Structural Equation Model (SEM) Correlation Between Work Breakdown Structure (WBS), Work Method and Risk Towards Cost Of Safety On Low-Cost Apartments Project

R Hadwiansyah and Y Latief

Faculty of Civil Engineering, University of Indonesia, Indonesia
Email: riezka.hadwiansyah@gmail.com, yusuflatief73@gmail.com

Abstract. Cost of safety is a fundamental aspect that is inevitable to be considered during the construction cost planning phase. The cost of safety estimation is determined based on several factors, including WBS (work breakdown structure), work method, risk and other contributing factors. This estimation is critical in construction, specifically for high rise building constructions. In a case where there is a lack of a suitable methodology in estimating the cost of safety, may incur inaccuracy and uncertainty in determining the actual cost of safety. Besides the mentioned factors, this study will use Structural Equation Model – Partial Least Square (SEM-PLS) in determining the construct model cost of safety, for the case of the build of low-cost apartment building (Rusunawa).

Keywords: SEM, Cost of safety, Apartment, WBS, Risk, Work Method

1. Introduction

Rusunawa, also known as a Low-cost apartment, has been a great solution to solved the overpopulated city, providing housing for low-income or non-permanent jobs with contract-based residents. It also becomes a solution for new families who are not eligible for credit housing (KPR) [1]. Along with the construction of low-cost apartments, project developments achieve positive performance and have its downside. Based on the BPJS statistics data, there are approximately 110,285 workplace accidents in construction sites in 2015, and 101,637 accidents in 2016. It was observed that there has been an increase in the following year, with 123,041 recorded accidents, and 174,105 accidents in 2019. The increase of accidents up to 40% is caused by the increase of projects around Indonesia, based on Presidential Regulation No. 3 of 2016 on Acceleration of Strategic National Project Implementation. The number of accidents in construction project sites will potentially increase in 2019, due to the increasing number of projects compared to previous years [2].

Developing construction project plans requires adequate planning from the design plan phase, construction, and the final handover. According to Ervianto [3], a construction project is a series of activities that are only carried out once and are generally short-term. In addition, construction projects also have unique characteristics, require resources (manpower, materials, machines, money, methods), and require organization. A study conducted by the Construction Industry Institute in 2012 revealed poor performance in the industrial project sector, where nearly 70% of projects exceeded the 10% variation of the expected cost and schedule [4]. An important part of the project cost element is OSH costs. OSH cost is an expense or cost for accident prevention measures undertaken by contractors [5]. According to Ministry Regulation of Public Work No. 05, 2014, the cost of OSH Construction in the Field of Public Works is the cost required to implement Safety
and Health Management System in every construction work that must be calculated and allocated by the Service Provider and the Service User. The cost of administering OSH in Indonesia is regulated in Circular Letter No. 66 of 2015 concerning the Cost of Implementing an Occupational Safety and Health Management System in the Field of Public Work [6].

WBS will help analyze the components of each job in more detail and accurately. [7] WBS has 4 important objectives, such: 1) As a planning and design tool that can help project managers and teams to identify and manage projects effectively. WBS is a tool for designing structures that represent relationships between project unit clearly; 2) As a planning tool to show the completeness of the work packages in the project and detailed instructions for completing the project in each work unit; 3) Being a tool to determine the job milestone, project status reports to senior managers and customers, and the estimated results of each work WBS can prevent negligence of less / wrong project end results and help managers monitor project objectives and clarify tasks estimate workload; and 4) As a tool to accurately estimate time, cost, and resources.

The characteristics of WBS depend on the nature of the project and how the project manager wishes to plan and manage the project [8]. Decomposition of the WBS-based functions is being utilized to easily manage the deliverables. In planning, WBS has 5 main indicators in the management process [9]: Work package, Job package description, Person in charge, Reference document, and Required resources.

Referring to the Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia Number 21 / PRT / M / 2019, the method is a series of construction implementation activities that follow procedures and have been designed in accordance with knowledge or standards that have been tested. For construction works that use labor-intensive methods or use a lot of labor but use little machine tools, the need for Construction Safety Personnel is determined by the Construction Safety Risk assessment. This describes the components of the work method into 3 (three) aspects: scope of work, job description, and stages of work [10].

Assessment of Risk Safety Construction is the calculation of the amount of potential is based on the possibility of the existence of events that have an impact on the loss on the construction, the soul of man, the safety of the public, and the environment that may arise from certain sources of danger, occurs in Construction Work by calculating the frequency value and the severity value. Thus, the level of risk on project construction is set in the Risk Safety Construction and is categorized into 3 (three) levels: low risk, medium risk, and high risk [11].

On the Regulation of the Minister of Public Works and Housing of the People of the Republic of Indonesia number 1 Year 2020 About the Standards and Guidelines for Procurement of Works Construction Integrated Design and Build Through the Provider has set some conditions on the cost of OSH are as follows: 1) Cost of Occupational Health and Safety (OSH) Construction of a general nature in accordance with the Regulation of the Minister of Public Works No. 5 of 2014 on Guidelines for Safety and Health Management System (SMOSH) The work of the Sector Construction Works included into the cost of the general cost of OSH; and 2) Calculation of costs for the purposes of OSH which are general as Personal Protective Equipment: helmets, vests, boots, mask, rain jacket, hat, safety glove, eye protectors and others already calculated in the cost of general overhead.

2. Method

2.1. Research design
In this research we used some approach to answer the research question. First, the Survey method is used to obtain the research data derived from sources such as the conduct of questionnaires, interviews, and tests aimed to observe and record it systematically on phenomena that were
investigated [12]. The method is used to obtain the data used in identifying the plan of salvation that is used and validation of the results of the analysis of the variables that affect the cost of OSH. Second, Case studies are intended to determine the existing condition of the object of research, so that information on the factors that influence OHS costs can be known. The last, SEM method is a statistical technique that is able to analyze patterns of relationships. This method aims to analyze the pattern of relationships between latent constructs and their indicators, latent constructs with each other, and direct measurement errors. The SEM method also allows direct analysis of the dependent and independent variables. The overall research design is shown in Figure 1.

![Figure 1 Research Flow Diagram](image)

A research variable is an attribute or nature or value of people, objects, or activities that have certain variations that are determined by researchers to be studied and conclusions can be drawn. The variables in this study are: 1) WBS (X1); 2) Working Method (X2); 3) Risk (X3); 4) General cost of OSH (Y1); and 5) Specific costs of OSH (Y2).

2.2. Instruments

The instrument is a tool aids selected and used by researchers in its activities to collect the data, so that the activities are becoming systematic and can be easy. Instruments of research are referred to also as a means of measuring in a study [14] The collection of data aimed to test the hypothesis that has been formulated. The instrument of research uses SEM (Structural Equation Model) and the questionnaire as a tool to help research. This research uses a questionnaire as a material or tool for data collection. As for stage questionnaires, d nature of research is there are several, namely:

1). Stage I Questionnaire

Surveying experts with the help of instruments questionnaire early (form validation experts) regarding:

a. WBS, work methods, and risks that can affect OHS costs. These factors were obtained from literature studies. At the stage early, factors of each variable results of the study of literature is verified and clarified by experts.

b. The level of impact is indicated by the indicators that exist on the project.

2). Phase II Questionnaire

Once the process of verification, clarification, and validation of experts, deployment of instruments questionnaire phase II, a pilot survey. Questionnaires were given to prospective respondents on stage III questionnaires. On stage this, will obtain the results if the variables in the questionnaire is easy to understand.

3). Questionnaire Phase III

The submission of the stage III questionnaire through a survey of respondents. The questionnaire given to respondents to choose the level of influence of the variables are generated on the
instrument questionnaire phase III. The survey questionnaire phase III given to respondents that
the parties executing a job which involved directly in technical in the work of construction.

4). SEM-PLS
The next stage is the collection of primary data, then the data is obtained and analyzed using
statistical software, Statistical Product and Service Solutions (SPSS), and Structural Equation
Modeling (SEM-PLS) software. The SEM method is a statistical technique that can analyze
patterns of relationships. This method aims to analyze the pattern of relationships between latent
constructs and their indicators, latent constructs with each other, and direct measurement errors.

2.3. Data Analysis
2.3.1. Homogeneity Analysis
Homogeneity test is a test of whether or not the variances of two or more distributions are equal.
Homogeneity test is performed to determine whether the data in variables X and Y are homogeneous
or not. Homogeneity testing is then performed using the help of the SPSS 22 program. The
assumptions used are likely to be the same, so the significance value used is 0.05 where if the
significance value exceeds 0.05, it can be said that the variance of two or more groups is the same.

The data test technique used Kruskall Wallis H. One-Way Variety Method Kruskall Wallis
H test is a rank-based nonparametric test whose purpose is to determine whether there are statistically
significant differences between two or more groups of independent variables on the dependent
variable on a numerical / ratio scale and ordinal scale. The test carried out was the free K sample
test with the Kruskall Wallis H test with education groups, positions, and work experience in the
OSH field.

2.3.2. Variable Correlation with Smart PLS
a. Validity Test
Validity test is required with the aim to find out the level of validity of the instrument and the survey
results of respondents that have been conducted by researchers. This validity test is done by using a
standardized loading factor value obtained from SEM Smart PLS analysis results. 3.3.2 Standardized
loading factor is used to assess whether the extract has adequate discriminant validity or not, by
comparing the correlation indicator of a construct with the correlation of the indicator with another
construct. If the correlation value of a construct has a higher value than the correlation of other
construct indicators, then it can be said that the contract has a higher discriminant validity.
Standardized loading factor can describe the magnitude of the correlation of each indicator where
the indicator loading factor is more than 0.7 can be said to be valid as an indicator of measuring the
structure. [15] suggested that all items in the factor model must have a communality of more than
0.60 or a community average of 0.7 to justify the justification of factor analysis. Because indicator
values above 0.7 can be said to be ideal. However, if there is an indicator loading factor value below
0.7 and above 0.5 (range between 0.5 - 0.7), the indicator can still be used. By opening the main
menu on the toolbar calculate in the SmartPLS 3.3.2 program there is a PLS Algorithm option. This
step is often referred to as First Order Confirmatory Factor Analysis.

b. Reliability Test
Reliability test is done by looking at the composite reliability value of the indicator block that
measures the construct. The results of composite reliability will show a satisfactory value if above
0.7. A test of the adequacy of the data is needed to ensure that what has been collected and presented
in the weighing report is objectively sufficient. Test the adequacy of the survey data of the results of
respondents can be done using the KMO (Kaiser Meyer Olkin Measure) test obtained from the analysis using SPSS 22 application assistance in the Dimension Reduction - Factor. The data can be categorized as sufficient if the KMO value is above 0.5.

c. Evaluation of the Inner Model
Evaluation of structural models (inner model) is an evaluation of structural models to predict causality relationships between latent variables. Using a bootstrapping procedure that aims to predict the relationship between latent variables used in evaluating structural models by looking at the magnitude of the percentage of variance described to observe the value of R2, to construct latent endogenous, Stone - Geisser’s = Q2 to test predictive relevance and average variance extracted (AVE) for predictiveness by using resampling procedures. This procedure uses all original samples for resampling, which should be greater than the original sample. The minimum sample size in the number of bootstrap samples needed to reduce bias in all types of SEM estimates is 200 and is sufficient to correct the standard error estimate PLS [16]. Based on the complexity and characteristics of the model [17], the measurements are explained as follows: 1) If the model contains 5 or less constructs, where each construct is measured by more than 3 indicator items that have a large enough community (0.6 or more), then the required size is 100 to 150; 2) If there is moderate communality (0.45 - 0.55), or the model contains constructs measured by less than 3 indicator items, then the required sample size is more than 200; 3) If there is low communality or the model contains under identified constructs, then the required sample size is at least 300; and 4) If the model contains more than 6 constructs, of which are measured using less than 3 indicator items and have low communality, then the required sample size is at least 500.

From the results of the bootstrapping procedure on Smart PLS on outer loading, the relationship between the indicator and its latent variable is through the value of the T statistic. A statistical T value of more than 1.96 indicates a significant relationship between the indicator and its latent variable. The greatest statistical T value indicates the most dominant indicator in a variable.

3. Results and Discussion
Model Relationships SEM PLS by using software Smart PLS 3.3.2 is shown in Figure 2, and Table 1 shows the loading factor of each indicator for the variable.

![Figure 2 Model Relationships SEM PLS by using software Smart PLS 3.3.2](image-url)
Table 1 The loading factor of each indicator for the variable

|     | WBS  | Work Method | Risk | General cost of OSH | Specific cost of OSH |
|-----|------|-------------|------|---------------------|---------------------|
| X1.1| 0.766|             |      |                     |                     |
| X1.2| 0.786|             |      |                     |                     |
| X1.3| 0.769|             |      |                     |                     |
| X1.4| 0.780|             |      |                     |                     |
| X1.5| 0.799|             |      |                     |                     |
| X2.1|      | 0.852       |      |                     |                     |
| X2.2|      | 0.867       |      |                     |                     |
| X2.3|      | 0.843       |      |                     |                     |
| X3.1|      |             | 0.778|                     |                     |
| X3.2|      |             | 0.935|                     |                     |
| X3.3|      |             | 0.670|                     |                     |
| Y1.1|      |             |      | 0.814               |                     |
| Y1.2|      |             |      | 0.821               |                     |
| Y1.3|      |             |      | 0.882               |                     |
| Y1.4|      |             |      | 0.829               |                     |
| Y2.1|      |             |      |                     | 0.735               |
| Y2.2|      |             |      |                     | 0.783               |
| Y2.3|      |             |      |                     | 0.819               |
| Y2.4|      |             |      |                     | 0.799               |
| Y2.5|      |             |      |                     | 0.774               |
| Y2.6|      |             |      |                     | 0.656               |
| Y2.7|      |             |      |                     | 0.644               |

The loading factor value obtained in each indicator is more than 0.5 thus, it can be concluded that all indicators are valid because they meet the convergent validity value. Furthermore, the reflective indicators also need to be tested for discriminant validity by looking at the value of the square root of average variance extracted (AVE). The recommended value is above 0.5. Table 2 is the AVE value in this study:

Table 2 AVE values for each variable (Validity Test)

| Variables               | Average Variance Extracted (AVE) |
|-------------------------|----------------------------------|
| Work Breakdown Structure| 0.609                            |
| Work Method             | 0.730                            |
| Risk                    | 0.643                            |
| General cost of OSH     | 0.558                            |
| Specific cost OSH       | 0.700                            |
### Table 3 Value Composite Reliability (Reliability Test)

| Variables                        | Cronbach’s Alpha | Composite Reliability |
|----------------------------------|------------------|------------------------|
| Work Breakdown Structure         | 0.840            | 0.886                  |
| Work Method                      | 0.815            | 0.890                  |
| Risk                             | 0.709            | 0.841                  |
| General cost of OSH              | 0.867            | 0.898                  |
| Specific cost OSH                | 0.858            | 0.903                  |

### Table 4 Path Coefficient Bootstrapping Results (Correlation Between Variables)

| No | Correlation Between Variables | Original Sample(O) | T Statistics (|O/STDEV|) | Information |
|----|--------------------------------|---------------------|-------------------|-------------|
| 1  | Work Breakdown Structure Work Items → Work Methods | 0.048 | 7.004 | Significant |
| 2  | Work Breakdown Structure Work Items → Risks | 0.090 | 1.026 | Not Significant |
| 3  | Work Breakdown Structure Work Items → General Costs of OSH | 0.234 | 3.076 | Significant |
| 4  | Work Breakdown Structure Work Items → Specific Cost of OSH | 0.182 | 2.712 | Significant |
| 5  | Work Method → Risk | 0.268 | 3.761 | Significant |
| 6  | Work Method → General Cost of OSH | 0.301 | 3.502 | Significant |
| 7  | Work Method → Specific Cost of OSH | 0.192 | 2.589 | Significant |
| 8  | Risks → General Costs of OSH | 0.205 | 2.849 | Significant |
| 9  | Risks → Specific cost OSH | 0.260 | 3.720 | Significant |
In the path coefficient table 3 and 4, to see the significance of the influence between variables, it is necessary to look at the t-value (T-statistics), which is > 1.96. For example, Number 1, Work Breakdown Structure affecting Work Methods, has a value of 7.004 > 1.96, it can be said that Work Breakdown Structure has a significant correlation on Work Methods.

Work Breakdown Structure is reflected by 5 (five) indicators (Table 5), the work method (X2) is reflected by 3 (three) indicators (Table 6), and Table 7 shows X3 risk are reflected by 3 (three) indicators.

**Table 5. Indicators Variable X1 WBS**

| WBS Variable (X1) | Indicator      | T Statistics (| O / STDEV |) |
|-------------------|----------------|----------------|
| X1 WBS Work Package | X1.1 Work package | 17.643 |
|                   | X1.2 Job description | 20.094 |
|                   | X1.3 Person in charge | 18.573 |
|                   | X1.4 Reference document | 17.326 |
|                   | X1.5 Resource needed | 25.607 |

The dominant indicator among the five indicators above is the Resource needed with T Statistics = 25.607

**Table 6. Indicators Variable X2 Methods of Work**

| Work Method Variable (X2) | Indicator      | T Statistics (| O / STDEV |) |
|---------------------------|----------------|----------------|
| X2 Work Method            | X2.1 Scope of work | 26.421 |
|                           | X2.2 Job description | 31.998 |
|                           | X2.3 Stages of work | 27.314 |

The dominant indicator is Job Description with T Statistics = 31.998.

**Table 7. Variable Indicator X3 Risk**

| Risk Variable (X3) | Indicator    | T Statistics (| O / STDEV |) |
|--------------------|--------------|----------------|
| X3 Risk            | X3.1 Low risk | 10.660 |
|                    | X3.2 Medium risk | 29.508 |
|                    | X3.3 High risk  | 7.878 |

The dominant indicator is Medium risk with T Statistics = 29.508.

4. Conclusions

Based on the tables R 2 (R-Square results bootstrapping ) we have obtained value R Square of General cost of OSH 0.220 and Specific cost of OSH by 0.309. It means that the variability construct Cost of OSH can be described but not related directly in closely by the Work package, Job description, Person in charge, Reference document, Resource needed, Scope of work, Job description, Stages of work, low risk, medium risk and high risk with the value of the relationship of 22% on General of OSH and 30.9% for Specific cost of OSH. Based on the results of Smart PLS 3.3.2 with bootstrapping methods (Path Coefficient) discovering 9 the relationship between variables were observe to match the significance (T Statistics> 1.96) where 8 (eight) relationships between the variables were found significant and have mutual influence which the General cost of OSH is strong influenced by work method while Specific cost of OSH is strong influenced by the risk.
Acknowledgments
The author would like to thank the financial support provided by the University of Indonesia through PUTI Proceedings of the Fiscal Year 2020 with the contract number: NKB-1184 / UN2.RST / HKP.05.00 / 2020 managed by the Directorate of Research and Community Engagement (DRPM) University of Indonesia.

References

[1] PUPR. (2016). *Modul Pemanfaatan Rusunawa PUPR*.
[2] ISafety. (2018). ISafety Magazine. *BPJS TK*, Indonesia
[3] Ervianto, I. W. (2005). Manajemen Proyek Konstruksi Edisi Revisi, , Indonesia
[4] CII. (2012). Construction Industry Institute University of Texas, Houston. (n.d.). Quality in Construction. : https://www.construction-institute.org.
[5] Feng, Y. (2014). Exploring the interactive effects of safety investments, safety culture and project hazard on safety performance: An empirical analysis.
[6] PUPR. (2019). Pedoman Sistem Manajemen Keselamatan Konstruksi.
[7] Su, L. (2012). WBS-based Risk Identification for the Whole Process of Real Estate Project and Countermeasures.
[8] Ajizah, N. (2018). Perencanaan Sumber Daya Pada Pekerjaan Mekanikal Dan Elektrikal Bangunan Gedung Apartemen Berbasis Wbs(Work Breakdown Structure).
[9] Latief, Y. (2019). Pengembangan Kamus Work Breakdown Structure (WBS) Pada Pekerjaan Konstruksi Struktur Bawah Jembatan Baja. Pengembangan Kamus Work Breakdown Structure (WBS) Pada Pekerjaan Konstruksi Sturktur Bawah Jembatan Baja.
[10] PUPR. (2014). Pedoman Sistem Manajemen Keselamatan Dan Kesehatan Kerja.
[11] PUPR. (2019). Pedoman Sistem Manajemen Keselamatan Konstruksi.
[12] Basrowi, &. S. (2012). Memahami Penelitian Kualitatif. Jakarta: Rineka Cipta.
[13] Basrowi, &. S. (2012). Memahami Penelitian Kualitatif. Jakarta: Rineka Cipta.
[14] Sugiyono. (2007). *Metodologi Penelitian Bisnis*. PT. Gramedia, Indonesia.
[15] MacCAllum. (1999). Sample Size in Factor Analysis: The Role of Model Error.
[16] Loehlin, J. C. (1988). *Latent variable models: An introduction to factor, path, and structural analysis (3rd ed.).*
[17] Hair, J. F. (2011). *PLS-SEM: Indeed a silver bullet.*