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Confirmatory Factor Analysis (CFA) for Permit to Work (PTW) on Occupational Accident at Petrochemical Complex, Kerteh Terengganu

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ABSTRACT

There are a series of Process and Occupational Accidents occurring offshore and onshore facilities. It is disturbing that some of the Chemical Industrial accidents in all maintenance and construction activities despite having Permit to Work (PTW) to control the activities. Using quantitative research methods based on Structural Equation Modeling (SEM), this study to determine the purpose of this study was to examine the Confirmatory Factor Analysis (CFA) for PTW (work description, hazardous activity, work inspection, supporting document, and closeout) on occupational accidents. A total of 260 research samples were included in the study. Data were analyzed using IBM-SPSS-AMOS (SEM) program version 21.0. SEM analysis consists of two main models: the measurement model and structural model. Before the SEM test, some adjustment tests to ensure that the tested indicator represented the measured construct. The findings show that all constructs PTW show the compatibility of the hypothetical models tested is verified using the Fitness Indexes to see the values of Root Mean Square Error of Approximation, Goodness of Fit Index, Comparative Fit Index and Chi-Square/Degree of Freedom. Combined factorization analysis of all measurement models shows that the three categories of model compatibility indexes achieved for all models of constructs and discriminant validity.

Keywords: Confirmatory Factor Analysis (CFA), Occupational Accident, Permit to Work (PTW), Structural Equation Modeling (SEM)

1. INTRODUCTION

The researcher undertook this study due to many occupational accidents in the Petroleum Industry, which causes high injury and fatality that worry many parties, including the Company Management. It affects the company's reputation regarding safety performance and records-the accident occurring either on offshore platforms or onshore Petrochemical Plant. Once accidents occur, it gives a significant impact and lousy image to individuals and Company Management. The Petrochemical Plant is supposed to be the safest place to work with every measure taken by Company Management to ensure a safe work place and no accident happens, at all-time, but on many occasions, the occupational accident still happens. When the accident does occur, an accident investigation must take place. The accident investigation needs to put proper intervention to avoid its recurrence. One of the areas of concern is the Permit-To-Work System

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which had failed before. The accident could result from a breakdown of communication in the Permit to Work System in which the people do not do the proper shift handover. Even though the memo and warning to all the people at different work locations, the lesson was not learned from the previous few occupational accidents.

The Permit to Work is a formal procedure, and deficiencies in PTW are not acceptable. However, sometimes when the people did not pay serious attention in fulfilling all the requirements in filling up work description, checking worksite and hazardous activity, or not properly close out of the Permit To Work itself. The insufficient resources include fulfilling and verification on all the requirements of supporting documents such as lockout-tag out, any bypass or isolation which will trigger the accident while performing the job. The importance to do worksite inspection can be looking by [1] on his paper regards to Human Error Analysis in permit-to-work which states of worksite inspection when the requirement to have the competent person for gas testing in confine space to check the worksite because few accidents occurred when people work in confine space does not do the thorough worksite inspection in the Confine Space before the work can start. The worksite inspection is one of the elements in the Permit-To-Work system. [2] States that the safety work permit is one of the administrative interventions that need consideration and affect safety behavior. Checking the "hazardous activity" procedure in Permit-To-Work issuance. It is related to work activities such as working at height and excavation work in the construction industry to prevent any occupational accident. The purpose of this study was to examine the Confirmatory Factor Analysis (CFA) for work description, hazardous activity, work inspection, supporting document and closeout, on occupational accidents.

2. RESEARCH METHODOLOGY

The research method used is quantitative, where the survey method is a quantitative research procedure that is very suitable for large populations and samples representing the research population. The findings from the quantitative analysis can provide a holistic understanding of research questions [3]. Therefore, findings involving large sample sizes can be generalized from samples to populations with the same background. The survey method involves collecting data through a questionnaire as the main instrument [4,5,16]. According to [6], this questionnaire is efficient for large populations to get a more comprehensive sample description of the question inquiries, especially for large samples and distances from one another and cost. Therefore, the questionnaire is the most suitable measuring instrument for use in this study. The advantages of using questionnaires are easy to manage, process, analyze, and information directly from samples in a short time [7].

Data were analyzed using Structural Equation Modeling (SEM) with IBM-SPSS-AMOS program version 21.0. with two main models, namely the measurement model and the structural model. Before the SEM test, initial adjustment tests should ensure that the tested indicator represents the measured construct. There are two analyzes as prerequisites before the SEM analysis is performed: 1) Exploration Analysis Factor (EFA) and 2) Confirmation Factor Analysis (CFA). Validation factor analysis (CFA) is a test of the measurement model to ensure that each construct meets procedures such as validity and reliability for each experiment [4,8,9,14,15,16,20,21]. Comparison of model measurement is essential to ensure that any latent construct in this study is compatible with the data studied to continue with SEM analysis [8,9,21].

Using the CFA method can assess how factors are observed significantly to the latent construct used. This assessment is done by examining the stiffness value of the regression pathway from factor to the observed variable (factor loading) rather than the relationship between factors [14,15,16]. Through CFA, any item not conforming to the measurement model is derived from the model. This inequality is due to the low load factor value. Therefore, researchers need to apply the CFA process to all model-related constructs, either separately or collectively (combined CFA

models) [16,17,18,19]. The compatibility of the hypothetical models tested is verified using the Fitness Indexes to see the values of Root Mean Square Error of Approximation (RMSEA < 0.08), Goodness of Fit Index (GFI > 0.90), Comparative Fit Index (CFI > 0.90), and Chi-Square/Degree of Freedom (chisq/df < 5.0). According to [20], if the value of $\chi 2$ is less than 2.00 but significant, it should be noted whether the sample is large or vice versa. A sample size above 200 can cause $\chi 2$ to be significant. Therefore, Hair and his colleagues propose two other indices, CFI and RMSEA, to ensure that the CFA analysis establishes a dimensionless research model. If the CFI value exceeds 0.90 and the RMSEA is less than 0.08, it proved that Unidimensionality exists for the formation of each construct.

3. RESULTS AND DISCUSSION

3.1 Confirmatory Factor Analysis (CFA)

Two models need to be analyzed to implement the Structural Equation Modeling-SEM Measurement Model and Structural Model. [9,10,11,13,16,17,18,19] suggest two steps to follow Structured Equation Modeling (SEM).

a) Verification of the Measurement Model of all contracts involved through the CFA method.
b) Model all constructs into Structural Models and Modeling Structural Equations.

According to [9,11,13,16,17,18,19], the Measurement Model by the research data is important to verify the SEM. If the Measurement Model does not match the data from the field, the Built-in Structured Equation Model is invalid. Therefore, the first step in SEM analysis is to determine the Measurement Model according to the data from the field. CFA method is to determine Model Compatibility and Model Measurements with field data. Through the CFA approach, researchers examined statistically to validate the proposed construction model. Table 1 shows the three requirement categories of compatibility indexes by building Absolute Fit, Incremental Fit, and Parsimonious Fit models.

Table 1 Three Compatibility Index Categories as well as Recognized Index Types

Name of Category	Name of Index	Level of Acceptance
Absolute Fit Index	RMSEA	RMSEA < 0.08
	GFI	GFI > 0.90
Incremental Fit Index	AGFI	AGFI > 0.90
	CFI	CFI > 0.90
	IFI	IFI > 0.90
	TLI	TLI > 0.90
	NFI	NFI > 0.90
Parsimonious Fit Index	Chisq/df	Chi-Square/ df < 3.0

Source: [9]

Five exogenous constructs and one endogenous construct were involved in this study. The exogenous constructs are the Work Description, Hazardous Activity, Work Inspection, Supporting Document, and Close-Out. The first exogenous construct is the Work Description. The Work Description construct input is using five items. The second exogenous construct is the Hazardous Activity, and this construct was measured using five items. The third exogenous construct is Work Inspection, and this construct has one construct (measured using ten items). The four exogenous constructs are Supporting Document, and this construct has one construct (measured using six items). Finally, the five exogenous constructs are Close Out, and this construct has one construct (measured using four items). The endogenous construct in the model is Occupational Accident, and this construct has three sub-constructs, namely Engineering Effect (measured using four items), Human Effect (measured using five items), and Environment Effect (measured using four items).

3.2 CFA Analysis for Conventional Work Description Measurement Models

The Measurement Model for the construct of Work Description has reached the level of Compatibility Index. The Compatibility index means that Building Validity for this construction is acceptable [9,10,11,12,16,22]. Figure 1 show the measurement model for the layout of Work Description construct.

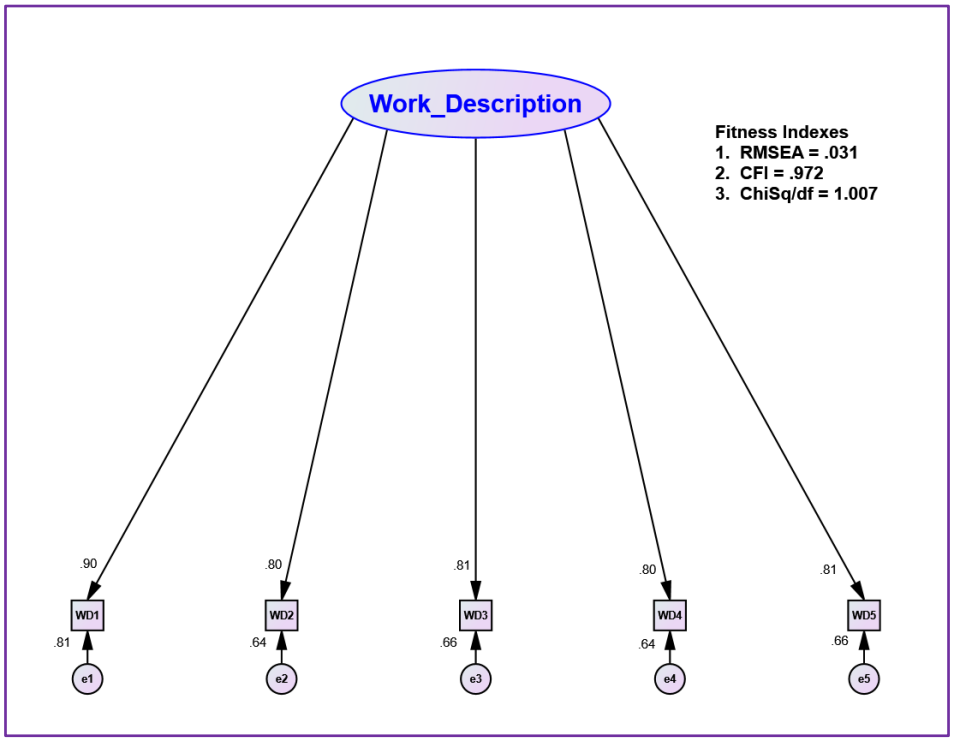

Figure 1. Layout Measurement Model for Work Description Construct

The Analysis of Fitness Index in Table 2 shows that the Work Description construct model has reached the Compatibility Index level. The value of the Compatibility Index indicates that Building Validity for this construction is acceptable [9,10,11,12,16,22].

Table 2 Analysis to Determine Validity for Work Description Construct

Name Category	Name Index	Index value	Research Findings
1. Absolute fit	RMSEA	0.031	Reached the set level
2. Incremental fit	CFI	0.972	Reached the set level
3. Parsimonious fit	ChiSq/df	1.007	Reached the set level

Table 3 below shows the values of Convergent Validity (AVE) and Composite Reliability (CR). The AVE value exceeds the minimum limit of 0.5 (reaches the specified limit) and the CR value exceeds the minimum limit of 0.6 (reaches the specified limit) [9,16]. This value achievement indicates that Convergent Validity (AVE) and Composite Reliability (CR) have been achieved.

Table 3 AVE and CR Values of Work Description Construct

Construct	Sub- Construct	Factor Loading	CR (above > 0.6)	AVE (above > 0.5)
Work Description	WD1	0.90	**0.914**	**0.680**
	WD2	0.80		
	WD3	0.81		
	WD4	0.80		
	WD5	0.81		

3.3 CFA Analysis for Hazardous Activity Conflict Measurement Mode

The Measurement Model for Hazardous Activity construct has reached the level of Compatibility Index level. Again, this level of compatibility means that Building Validity for this construct is acceptable [9,10,11,12,16,22]. Figure 2 show the layout measurement model for Hazardous Activity.

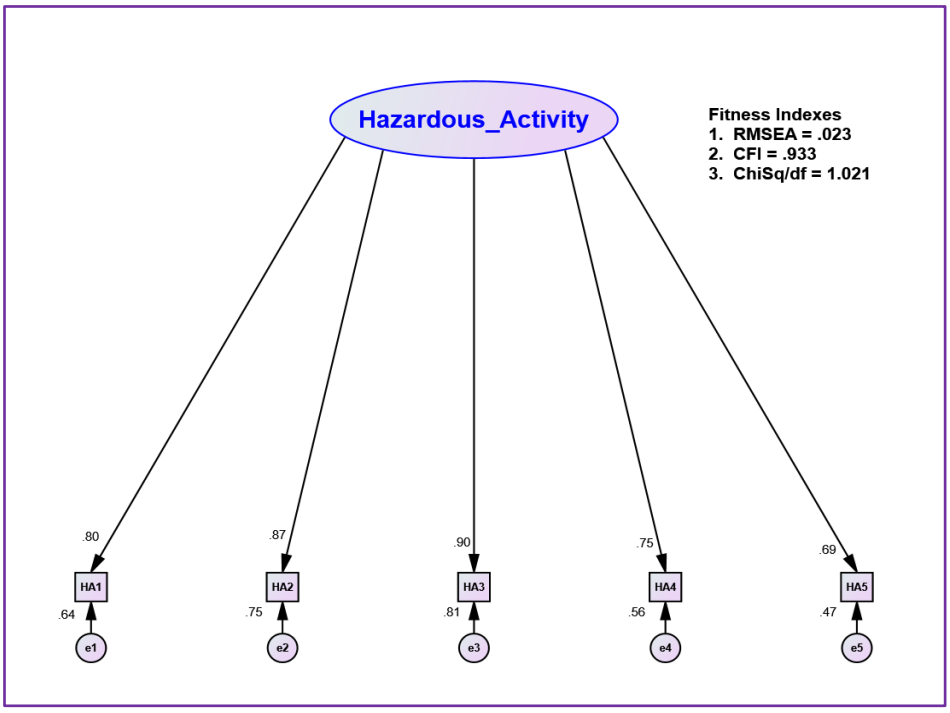

Figure 2. Layout Measurement Model for Hazardous Activity Construct

The Analysis of the Fitness Index in Table 4 shows the Hazardous Activity measurement model has reached the level of Compatibility Level. This level of compatibility means that Building Validity for this construct is acceptable [9,10,11,12,16,22].

Table 4 Analysis to Determine Validity for Hazardous Activity Construct

Name Category	Name Index	Index value	Research Findings
1. Absolute fit	RMSEA	0.023	Reached the set level
2. Incremental fit	CFI	0.933	Reached the set level
3. Parsimonious fit	ChiSq/df	1.021	Reached the set level

Table 5 below shows the values of Convergent Validity (AVE) and Composite Reliability (CR). The AVE value exceeds the minimum limit of 0.5 (reaches the specified limit) and the CR value exceeds the minimum limit of 0.6 (reaches the specified limit) [9,16]. This value achievement indicates that Convergent Validity (AVE) and Composite Reliability (CR) have been achieved.

Table 5 AVE and CR Values of Hazardous Activity Construct

Construct	Sub- Construct	Factor Loading	CR (above > 0.6)	AVE (above > 0.5)
Hazardous Activity	HA1	0.80	**0.902**	**0.649**
	HA2	0.87		
	HA3	0.90		
	HA4	0.75		
	HA5	0.69		

3.4 CFA Analysis for Work Inspection Model

The Measurement Model for Work Inspection construct has reached the level of Compatibility Index level. Again, this level of compatibility means that Building Validity for this construct is acceptable [9,10,11,12,16,22]. Figure 3 show layout measurement models of Work Inspection construct.

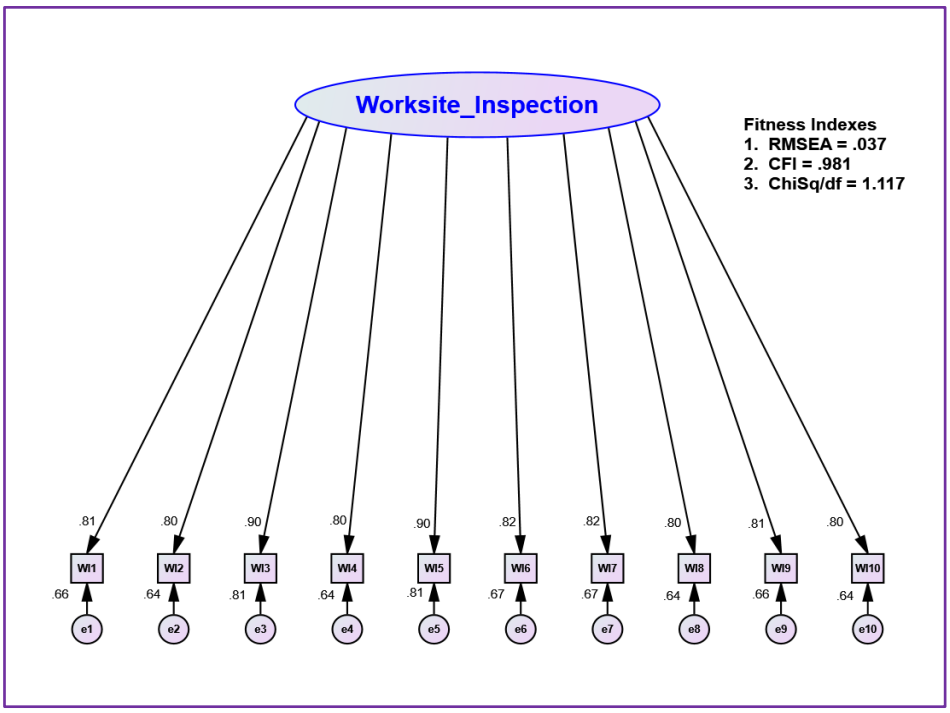

Figure 3. Layout Measurement Model for Work Inspection Construct

The Analysis of Fitness Index in Table 6 shows measurements of construct model Work Inspection has reached the level of Compatibility Level. This level of compatibility means that Building Validity for this construct is satisfactory [9,10,11,12,16].

Table 6 Analysis to Determine Validity for Work Inspection Construct

Name Category	Name Index	Index value	Research Findings
1. Absolute fit	RMSEA	0.037	Reached the set level
2. Incremental fit	CFI	0.981	Reached the set level
3. Parsimonious fit	ChiSq/df	1.117	Reached the set level

Table 7 below shows the values of Convergent Validity (AVE) and Composite Reliability (CR). The AVE value exceeds the minimum limit of 0.5 (reaches the specified limit) and the CR value exceeds the minimum limit of 0.6 (reaches the specified limit) [9,16]. This value achievement indicates that Convergent Validity (AVE) and Composite Reliability (CR) have been achieved.

Table 7 AVE and CR Values of Work Inspection Construct

Construct	Sub- Construct	Factor Loading	CR (above > 0.6)	AVE (above > 0.5)
Work Inspection	WI1	0.81	**0.956**	**0.684**
	WI2	0.80		
	WI3	0.90		
	WI4	0.80		
	WI5	0.90		
	WI6	0.82		
	WI7	0.82		
	WI8	0.80		
	WI9	0.81		
	WI10	0.80		

3.5 CFA Analysis for Supporting Document Conflict Measurement Model

The Measurement Model for Supporting Document construct has reached the level of Compatibility Index level. Again, this level of Compatibility means that Building Validity for this construct is adequate [9,10,11,12,16,22]. Figure 4 show the layout measurement model for Supporting Document construct.

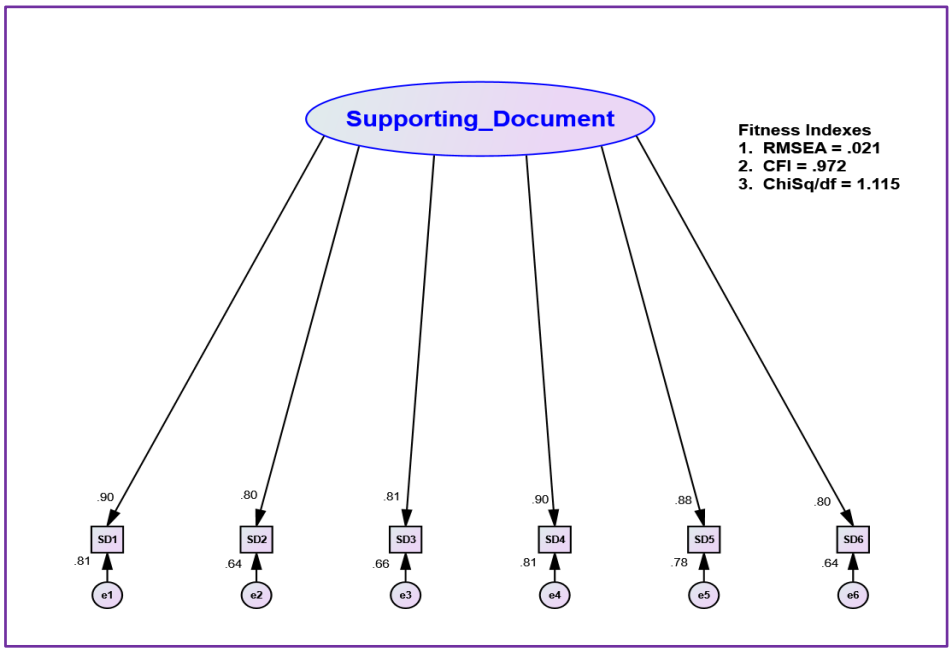

Figure 4. Layout Measurement Model for Supporting Document Construct

The Analysis of the Fitness Index in Table 8 shows the Supporting Document measurement model has reached the level of Compatibility Level. This level of Compatibility means that Building Validity for this construct is satisfying [9,10,11,12,16,22].

Table 8 Analysis to Determine Validity for Supporting Document Construct

Name Category	Name Index	Index value	Research Findings
1. Absolute fit	RMSEA	0.021	Reached the set level
2. Incremental fit	CFI	0.972	Reached the set level
3. Parsimonious fit	ChiSq/df	1.115	Reached the set level

Table 9 below shows the values of Convergent Validity (AVE) and Composite Reliability (CR). The AVE value exceeds the minimum limit of 0.5 (reaches the specified limit) and the CR value exceeds the minimum limit of 0.6 (reaches the specified limit) [9,16]. This value achievement indicates that Convergent Validity (AVE) and Composite Reliability (CR) have been achieved.

Table 9 AVE and CR Values of Work Inspection Construct

Construct	Sub- Construct	Factor Loading	CR (above > 0.6)	AVE (above > 0.5)
Supporting Document	SD1	0.90	**0.939**	**0.722**
	SD2	0.80		
	SD3	0.81		
	SD4	0.90		
	SD5	0.88		
	SD6	0.80		

3.6 CFA Analysis for Close Out Model

The Measurement Model for Close Out construct has reached the level of Compatibility Index level. Again, this level of Compatibility means that Building Validity for this construct is adequate [9,10,11,12,16,22]. Figure 5 show the layout measurement models of Close Out construct.

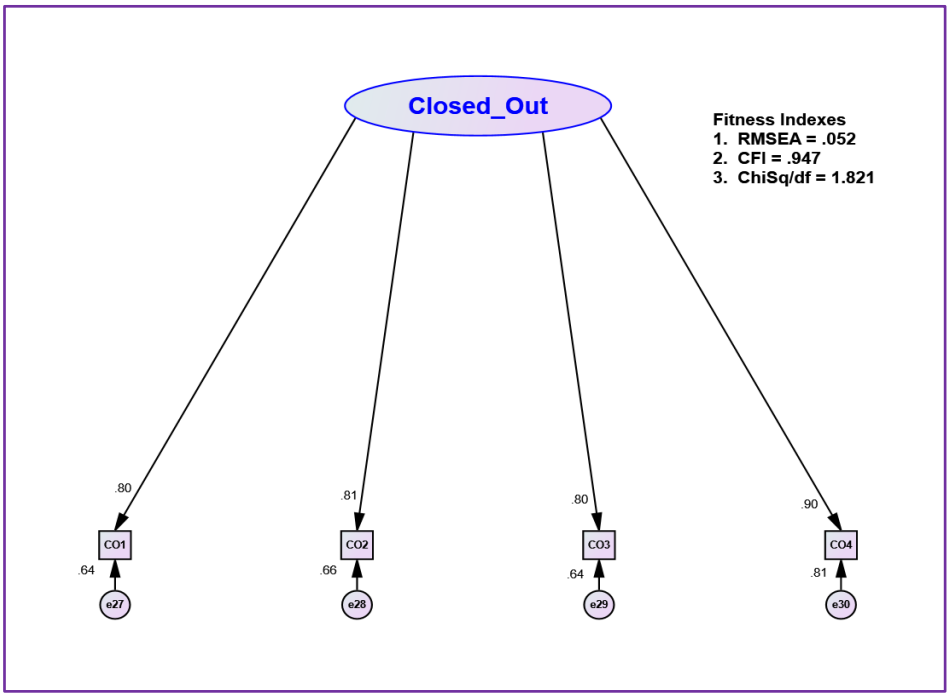

Figure 5. Layout Measurement Model for Close Out Construct

The Analysis of Fitness Index in Table 10 shows Measurements of Construct Model Close Out has reached the level of Compatibility Index. This level of Compatibility means that Building Validity for this construct is satisfactory [9,10,11,12,16].

Table 10 Analysis to Determine Validity for Close Out Construct

Name Category	Name Index	Index value	Research Findings
1. Absolute fit	RMSEA	0.052	Reached the set level
2. Incremental fit	CFI	0.947	Reached the set level
3. Parsimonious fit	ChiSq/df	1.821	Reached the set level

Table 11 below shows the values of Convergent Validity (AVE) and Composite Reliability (CR). The AVE value exceeds the minimum limit of 0.5 (reaches the specified limit) and the CR value exceeds the minimum limit of 0.6 (reaches the specified limit) [9,16]. This value achievement indicates that Convergent Validity (AVE) and Composite Reliability (CR) have been achieved.

Table 11 AVE and CR Values of Close Out Construct

Construct	Sub- Construct	Factor Loading	CR (above > 0.6)	AVE (above > 0.5)
Close Out	CO1	0.80	**0.897**	**0.687**
	CO2	0.81		
	CO3	0.80		
	CO4	0.90		

3.7 Confirmation Factor Analysis of All Measurement Models (Pooled CFAs)

The Integrated Validation Factor (CFA) analysis is required to evaluate the correlation value between constructs in the Discriminant Validity procedure. If the correlation value between constructs exceeds 0.85, both constructs are said to be excessive [9, 12,13,16,22]. For overly complex models involving second-order construction, joint validation factor analysis is complicated. *Second level construction* is a construct with dimensions or substructures where each dimension or substructure has a certain number of items. The researcher will find it challenging to combine all the second-level constructs in one model to conduct Pooled Confirmatory Factor Analysis.

Figure 6 shows the procedural findings of Combined Factor Confirmation (Pooled CFA). The value on a single-headed arrow is the weighting factor of each item, while the value on the double-headed arrow is the correlation between the constructs. Through the Combined Validity Factor Analysis method, only one model of the compatibility index represents all the constructed constructs.

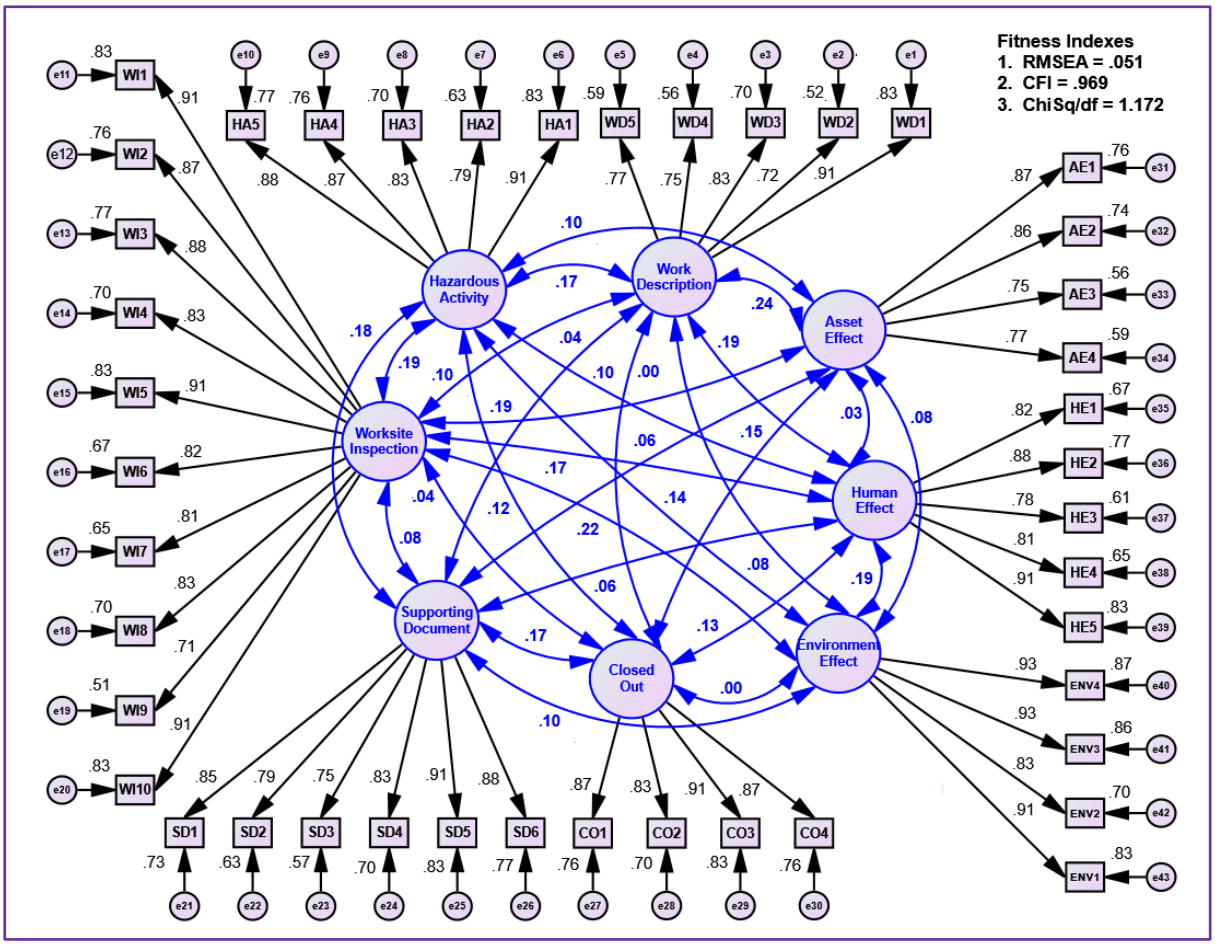

Figure 6. Findings of Results from the CFA Construct Combinations Procedure (Pooled CFA)

The findings from Table 12 show that the three categories of model compatibility indexes for all construction model constructions are adequate.

Table 12 Comparison of Value Index Models for Three Compatibility Categories

Name Category	Name Index	Index value	Research Findings
1. Absolute fit	RMSEA	0.051	Reached the set level
2. Incremental fit	CFI	0.969	Reached the set level
3. Parsimonious fit	ChiSq/df	1.172	Reached the set level

Table 13 below shows the values of Convergent Validity (AVE) and Composite Reliability (CR). The AVE value exceeds the minimum limit of 0.5 (reaches the specified limit) and the CR value exceeds the minimum limit of 0.6 (reaches the specified limit) [9,16]. This value achievement indicates that Convergent Validity (AVE) and Composite Reliability (CR) have been achieved.

Table 13 AVE and CR Values of Close Out Construct

Construct	Sub- Construct	Factor Loading	CR (above > 0.6)	AVE (above > 0.5)
Work Description	WD1	0.91	**0.897**	**0.638**
	WD2	0.72		
	WD3	0.83		
	WD4	0.75		
	WD5	0.77		
Hazardous	HA1	0.91	**0.932**	**0.734**

Activity	HA2	0.79		
	HA3	0.83		
	HA4	0.87		
	HA5	0.88		
Work Inspection	WI1	0.91	**0.963**	**0.723**
	WI2	0.87		
	WI3	0.88		
	WI4	0.83		
	WI5	0.91		
	WI6	0.82		
	WI7	0.81		
	WI8	0.83		
	WI9	0.71		
	WI10	0.91		
Supporting Document	SD1	0.85	**0.933**	**0.700**
	SD2	0.79		
	SD3	0.75		
	SD4	0.83		
	SD5	0.91		
	SD6	0.88		
Close Out	CO1	0.87	**0.926**	**0.758**
	CO2	0.83		
	CO3	0.91		
	CO4	0.87		
Environment Effect	ENV1	0.91	**0.945**	**0.812**
	ENV2	0.83		
	ENV3	0.93		
	ENV4	0.93		
Human Effect	HE1	0.82	**0.924**	**0.708**
	HE2	0.88		
	HE3	0.78		
	HE4	0.81		
	HE5	0.91		
Asset Effect	AE1	0.87	**0.887**	**0.663**
	AE2	0.86		
	AE3	0.75		
	AE4	0.77		

Another requirement of the validity that all constructs in the model need are Discrimination Validity. Discriminatory validity is necessary to prove that all constructs in the model do not have a strong relationship, causing multicollinearity problems (11,12,13,16,22]. This verification requires researchers to develop the Discrimination Index Validity Summary table. Table 14 shows the Summary of Discrimination Validity Index among all constructs in the model.

Table 14 presents the root values of the Index of Concentration Validity (AVE) for each construct on the diagonal matrix. Another value in the table is the correlation between the two constructs. According to [9,11,12,13,16,22], The constructs achieving Discrimination Validity if all the root values of convergence validity (AVE) (Diagonal) are greater than other values of both rows and columns. Findings from Table 8 show Discrimination Validity for all constructions in the model achieved.

Table 14 Summary of Discrimination Validity Index

	WD	HA	WI	SD	CO	EE	HE	AE
WD	**0.799**							
HA	0.170	**0.857**						
WI	0.100	0.190	**0.850**					
SD	0.040	0.180	0.080	**0.837**				
CO	0.000	0.120	0.040	0.170	**0.871**			
EE	0.080	0.140	0.220	0.100	0.000	**0.901**		
HE	0.190	0.100	0.170	0.060	0.130	0.190	**0.841**	
AE	0.240	0.100	0.190	0.060	0.150	0.080	0.030	**0.814**

4. CONCLUSION

Overall, the CFA analysis on the measurement model for the Work Description, Hazardous Activity, Work Inspection, Supporting Document and Close Out, has been shown to have reached the fitness index. While the combined factorization analysis of all measurement models (Pooled CFA) shows that the three categories of model compatibility indexes for all models of constructs are adequate and satisfy discriminant validity for all constructs in the model.

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