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Enhancing Total Construction Safety Culture in Indonesia's New Capital: A Structural Equation Modeling Approach

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ABSTRACT

The establishment of Indonesia's new capital, Ibu Kota Nusantara, was a massive project that created significant risks during the construction phase, such as construction accidents. In response, total construction safety culture was developed to make a belief and implement strategies for minimizing risks. This research aimed to recommend strategies based on a structural equation model of total construction safety culture to improve safety performance. Using structural equation modeling with a partial least square approach, strategies were categorized into two aspects, covering the macro impact of construction accidents (national scope) and the micro and meso impacts (company and project scope). The macro strategy recommended the creation concept of nomenclature and criteria within government regulations related to construction safety The suggestion for the government regualation would cover construction safety ecosystem in Indonesia. Meanwhile, the micro and meso strategies concept included practical steps such as technology transformation, tacit knowledge, and improved supervision methods. By transformationing technology in construction safety such as using movement sensor and Building Information Modeling, it will be helpfull for the contractors to monitor all of the manpower and create safer working enivronment. Additionally, they can be applied in other cases to minimize the risk of construction accidents.

1. INTRODUCTION

The new capital of Indonesia, also called Ibu Kota Nusantara (IKN) is located in Penajam, North Paser, East Kalimantan, and was founded by the Government to address problems in Jakarta such as high pollution, overpopulation, and land subsidence [1]. IKN aims to alleviate problems in Jakarta and also to become a new economic center that improves economic equality throughout Indonesia [1]. In addition, Law number 63 of 2022 is the basis for the establishment of IKN and provides a comprehensive overview of this development.

The president of Indonesia, Joko Widodo, said that IKN establishment is recently the largest in the world [2]. Due to the large amount of building work during establishment, there is a risk of construction accident. Furthermore, the number of workers in all building project at the IKN development phase reached 9,713 in August 2023 [3].

In this case, the construction project of coordination of ministry building safety report identified several unsafe conditions. In particular, a total of 30 unsafe conditions were observed during an audit of the contractor company. These unsafe conditions included lack of safety nets or barriers, lack of safety sign, and obstructed access routes. It is crucial to be aware that these safety defects could lead to fatal accident [4]. Consequently, the situation shows the reason a comprehensive safety culture is essential during construction phase. Whereas in IKN development, contractor plays a significant role in resource planning, monitoring, and design considerations as most project use design and build approach [1].

The phenomena of construction accident occur in many parts of the world, including Indonesia's new capital development, and has several impacts on macro, meso, and micro levels. Specifically, macro impacts (nation scope) lead to degradation of country Global Competitiveness Index (GCI) which refers to how a country can compete in international competitiveness [5]. Moreover, construction accident at micro level (project scope) can lead to increased project cost, delayed work schedule, and reduced work productivity [6]. In the aspect of meso impact (company scope), there can be a loss of client trust and satisfaction, loss of profit, and also penalties from the authorities [7, 8].

Evaluating construction safety management systems is crucial for minimizing accident [9]. Poor safety culture can occur due to uncooperative clients and insufficient resources [10]. Relating to this discussion, construction safety culture dynamics remain a challenge in Indonesian construction project [11].

Total construction safety culture was developed from the total safety culture theory, which described the importance of safety for sustainability across industry [12]. Furthermore, this phenomenon focuses specifically on the construction industry and covers all project life cycles such as conceptual design, detailed engineering design, procurement, construction, and start-up [10-14].

The purpose of total construction safety culture is to improve safety performance. Typically, the performance is measured using leading and lagging indicators, as described in Minister of Public Works and Public Housing Regulation Number 10 of 2021. Leading predicts future performance, such as risk measurement and planning, while lagging shows historical performance, including severity rate and accident records [15-17].

Total construction safety culture theory was developed by identifying key factors and indicators. These factors include Leadership, Competency, Commitment, Regulation, Project Scope, Resources, Supervision, and Training [13]. Aside from total construction safety culture, safety performance factors and indicators are also described in terms of leading and lagging [13].

After identifying these factors, it is necessary to analyze the relationship between total construction safety culture and safety performance. This analysis will assist in creating effective strategies for safety improvement and addressing micro, meso, and macro impacts of construction accident.

This research aims to propose recommendation strategies based on the relevance of total construction safety culture to improve safety performance. In addition, the strategies were developed for IKN establishment and other similar contexts. IKN establishment was achieved by focusing on contractor as an organization planning and executing the project, with the delivery system design and build.

2. METHOD

2.1 Research strategy

Several methods such as Delphi method, normality test, common method bias, and SEM were used in the research.

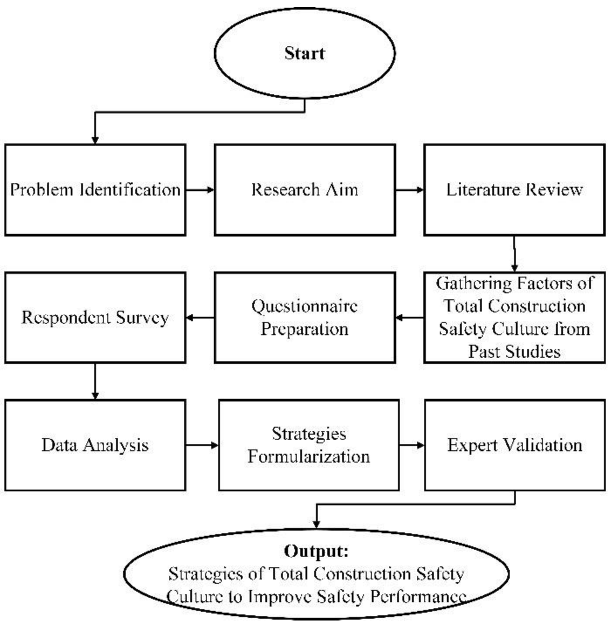

Figure 1. Research pattern

Table 1. Research question

Research Question	Research Strategy
How to develop a total construction safety culture strategies to enhance construction safety in IKN establishment?	Literature study, Delphi Method, Structural Equation Modeling

Based on Table 1 and Figure 1, the factors that created total construction safety culture were already described in the past research [10]. Moreover, Leadership (X.1), Competency (X.2), Commitment (X.3), Regulation (X.4), Project Scope (X.5), Resources (X.6), Supervision (X.7), Training (X.8), Leading (Y.1), Lagging (Y.2), and all indicators in these factors were already validated by the experts [13]. By using SEM, the relationship between total construction safety culture and safety performance was developed. Consequently, the significance of the impact of the total construction safety culture on construction safety performance was obtained.

2.2 Delphi method

Delphi method was used for expert validation to collect data from experts in the scope of research experience. The method was designed as a group communication stage aimed at achieving convergence of opinions on real issues [11].

2.3 Normality test

Normality examination was conducted to determine whether different sample or population data shared the same characteristics and perceptions [18]. Kruskall-Wallis statistic examination was used for normality test in this research. Additionally, this test was a non-parametric statistical tool in an independent sample group procedure that compared two different groups [19]. The examination had a requirement where Hypothesis 0 (H0) was rejected when P-Value (Asymp. Sig) $<\alpha$ (0.05), and H0 accepted when P-Value (Asymp. Sig) $>\alpha$ (0.05) as there were no difference perception [19].

2.4 Common method bias

Common method bias was regularly used to detect a bias in exploratory factor analysis [20]. Subsequently, bias in research happened when a respondent received an intervention on answering a questionnaire [20]. Harman single-factor test was the method used in this examination to provide a variance value based on the respondent's answer [21]. In addition, a data element was said to be free of bias when the variance value of Harman single-factor test was less than 50% [22].

2.5 Structural equation modeling

SEM was used in investigating the variable relation and measuring variables which was difficult to quantify [23]. Furthermore, the research used the PLS method because PLS-SEM was suitable for theory development that was still progressing [24].

Tables 2 and 3 showed SEM parameters and criteria that passed when the research required to be feasible. The outer model was used for validity and reliability examination, while inner model was for structural and hypothesis feasibility examination.

Table 2. SEM outer model parameters [25, 26]

Type of Test	Parameters	Criteria
Validity Test	Outer Loading	>0.7
	Average Variance Extracted (AVE)	>0.5
Reliability Test	Composite Reliability	>0.7
	Cronbach's Alpha	>0.7

Table 3. SEM inner model parameters [25, 26]

Type of Test	Parameters	Criteria
Structural Test	R-Square	R^2<0.25=very weak
		0.25≤R^2≤0.50=weak
		0,50≤R^2≤0,75=Moderate
		0,75≤R^2=Substantial
	T-Statistic	>1.96
	Q^2 Predict	>0
Structural Model Fit	Standard Root Mean Square (SRMR)	<0.08

2.6 Respondent and expert criteria

The minimum sample size required for sample quantity for SEM was 100 respondents [27], all of whom had at least 3 years of experience working in contractor company, and were included in IKN establishment. In addition, all the respondents had a minimum bachelor's degree, and three experts, each with a minimum of 15 years of experience in construction safety topics and field, were required to have at least a bachelor's degree as well [28].

2.7 Observation

The observation is conducted to verify that in the working field, there are construction safety implementation that do not comply with the existing standards and government regulation. This method is also used as an additional evidence that total construction safety culture it is need to be develope to support and improve safety performance.

3. RESULTS AND DISCUSSION

Questionnaire was distributed to all respondents which was suitable to the criteria. Around 120 respondents already answered the research instrument and response rate of the questionnaire in this research was 120%.

3.1 Normality test analysis

Normality test in this context was categorized into two aspects. The first was based on years of working experience and the second was educational background [17].

Table 4. Calculation of normality test

Indicators	Kruskal-Wallis H	df	Asymp. Sig.
X1.1	1.664	1	0.197
X1.2	1.405	1	0.236
X1.3	0.309	1	0.578
X1.4	1.446	1	0.229
X2.1	1.077	1	0.299
X2.2	2.003	1	0.157
X2.3	0.003	1	0.957
X2.4	2.802	1	0.094
X3.1	0.175	1	0.676
X3.2	0.039	1	0.843
X3.3	0.974	1	0.324
X4.1	0.836	1	0.361

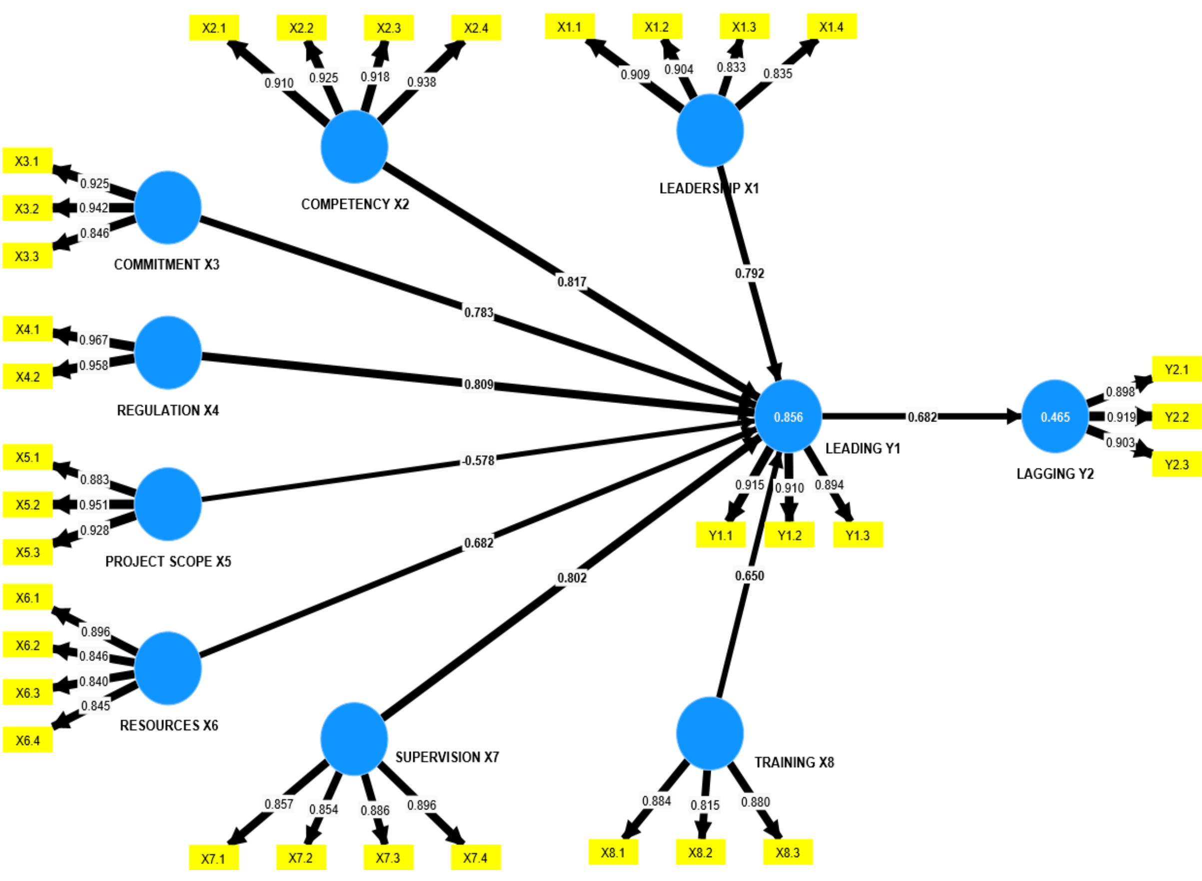

Figure 2. Structural model hypothesis

Table 4 showed the example of Kruskall-Wallis normality test and after determining the examination, the years of working experience category had a result that there were 14 of 33 indicators having Asymp. Sig>0.05, meaning only 42.42% indicators passed the requirements (H0 rejected). Besides this result, 20 of 33 indicators of the education background category had Asymp. Sig>0.05, meaning 60.61% of the indicators passed the criteria (H0 accepted). Therefore, the factors that made respondents answer different responses to the questionnaire were from the years of working experience [29].

3.2 Common method bias (CMB) analysis

All of the indicators were examined with Harman single-factor test to determine the bias of the data.

Table 5. Calculation of common method bias test

Total Variance Explained		
Extraction Sums of Squared Loadings		
Total	% of Variance	Cumulative %
16.335	49.501	49.501

Table 5 showed an example of Harman single factor test calculation and as a result, percentage of variance for common method bias was 49.501%. Moreover, this result showed the research was bias-free, according to the Harman single factor test criteria which was a variance value of less than 50% [24].

3.3 Structural equation modeling (SEM) analysis

Figure 2 showed the structural model hypothesis of in the research. Hypothesis 0 (H0) of this exploration stated that every path of total construction safety culture variable had a positive influence on safety performance variable (leading and lagging) [30-34].

Table 6 showed structural equation modeling for outer model recapitulation. Based on the outer model requirements and criteria, all of the aspects passed the requirements, meaning that this data was valid and reliable [25, 26].

According to Table 7, structural hypothesis path was tested and all the elements met the requirements. Specifically, R^2 value for leading variables was 0.856, which was substantial and represented 85.6% of the indicators for leading aspect of construction safety performance. However, lagging variable had R^2 value of 0.465, which was considered weak. This signified that in the future, lagging would need improvement for better representation. The Q^2 elements, which showed the prediction path test of the hypothesis, also met the test requirement [26].

There were two different ways to explain path interrelation:

1) Direct relation: This followed the hypothesis where total construction safety culture variables were directly connected to safety performance variables.
2) Indirect relation: This used Leading (Y.1) as a mediating variable, connecting total construction safety culture variables to Lagging (Y.2) indicator.

Table 6. SEM outer model analysis result

Variables	Indicators	Outter Loading	Average Variance Extracted	Composite Reliability	Cronbach's Alpha
Leadership (X.1)	X1.1	0.909	0.759	0.926	0.894
	X1.2	0.904			
	X1.3	0.833			
	X1.4	0.835			
Competency (X.2)	X2.1	0.910	0.852	0.958	0.942
	X2.2	0.925			
	X2.3	0.918			
	X2.4	0.938			
Commitment (X.3)	X3.1	0.925	0.819	0.931	0.889
	X3.2	0.942			
	X3.3	0.846			
Regulation (X.4)	X4.1	0.967	0.926	0.962	0.920
	X4.2	0.958			
Project Scope (X.5)	X5.1	0.883	0.849	0.944	0.911
	X5.2	0.951			
	X5.3	0.928			
Resources (X.6)	X6.1	0.896	0.734	0.917	0.880
	X6.2	0.846			
	X6.3	0.840			
	X6.4	0.845			
Supervision (X.7)	X7.1	0.857	0.763	0.928	0.896
	X7.2	0.854			
	X7.3	0.886			
	X7.4	0.896			
Training (X.8)	X8.1	0.884	0.740	0.895	0.824
	X8.2	0.815			
	X8.3	0.880			
Leading (Y.1)	Y1.1	0.915	0.821	0.932	0.891
	Y1.2	0.910			
	Y1.3	0.894			
Lagging (Y.2)	Y2.1	0.898	0.822	0.933	0.892
	Y2.2	0.919			
	Y2.3	0.903			

Table 7. SEM inner model analysis result

Variables	Indicators	Predictive Relevance (Q^2)	R-Square (R^2)
Leading (Y.1)	Y1.1	0.658	0.856
	Y1.2	0.671	
	Y1.3	0.698	
Lagging (Y.2)	Y2.1	0.229	0.465
	Y2.2	0.287	
	Y2.3	0.240	
Direct Relation		**T *Statistics* (|O/STDEV|)**	**P Values**
X4 → Y1		2.452	0.014
X1 → Y1		2.233	0.026
X3 → Y1		2.928	0.003
X2 → Y1		2.285	0.022
Y1 → Y2		10.521	0.000
X5 → Y1		2.886	0.004
X8 → Y1		2.066	0.039
X7 →Y1		3.408	0.001
X6 → Y1		2.158	0.031
Indirect Relation		**T *Statistics* (|O/STDEV|)**	**P Values**
X4 → Y1 → Y2		2.367	0.018
X1 → Y1 → Y2		2.145	0.032
X3 →Y1 → Y2		2.755	0.006
X2 → Y1 → Y2		2.282	0.023
X5 → Y1 → Y2		2.792	0.005
X8 → Y1 → Y2		1.994	0.046
X7 → Y1 → Y2		3.258	0.001
X6 → Y1 → Y2		2.158	0.031

All these relations met the requirements, as shown by T-Statistic value above 1.96 (>1.96) [25, 26]. This value signified that H0 was accepted, or all the total construction safety culture positively influenced safety performance variables.

3.4 Observation result

The observation activity found that out 33 of total construction safety culture indicators, there are 4 indicators that have not met the standards. These indicators are workers involvement (X3.2), organization regulation (X4.2), work environment (X5.2), and cost of safety (X6.4). This means that the compliance value for the implementation of construction safety in the case study is 87.88%/100%. This percentage can be used by contractors as a key performance index to measure the construction safety implementation.

Figure 3. Observation documentation

Figure 3 is the example of the observation documentation. That picture is located in IKN establishment, where there is no safety net to protect the worker to prevent from falling from high place and bored pile hole.

3.5 Strategies recommendations

Following the strategies recommendation, expert validation was required to validate the analysis result. In addition, a strategy will be recommended by the path relation hypothesis.

Table 8 showed a recap of expert description which met the requirements in the context of this research. On the other hand, Table 9 describe recommendation strategies for direct relation of total construction safety culture toward safety performance. It is crucial to acknowledged that these strategies were designed for macro impact of construction accident. Specifically, strategies recommended additions or changes to the criteria and nomenclature in Norms, Standard, Guidelines, and Criteria of construction safety developed by Indonesian governments. Experts suggested that construction safety regulations made by the government should be evaluated periodically [35]. This was because the implementation of construction safety regulations included all construction service provider and contractor as project executor [36]. Expert 3 particularly recommended that construction safety regulations should be simplified to facilitate construction service providers, especially contractor. All experts agreed with the recommendation strategies provided, which included adding to existing construction safety regulations and improving construction knowledge for application in project.

Indirect relation strategy covered micro and meso impacts of construction accident phenomena. This strategy recommended the use of technologies for transformation and improvement of construction knowledge application in project and company. In the context of indirect relation between Regulation (X.4) and Lagging (Y.2) through Leading (Y.1), experts suggested implementing a reward and punishment system by construction service providers, especially contractors. This idea was to create more awareness and motivation among all project personnel [37]. Regarding Leadership (X.1) toward Lagging (Y.2) through Leading (Y.1), agile leadership style combined with firmness was recommended for project and company leaders. A constructive leadership style was considered a support system for increasing construction safety, creating safety culture, and improving personnel skills and characters [38, 39]. In the aspect of Commitment (X.3) toward Lagging (Y.2) through Leading (Y.1), the recommendation strategy focused on workers and company commitment. It was suggested that workers and company representative should discuss problems existing in the work field [40]. To streamline communication with stakeholders and all project personnel, the expert recommended that contractor could use BIM 360 as a platform. This process would allow for decision-making regarding project matters that were directly integrated with technical data [41].

Table 8. Expert's personal description

Categories	Expert 1	Expert 2	Expert 3
Name	DVI	DA	BP
Gender	Male	Male	Male
Age	46	35	57
Occupational	IKN Authority	Indonesian Railways Company	Contractor of State Company
Position	Leader Expert IKN Authority	Manager	Director of Entity Company
Work Experience	>15 Years	>15 Years	>15 Years
Last education	Doctor	Doctor	Doctor

Table 9. Direct relation strategies

Direct Relation	Strategies Recommendation
X4→Y1	1.) In Public Housing and Public Works Ministerial Regulations Num. 10 of 2021 was required to be the main construction safety regulation in Indonesia, or the government can make a new main regulation of construction safety which covers any technical references such as Standard Nasional Indonesia or ASTM. 2.) In Public Housing and Public Works Ministerial Regulations Num. 10 of 2021, the rule would show clarity of the penalty regulation for the construction service provider when not meet the construction safety requirements.
X1→Y1	In Public Housing and Public Works Ministerial Regulations Num. 10 of 2021, Chapter 6 clause 2 (a), Chapter 7 clause 1 (a), dan Attachment D part D.2.1 Num. 1/1.1: 1.) Leadership criteria would be presented in construction safety function and responsibility such as influencing good behavior, safe acts, and obligation to secure the safety in the construction process.
X3→Y1	In Public Housing and Public Works Ministerial Regulations Num. 10 of 2021, Chapter 7 clause 1 (c) dan Attachment A: 1.) Criteria for organizational commitment in the implementation of construction safety that was open and transparent in addressing all issues. These criteria included evaluating incidents that occurred in the work area as a form of learning that was conducted. In Public Housing and Public Works Ministerial Regulations Num. 10 of 2021, Attachment D.2.2 Part A.3 Num. 4: 1.) The criteria for good workers in the implementation of construction safety are those who actively provide feedback concerning the organization's construction safety practices. 2.) Workers are subject to sanctions if found not complying with construction safety regulations. In Public Housing and Public Works Ministerial Regulations Num. 10 of 2021, Chapter 9 clause 1 (d): 1.) There were requirements to be a standard or template for communication flow related to construction safety for all project stakeholders.
X2→Y1	In Public Housing and Public Works Ministerial Regulations Num. 10 of 2021, Attachment D Part D.2.1 No. 4/1.2: 1.) Control of subcontractors and suppliers should be combined with the main contractor's work safety plan document, as the work safety plan document included the construction safety of all personnel in the work area, and the contractor was responsible for a combination.
Y1→Y2	In Public Housing and Public Works Ministerial Regulations Num. 10 of 2021, Attachment Section III part I No. 5: 1.) There was a requirement for a more comprehensive explanation of the definitions of leading and lagging indicators to make regulation easier to understand. 2.) Addition of performance criteria or the percentage of compliance in the application of lagging and leading indicators, as an example of the safety performance on the project.
	In Public Housing and Public Works Ministerial Regulations Num. 10 of 2021, Chapter 5 clause 1 (a) and 1 (g), Attachment Bab IV: 1.) Construction service providers were required to submit as-built drawings to stakeholders for verification of the work results against the field results, basic design, and detailed engineering design (DED).
X5→Y1	In Public Housing and Public Works Ministerial Regulations Num. 10 of 2021, Chapter 2 clause 10, attachment D part D.2.1 No. 2 (1.2a): 1.) The criteria for a safe and comfortable working environment include a workspace that was free from internal and external disturbances. Examples of internal disturbances are malfunctioning heavy equipment or construction defects that lead to building failures and construction accident. In addition, external disturbances include the presence of third parties interfering with the project for matters unrelated to the continuity of the construction.
X8→Y1	In Public Housing and Public Works Ministerial Regulations Num. 10 of 2021, Chapter 37: 1.) Work competency certificates must be renewed in accordance with the validity period of the certificate. 2.) Personnel who did not renew their competency certificates may be declared incompetent.
X7→Y1	In Public Housing and Public Works Ministerial Regulations Num. 10 of 2021, Chapter 11 clause 1a, Chapter 11 clause 1b, Attachment A part A.2.2 description in picture A.4: 1.) There was a requirement to be a deadline decision concerning the rectification of work following audits and inspections for the smoothness and safety of construction, especially when the service provider made intentional mistakes.
X6→Y1	In Public Housing and Public Works Ministerial Regulations Num. 1 of 2022, Chapter III clause 18:

Direct Relation	Strategies Recommendation
	1.) The cost of implementing occupational health and safety system management is aimed at all construction projects, ranging from small, medium, to large scale, according to the job risk criteria in Article 34 of Regulation No. 10 of 2021 issued by the Ministry of Public Works and Housing. In Public Housing and Public Works Ministerial Circular Letter Num. 10 of 2022, Attachment I section C: 1.) The process of material inspection must be accompanied by the service user or represented by the supervising consultant as a form of validating materials that meet specifications. In Public Housing and Public Works Ministerial Circular Letter Num. 10 of 2022, Attachment I section D: 1.) The completed calibration process needs to be given a fixed period or timeframe for re-inspection or recalibration.

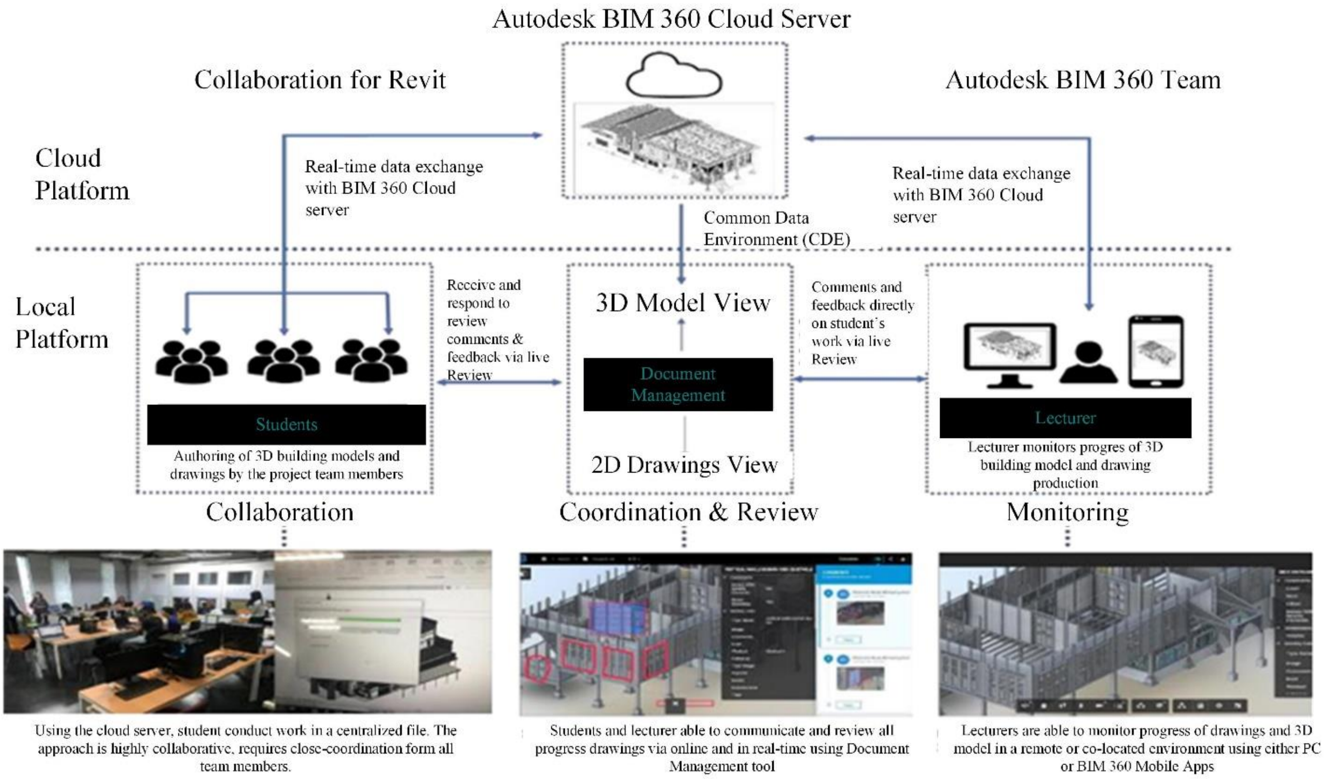

Figure 4. BIM 360 implementation [42]

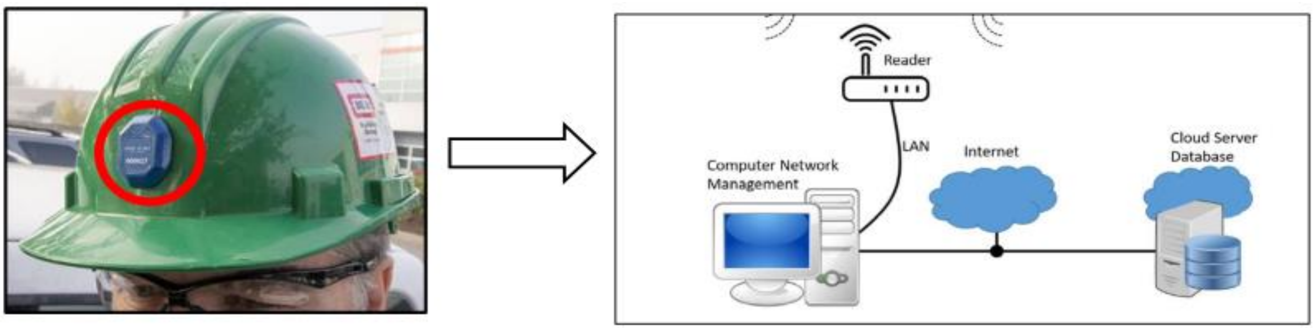

Figure 5. RFID implementation [47]

Figure 4 showed that BIM 360 could integrate work progress, building design, and work environment area as a group, making work easier and more effective, while minimizing undesirable occupational risk [42]. For Competency (X.2) toward Lagging (Y.2) through Leading (Y.1), it was recommended that the person in charge of contractor company conduct periodic construction safety competency tests for personnel to refresh and remind the individuals about the importance of safety [43]. To increase safety performance, training sessions were suggested. Specifically, Training (X.8) toward Lagging (Y.2) through Leading (Y.1) strategy recommendations included case studies, field implementation of construction safety, and coaching sessions held by company. Following this process, a certification could be provided at the end of the training to describe how well personnel understood construction safety [44]. In the aspect of Supervision (X.7) toward Lagging (Y.2) through Leading (Y.1), the behavior-based safety (BBS) method was recommended. This included analyzing personnel behavior in the work field, discussing safety issues with workers, and reminding each other to obey safety rules. This method could gradually change personnel behavior from poor to mature [45].

Strategy Resources (X.6) toward Lagging (Y.2) through Leading (Y.1) could be implemented by using Cubicost, which was integrated with the DED. This tool could calculate engineering estimates of materials quantity called BIM-Based Quantity Take Off [46]. A lack of material quantity would influence construction safety from a technical perspective and could also affect building strength when considering structural material. Lastly, the recommendation strategy for Project Scope (X.5) toward Lagging (Y.2) through Leading (Y.1) could be implemented by using Radio Frequency Identification (RFID) to monitor personnel in the working area.

Figure 5 showed the implementation of RFID for construction safety purpose, which was combined with BIM for project layout to detect danger zones in work area. Following this discussion, all of the project personnel used the device of RFID in each personnel helmet to signal to the cloud base to know where the individuals were. Hazard zone was identified in the project planning and it would be announced that this area was restricted to be passed. In addition, this process allowed the work environment safer for the project personnel [47].

Additionally, there were 3 factors influencing safety performance developed from focus group discussions with expertise in the field.

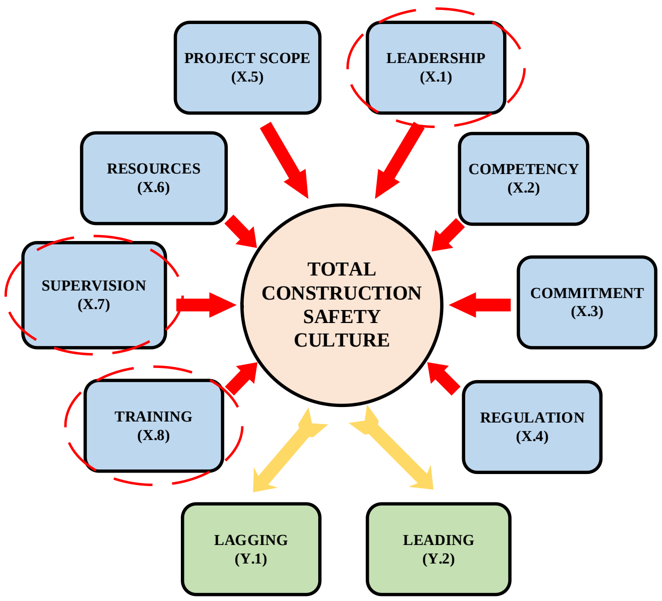

Figure 6. Theory of total construction safety culture interrelation towards safety performance

Figure 6 showed leadership, supervision, and training as the most impactful factors of total construction safety culture. Construction safety culture leadership served as a mediator in the hierarchy among personnel [48]. Additionally, efficient work was also achieved in construction project by managers who had a clear vision, mission, and decisive attitude [49]. Supervision is equally important as it included the process of validating the planning and implementation of construction safety, as well as the learning evaluation process to achieve improvements in the safety system over time. Training was fundamental in shaping personnel to be aware, skilled, and have a good attitude in the work, ensuring the staff followed and believed in the importance of implementing construction safety [50].

4. CONCLUSIONS

Total construction safety culture was developed based on research findings that show the hypothesis of this study is accepted (H0 accepted) through the structural equation modeling conducted, meaning all hypotheses have a significant impact. Additionally, there is further evidence from field observations indicating non-compliance in construction safety practices, where 4 out of 33 indicators have not met the appropriate safety standards. Based on these findings, a strategic concept aimed at improving construction safety performance is being formulated, focusing on the development of a total construction safety culture. The first strategy is to provide recommendations for enhancing construction safety on a macro (national) scale. This is achieved by suggesting the addition of nomenclature and criteria in Indonesian government regulations on construction safety, to create a well-functioning and safe performance ecosystem of construction industry. Furthermore, strategies to improve construction safety performance on a micro and meso scale include technology transformation, such as the use of Building Information Modeling (BIM) and RFID, the dissemination of tacit knowledge, and updates to the supervision method process during the construction phase. This strategy is proposed so that contractors, as project implementers, can easily monitor the risks present during the construction period. Additionally, we encourage project implementers to adapt to technological advancements that can assist in the project execution process.

There was hope that with the recommendations provided in this research, the construction industry in Indonesia would reduce unwanted incidents and support sustainable construction project implementation. For future exploration, total construction safety culture factors would be more impactful when the influences were all interrelated. Total construction safety culture implementation is also can be a topic in future research.

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