance with applicable regulations help minimize accidents and environmental impacts. Integrating safety and environmental management into daily construction operations promotes productivity, sustainability, and responsible project implementation [19].

Safety Maturity Model

Based on the results of the score recapitulation in the previous table, the spectrum of the Safety Maturity Level was obtained, illustrating the position of each research dimension as shown in the following figure

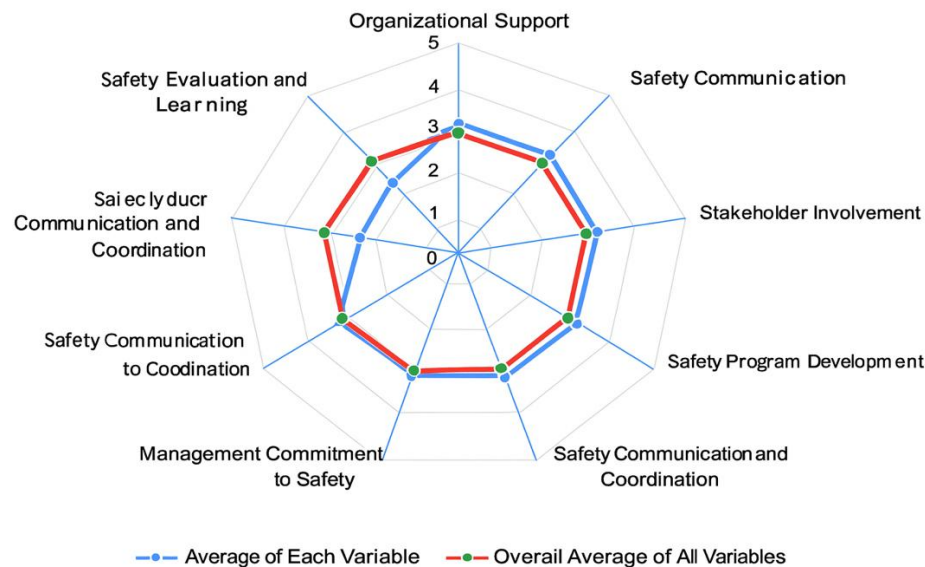


Figure 4. Safety Maturity Model Spectrum

The results show that the maturity of safety culture in planning consultancy firms remains at the Compliant level (mean 2.78), confirming that safety practices are still dominated by regulatory obligations rather than organizational values. These findings are aligned with the argument that organizations at the Compliant stage primarily “do safety because they must,” not because it is embedded in internal culture. Four indicators were identified at the Reactive level—particularly Safety Communication (X8) and Safety Evaluation & Learning (X9)—which indicates limited cross-disciplinary coordination and insufficient institutional learning from past events. SEM-PLS results demonstrate exceptionally strong predictive power, with $R^2 = 0.948$ for Safety Performance (Y1) and $R^2 = 0.935$ for Project Performance (Y2). This confirms previous studies, showing that organizational culture strongly predicts safety outcomes. [11], [12] The results indicate that planning consultants can significantly improve downstream construction safety by strengthening upstream design processes, especially through communication, knowledge transfer, and evaluation systems.

These results directly address the research questions by identifying critical safety-culture determinants, validating the measurement and structural models, and demonstrating clear causal pathways linking cultural maturity to performance outcomes. Theoretically, the study expands safety-culture scholarship by providing an empirically grounded SEM-PLS model specific to planning consultants—an understudied upstream actor in construction safety research. Practically, the findings highlight priority interventions such as strengthening communication mechanisms, building structured learning systems, and enhancing leadership involvement.

CONCLUSION

This study concludes that the safety-culture maturity of planning consultancy firms in Indonesia remains at the Compliant level, indicating that safety practices are still driven primarily by regulatory obligations rather than internalized organizational values. The analysis confirms that nine dimensions of safety culture collectively demonstrate strong predictive power on Safety Performance and Project Performance, validating the robustness of the proposed conceptual model and answering all research objectives and problem statements. Among the variables tested, Safety Evaluation & Learning emerges as the most dominant predictor, while Safety Communication is identified as the weakest cultural dimension—findings consistent with prior literature emphasizing the centrality of organizational learning in building resilient safety systems. However, the study is limited by its reliance on perception-based survey data, the cross-sectional nature of sampling, and the absence of direct project-accident statistics within design firms. Future research should

incorporate longitudinal data, broader respondent demographics, BIM-based risk analytics, and comparative studies between design and construction organizations to enrich understanding of safety-culture evolution across the project lifecycle.

ACKNOWLEDGEMENT

The author expresses profound appreciation to the experts and practitioners in construction safety who participated in the instrument validation process and provided valuable input throughout this research. Gratitude is also extended to the respondents from planning consultant firms who generously dedicated their time to complete the survey and share their professional experiences.

The author would also like to thank the academic supervisors, colleagues at the Department of Civil Engineering, and the entire academic community of the University of Indonesia for their scientific support, research facilities, and a conducive academic environment. Appreciation is likewise extended to institutions and other parties who assisted in providing data and supporting information.

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