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Structural Equation Model for Analyzing the Factors Affecting Construction Safety Cost of Vertical Residential Buildings in Indonesia

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Abstract

The construction safety management system (CSMS) in a project is always taken into account, however, its implementation does not always run optimally. This is because there are many aspects related to safety costs that may not have been considered. Companies prefer to implement policies on safety which are more economical in order to both earn the maximum profit and reduce the necessary costs. Therefore, the objective of this study is to analyse the factors affecting the construction safety costs of high-rise residential buildings in Indonesia. It was conducted through a quantitative approach, using survey questionnaires and SEM analysis. The results showed that 9 factors affect the construction safety costs, and 11 hypothetical and 9 proven relationships were confirmed from them.

Keywords: Construction, safety costs, vertical residential building

I. INTRODUCTION

The Indonesian government planned to reduce the housing backlog from 7.6 to 5.4 million, between 2015 and 2019, by constructing high-rise residential buildings such as Rusunawa. Furthermore, to meet this target, 518,489 flat-bed units were built in 2018 [1]. However, the development program did not run optimally. Between late 2017 and early 2018, successive construction accidents occurred on national scale infrastructural projects. An example was the accident that occurred on the 18th of March, 2018, during the construction of Rusunawa, where, a 4 meters long iron pipe fell and killed a woman [2]. It was recorded that before August 2020, 88 major accidents had occurred in the construction sector, and about 30% of them were in building projects.

All requirements for the construction of Rusunawa including: labour, materials, equipment, and the construction environment need to meet safety, health and sustainability standards, which together is known as construction safety [3] [4]. According to John Ridley [5], working at high altitude increases the risks of accidents. Therefore, a lot of control is needed, which affects the cost of projects.

Safety management is usually taken into account during the planning stage of construction. However, its implementation in the field does not always run optimally. This is because the cost required for its implementation is rarely analyzed comprensively [6].

The number of accidents in the construction sector prompted the Ministry of Public Works and Public Housing (PWH) through the Directorate General of Construction to make amends to the technical regulations related to the implementation of construction safety. One of them was by issuing a circular which stated that construction safety costs should be a separate budget item in the general cost, and should amount to 1% -2.5% of the project value. However, this policy only lasted a few months, because it was replaced by a new regulation concerning the guidelines for implementing construction safety management system (CSMS). This regulation encourages contractors to implement construction safety by adding its costs to the bill given to the work owner. Therefore, there is no longer any excuse for it to be absent from the project's budget. However, since the promulgation of this regulation in December 2019, until September 2020, 37 major construction accidents occurred. This is because the regulation does not provide clear guidelines regarding the procedure for calculating construction safety costs [7].

II. THEORITICAL STUDY

Building height

The Rusunawa building construction in Indonesia was initiated by the PWH Ministry in various areas of the country to overcome the lack of housing in big cities [1]. It constituted of flats which have a number of floors varying from 2 to 8, therefore they were included in the low and medium-rise building category.

Based on height, the multi-story building category is divided into 3, namely the high-rise buildings with more than 8 floors, medium-rise buildings with 5 to 8 floors, and low-rise buildings with fewer than 5 floors [8].

Work Breakdown Structure (WBS)

The implementation of construction work started with the determination of the work scope, and this is carried out through 6 processes. They include, defining the scope, planning how it will be managed, collection of requirements, creating the Work Breakdown Structure (WBS), validation, and control [9]. After this has been carried out, It becomes easy for hazards to be identified in construction activities, through the WBS output. As stated by Sacks, the determination of occupational safety and health hazards in a construction work needs to be carried out in every activity that exists in that job [10].

WBS is a hierarchical description of the entire scope of a construction work, which is compiled by the implementation team, in order to complete the work's objectives [11]. It is prepared by using work scope and other documents. Therefore, different scopes will result in different WBS [10].

Constructing a WBS involves describing the deliverables and project work hierarchically, and in the form of a top-down list explaining the components that need to be built, including the work related to them. Moreover, every instance of its tier represents an increasingly detailed project definition.

WBS is a project system which is divided into manageable work packages, components, or WBS elements and aims to provide a general framework for scheduling scope, costs, responsibilities allocation, communication, risk assessment, supervision, and control [9]. Moreover, the risks that exists each of these activities will determine the control measures that will be put in place, in order to prevent or reduce it [3].

Working method

Basically, the construction implementation method involves the application of the engineering concept, based on the linkage between the requirements in the tender/procurement documents, the technical and economic conditions in the field, and all resources including the contractor's experience [12]. Working method is closely related to WBS, and choosing the right one, according to the project location, will greatly affect construction safety [13]. Furthermore, referring to the PWH Ministry Regulation Number, 21/PRT/M/2019 [14], it is a series of construction implementation activities that follow procedures, and have been designed in accordance with the knowledge or standards that have been tested.

In a construction work which uses labour-intensive methods or a lot of labour, however few machine tools, the safety needs of its personnel are determined by the construction safety risk assessment. Furthermore, the components of the method used in this type of work are broken down into three aspects, namely; work scope and stages, and job descriptions [3]. In building architectural work, the methods uses are usually related to planned design choices or alternatives. Moreover, in construction activities, the function of various methods is explained by a working drawing presence/shop drawing and manual work. According to Roswidiyastuti [15], the estimated cost along with quality costs and the costs themselves needs to be based on an implementation work method that is in accordance with the stages in the WBS plan.

Location

Identifying hazards in construction work is not easy because in the manufacturing industry for example, it is assumed that people are exposure to hazards only where accidents are common. Nonetheless, this is not always true because construction work takes place in different locations, as it moves according to the project location. According to Sacks, hazards determination in construction work is carried for each activity, and the place where a worker performs the activities [10].

The Rusunawa development location is spread across 34 provinces in Indonesia. Furthermore, considering that the geographically, this country is an archipelago, consisting of 17,504 islands, with an area of 1,910,931 km2 (Wikipedia, 2020), these development locations have different characteristics, and causes different occupational risks. According to Allan's construction safety principles, there are 2 conditions in every construction work location. The first is the conditions around the project site, such as land use, soil stability and contamination, traffic systems and limitations, environmental disturbances such as vandalism or thuggery, ambient noise disturbances, and other disturbing factors. While the second is the conditions within the project site, such as status and location of land for supporting activities, traffic conditions and limitations, land investigations results, obstructions under the ground, land contamination, and groundwater conditions [16]. Similarly, Ronald [17] stated that narrow locations are one of the factors that leads to accidents in building construction.

In addition to the different risks in each location, Indonesia's territory characters also make a difference in construction costs. Moreover, according to BPS, the construction cost index issued every year [18] also determines the total cost of resources used, especially for the worker's wages, materials, and equipment. The number of Rusunawa scattered throughout this country has a different construction cost index in each region.

Risk

The construction sector is one of the sectors with a high-level danger [19, 20]. This is because workers herein are not only exposed to hazardous conditions at their worksite, however, they also face health risks during the construction process. The occupational illnesses affecting these workers have not been accurately measured, however, an educated guess is that they suffer both acute/short-term and chronic/long-term illnesses from their exposure to chemicals, dust, fibbers, noise, radiation, vibration, and extreme temperatures [21]. In addition to health-related hazards, different location conditions according to Allan will affect the work scope, therefore, risks and their various control methods should be contained in the safety plan [16].

According to John Ridley [5] the dangerous conditions experienced during the construction of high-rise buildings increases the risk of accidents. For instance, the fall rate in America at 32% [14]. According to Dong, the highest death rate during construction in the UK occurs due to falls from heights, and it amounted to 44% from 1999 to 2007 [14]. This is similar to the percentage recorded in Hong Kong, which is more 47% [22]. Fall also accounts for about 51% of the accidents in the construction industry [23], and this claim is supported by the analysis conducted by Im [24] in Korea, which showed that of the 10,276 victims of work accidents, it was responsible for 53%. Moreover, according to Ardan dalam Rosmariani, fall is still the highest cause of building related accidents in Indonesia [25].

Risk Level according to the PWH Regulation is divided into 3, namely, Small, Medium, and Large. Furthermore, it is obtained from the risk assessment results, which is calculated from frequency and severity. Finally, when it is high, it means accidents often occurs, and can cause death/permanent disability to humans, fatal damage to equipment, materials, or the environment [3].

Control system

According to Roswidiyastuti [15], risk identification is carried out during the work stages of the WBS, to determine the priorities for reducing accidents, and occupational diseases. Furthermore, it uses data which are based on a detailed and systematic Job Safety Analysis (JSA). Hazard identification is generally carried out with the help of the WBS and the working method by considering the following:

1. Potential sources of hazards are identified by taking into account:
    a. Conditions or events that could create a hazard
    b. Types of accidents and occupational diseases that may occur
2. Risk assessment is carried out after identification of the potential sources of danger and it is based on:
    a. The frequency of incidents/accidents at work.
    b. The severity/consequence that occurs due to the incident/accident.

Hazard control is arranged hierarchical by identifying the risk level of each hazard. Meanwhile, the control needs to be determined according to the control hierarchy in ISO 45001, namely: (1) hazard elimination, this involves, substituting less dangerous processes, operations, materials or equipment in the place of more dangerous ones (2) use engineering controls and work rearrangements, (3) administrative control, including training, and (4) using adequate personal protective equipment [26]. Hazard control in a construction project is contained in a safety plan document. Meanwhile, this document is prepared at the tender time, namely in the bid document, and is updated during the preparation for the work implementation by the winning bidder [27].

Program

The CSMS includes the processes required to ensure that construction projects are carried out with great care. Therefore, they are protected from accidents that may result in injury or death, which then results in loss of resources and directly or indirectly affect project costs [3].

In CSMS, control is carried out by implementing a construction safety program, and in Ministry Regulation [3], this program consists of 9 (nine) components, namely: 1) preparation of a construction safety plan, 2) outreach, promotion, and training, 3) work and personal protective equipment, 4) insurance and licensing, 5) construction safety personnel, 6) medical facilities, infrastructure, and equipment, 7) necessary signs, 8) consultation with construction safety experts, and 9) activities and equipment related to construction safety risk control. Meanwhile, by calculating the need for this program to be implemented in a project, including the provision number of personal protective equipment (PPE), work protective equipment (WPE), Fire Extinguisher, and others according to the safety objectives and program, the total safety cost can be estimated [6].

General and specific cost

In the regulation of the Minister of PWH, Number 28 of 2016, construction safety costs are divided into 3 (three). The first is the general costs in the form of PPE [28], the second is the special costs, such those for special construction safety needs, for example, diving and acidic equipment, and the third includes those that need to be accommodated in the mobilization of equipment (preparatory work). Provisions for special construction safety items in the copyright sector include mobilization of safety personnel, WPE, signs, health facilities, labor insurance, and licensing.

Javier stated in a research that there are 4 (four) construction safety components in regards to general items, and they include, personal and general protective equipment, sign, and others. Meanwhile, there are 8 occupational health and safety components in regards to specific items and they include, preparation, socialization and promotion, insurance and licensing, safety personnel, health facility, sign, consultation with experts related to construction safety, and others. Finally, there are 2 components which are part of both the General and Specific items, and this is significant.

Hypotheses

Some of the literature reviews above are the basis for the development of this research's framework, which is in a hypothesis form that there are several factors that affect the amount of construction safety costs. These factors include building height, location, WBS, work methods, risks, control systems, and safety programs. Meanwhile, this cost is divided into two groups, namely the general and specific cost [28, 29]. In order to explore the influences of these seven key latent factors on construction delay, eleven hypotheses were drawn as follows:

Hypothesis 1: the location of the construction project (X1) affects the Work breakdown Structure (X3)

Hypothesis 2: building height (X2) affects the work breakdown structure (X3)

Hypothesis 3: work breakdown structure (X3) influence working method (X4)

Hypothesis 4: work breakdown structure (X3) influences risk (X5)

Hypothesis 5: work breakdown structure (X3) influences control system (X6)

Hypothesis 6: working method (X4) influencing risk (X5)

Hypothesis 7: risk (X5) influences control system (X6)

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Hypothesis 8: working method (X4) influences program (X7)

Hypothesis 9: risk (X5) influences program (X7)

Hypothesis 10: control system (X6) influences program (X7)

Hypothesis 11: general cost influences program (X7) (Y1)

Hypothesis 12: program (X7) influences special costs (Y2)

A hypothetical diagram of the structural model is presented in Figure 1, and the arrow therein represents the description of hypothesized influences in the structural model.

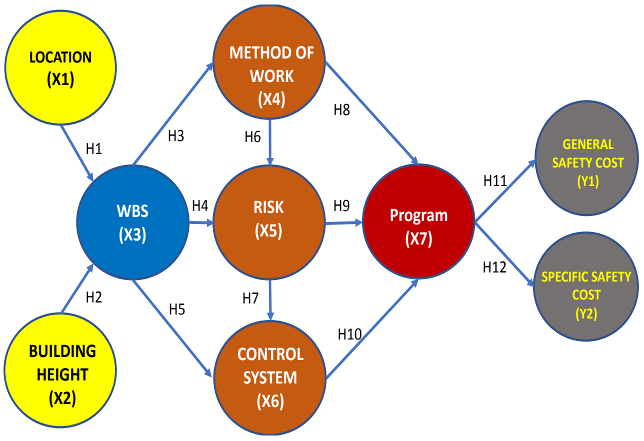

Fig. 1. Hypothetical Diagram

III. METHODOLOGY

The hypothesis in this study was tested using the Partial Least Square (PLS) method. Meanwhile, PLS is an alternative analysis method with variance-based Structural Equation Modeling (SEM). Technically, SEM is divided into 2/two groups, namely covariance and component based/variance SEM using the SmartPLS software. Moreover, the covariance type is represented by LISREL. The main difference between Covariance and Component Based SEM with PLS (which will then be referred to as Variance based with PLS) is that in the Covariance type the analyzed model needs to be developed based on strong theory, and it aims to confirm the model using empirical data. While the Variance based with PLS focuses more on predictive models, therefore, a strong theoretical support is not really important. The covariance Based SEM is more aimed at providing a statement about the causality relationship or providing description of this relationships' mechanism (cause-effect). Meanwhile, the Component-Based type with PLS aims to find predictive linear relationships between variables. The smart method PLS uses variance-based SEM, and the PLS design is intended to overcome the analysis limitations.

OLS (Ordinary Least Square) regression technique is used when the characteristics of the data is as follows, (1) small data size, (2) there is a missing value, (3) data is distributed abnormally, and (4) when multicollinearity symptoms are present. However, this regression usually produces unstable data when the amount of data collected/samples is small, or there are missing values or multicollinearity between predictors because these conditions increase the standard error of the measured coefficients [30].

Table 1. Variable and Construct

Laten	Construct
X1. Location	X1.1 High Density
	X1.2 Medium Density
	X1.3 Low Density
	X1.4 Wide Area
	X1.5 Narrow Area
	X1.6 Land Stability
	X1.7 Contaminating
	X1.8 Traffic system
	X1.9 Premanism and vandalism
	X1.10 Sound Disturbance
X2. Building Heights	X2.1 Low (1-4 level)
	X2.2 Medium (5-8 level)
	X2.3 High (>8 level)
X3. Work Breakdown Structure	X3.1 Work Package
	X3.2 Work Package Description
	X3.3 Person in Charge
	X3.4 Reference documents
	X3.5 Resources
X4. Methods of work	X4.1 Scope of Work
	X4.2 Job description
	X4.3 Stages of Work
X5. Risk	X5.1 Low Risk
	X5.2 Medium Risk
	X5.3 High risk
X6. Control system	X6.1 Elimination
	X6.2 Substitution
	X6.3 Engineering Control
	X6.4 Administrative Control
	X6.5 Personal Protective Equipment
X7. Program	X 7.1 Preparation of Safety Plan
	X7.2 Socialization and Promotion
	X7.3 Personal Preotective Equipment and Protective Equipment
	X7.4 Insurance and Licensing
	X7.5 Safety Personel
	X7.6 Health Facility
	X7.7 Signage
	X7.8 Consultation with Expert
	X7.9 Other Task and equipment related to construction safety
Y1. General Cost	Y1.1 PPE
	Y1.2 Protective Equipment
	Y1.3 Signage
	Y1.4 Other Task and equipment related to construction safety
Y2. Specific Cost	Y2.1 Preparation of safety plan
	Y2.2 Socialization and promotion
	Y2.3 Safety Personel
	Y2.4 Health Facility
	Y2.5 Signage
	Y2.6 Consultation with expert
	Y2.7 Identity card

Several steps/stages need to be followed when conducting the PLS analysis, and they include:

1. Designing the Measurement Model/Outer Model: The initial stage is the designing of the Outer Model, which specifies the relationship between latency and the indicator.
2. Designing the Structural Model/Inner Model: The entails the designing of the inner model, which specifies the relationship between one latent and another.
3. Estimation of Path Coefficient and Loading Factor: This involves calculating the path coefficient to identify the relationship between latent and loading factors, and latent and their indicators.
4. Evaluate the goodness of fit: There are several tests for goodness of fits such as Convergent Validity and Composite Reliability.
5. Hypothesis testing: This is carried out using the resampling bootstrapping technique, which will re-sample the existing data until the criteria are met.

Questionnaire preparation

A quantitative approach was adopted to test the conceptual model in regards to the construction safety cost in Indonesia. Furthermore, data on the attributes measured were obtained through a survey, using a questionnaire. Respondents were asked to rate the perceived influence of the attributes measured in the form of an affirmative question by selecting one of the projects they participated in. Meanwhile, a five-point Likert scale where 1 = strongly agree, 2 = agree, 3 = disagree/disagree, 4 = disagree and 5 = strongly agree was adopted to guide the respondents to provide their objective responses with varying degrees of agreement or disagreement.

The identification of variables and constructs measured for the study and the questionnaire preparation were important steps in this study. Furthermore, a great amount of work was undertaken to identify the factors affecting the magnitude of construction safety cost. These factors were then reviewed and validated by experts. A questionnaire was compiled by including the key variables that affect construction safety cost Furthermore, to further strengthen the variables from the literature review results, the help of five experts from the construction industry in Indonesia were implored. A pilot survey was conducted before the respondent's survey started, with the aim of improving the survey questions. Therefore, each respondent had the same understanding of the questions posed in the questionnaire.

Respondents Selection

The Respondents were selected from a variety of professionals including contractors, clients, and engineers that were engaged in the construction sector in Indonesia. They all had experience in relatively large construction projects in India, and were selected based on their active involvement in those projects, especially in regards to multi-story buildings. Finally, the respondents were mostly workers in contracting companies and consultants that had participated in the construction of multi-story buildings. Furthermore, others were job owners (Table 2).

Table 2. Respondent

Type	Experience (years)	Respondent
Consultant		**11**
	< 5	5
	> 10	1
	5-10	5
Contractor		**177**
	< 5	64
	> 10	43
	5-10	70
Owner		**35**
	`	8
	> 10	8
	5-10	19
Total		**223**

Below are the various stages that were followed in this study:

1. The first stage was theoretical and was based on construction safety cost. It required a good knowledge of various elements from the litrratures of previous studies that discussed the topic of construction safety costs. Furthermore, it asked for opinions from experts to validate its theoretical studies results, which were used at a later stage. Meanwhile, those results showed that several constructs were omitted. This is because the assessment experts had no effect on construction safety costs.
2. The next stage was the collection of primary data, and was carried out using questionnaires.
3. After the primary data was collected the existing data was processed through a software, using the structural equation modeling (SEM) statistical technique. Meanwhile, this technique has the advantage of estimating the relationship between several related variables, and also describe the relationship pattern between latent constructs and variable indicators.
4. In this stage, experts validated the analysis results to get accurate results. Moreover, these results were the basis for the preparation of the questionnaires, to determine the single-case data.

III.I Dataset

Primary and secondary data were obtained through the following there stages:

1) Validation of variables and constructs obtained from literature reviews by experts. The expert herein is a person that have been involved in construction projects, with at least 15 years of experience. 5 experts consisting of 3 project managers and 2 construction safety auditors were used in this stage. Herein, several variables were removed because they were deemed not to affect construction safety costs, while those that affected it were left, and are shown in Table 2.
2) Surveying the respondents. Prior to the survey, a pilot survey was conducted on the questionnaire that had been compiled based on the variables and constructs that had been formed during the expert validation stage. This pilot survey was conducted on 10 target respondents, and the results were used to improve its questions, therefore, making it easier for respondents to understand.
3) After the pilot survey, an online survey was conducted using the google form, during the Covid-19 pandemic, therefore, face-to-face conditions were not possible, and forms were used. 500 forms were distributed, however, only 223 were obtained. Furthermore, SEM analysis was carried out on the results. Table 2 provides descriptive statistics of the respondents' profiles in terms of their professional roles and experiences in the construction industry. With the aim of finding the best response to this study, a questionnaire (in the google form) which had an introductory sentence that explained the objectives of the study was given online, through WhatsApp and email. 500 people received the questioners, however, only 237 were selected as respondents. Meanwhile, of the 237 respondents, some gave inappropriate and incomplete answers, therefore, only data from 223 of them were considered valid. This amount was sufficient for analysis using smart PLS, since the variance-based SEM method is able to analyze even small amounts of data.

III.II.I Pre-processing

After data was obtained from the respondents, several tests were conducted, including:

1) Outer model analysis

This analysis was carried out to ensure that the measurement used were valid and reliable. Furthermore, it was carried out using the following tests:

- Validity test

When looking for the convergent value, validity is the factor loading value on the latent variable, including its indicators. The expected value should be > 0.7 and Table 2 shows that there were all indicator met the expected value.

Table 3. Confergent Validity

Laten	Indicator	Outer Loading	Interpretation
X1	X1.1	0,862	Valid
	X1.2	0,809	Valid
	X1.3	0,758	Valid
	X1.4	0,791	Valid
	X1.5	0,855	Valid
	X1.6	0,833	Valid
	X1.7	0,799	Valid
	X1.8	0,837	Valid
	X1.9	0,716	Valid
	X1.10	0,775	Valid
X2	X2.1	0,827	Valid
	X2.2	0,915	Valid
	X2.3	0,873	Valid
X3	X3.1	0,854	Valid
	X3.2	0,878	Valid
	X3.3	0,843	Valid
	X3.4	0,858	Valid
	X3.5	0,865	
X4	X4.1	0,929	Valid
	X4.2	0,913	Valid
	X4.3	0,939	Valid
X5	X5.1	0,694	Valid
	X5.2	0,795	Valid
	X5.3	0,888	Valid
X6	X6.1	0,867	Valid
	X6.2	0,899	Valid
	X6.3	0,900	Valid
	X6.4	0,874	Valid
	X6.5	0,886	Valid
X7	X 7.1	0,812	Valid
	X7.2	0,824	Valid
	X7.3	0,885	Valid
	X7.4	0,798	Valid
	X7.5	0,883	Valid
	X7.6	0,886	Valid
	X7.7	0,864	Valid
	X7.8	0,796	Valid
	X7.9	0,884	Valid
Y1	Y1.1	0,906	Valid
	Y1.2	0,910	Valid
	Y1.3	0,898	Valid
	Y1.4	0,885	Valid
Y2	Y2.1	0,792	Valid
	Y2.2	0,846	Valid
	Y2.3	0,873	Valid
	Y2.4	0,863	Valid
	Y2.5	0,827	Valid
	Y2.6	0,756	Valid
	Y2.7	0,772	Valid

Table 4. Reliability Test

Variable	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)	R2
X1	0,939	0,942	0,948	0,647	
X2	0,842	0,847	0,905	0,761	
X3	0,912	0,913	0,934	0,739	0,680
X4	0,918	0,919	0,948	0,860	0,455
X5	0,717	0,788	0,837	0,634	0,341
X6	0,931	0,931	0,948	0,783	0,570
X7	0,951	0,954	0,959	0,721	0,705
Y1	0,922	0,923	0,944	0,810	0,421
Y2	0,918	0,922	0,935	0,672	0,419

Validity test was conducted on the reflective indicators using the correlation between the item and the construct scores. Moreover, measurements with these indicators indicated a change in an indicator and a construct. Reflective indicators are suitable for measuring perception, therefore, they were used.

The table above shows that the loading factor gave a value above the recommended value of 0.7, Thus they explained the latent variables satisfactorily.

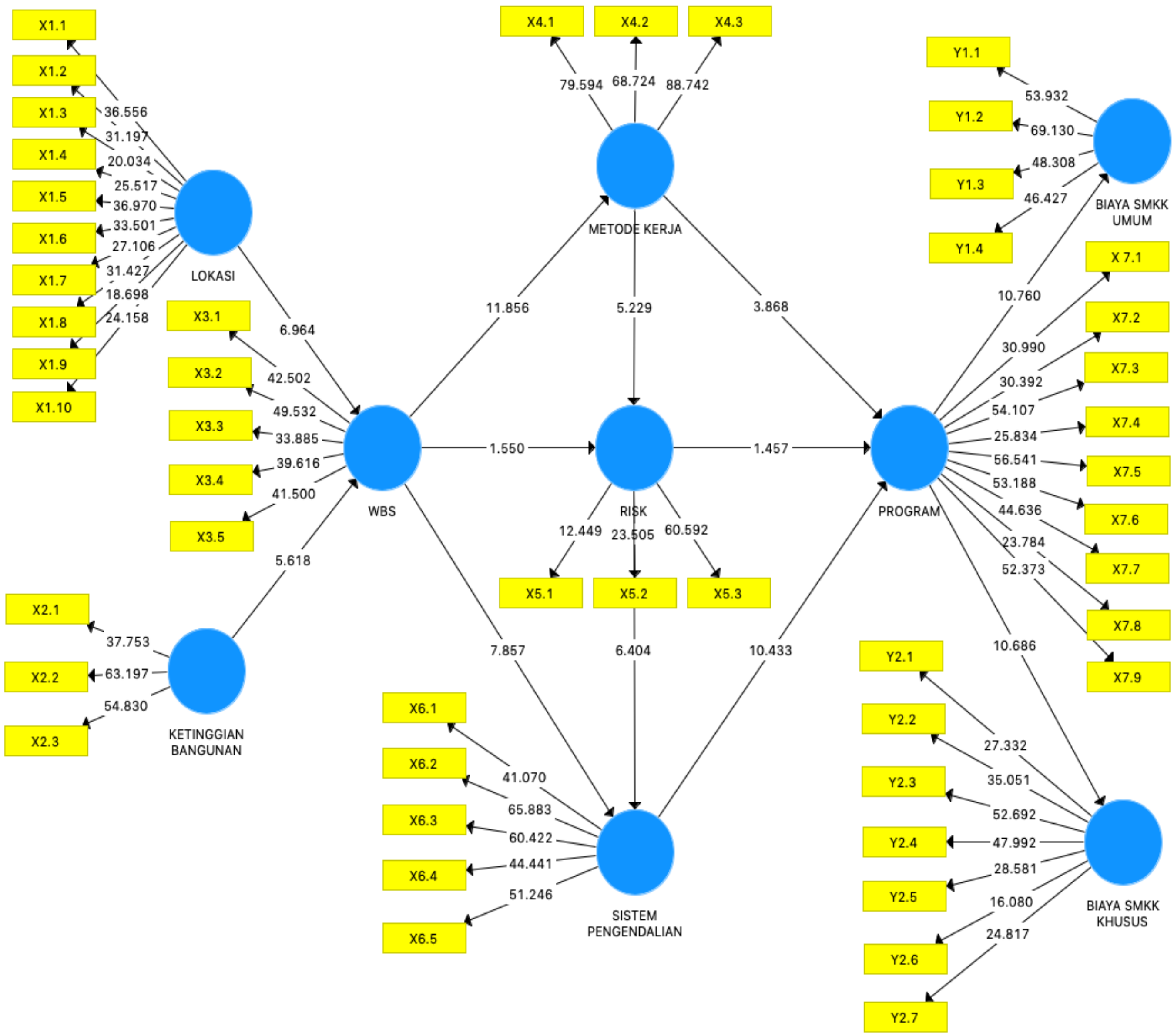

Figure 2. T Statistics Value

- Reliability test

A variable has sufficient reliability when it has a composite reliability and an AVE value greater than 0.7 and 0.5 respectively. The following are the results of the reliability test for each latent variable, using the SmartPLS software.

- Composite Reliability: Data that had composite reliability > 0.7 had high reliability.
- Average Variance Extracted (AVE). Expected AVE value > 0.5.
- Cronbach Alpha. The reliability test was strengthened by Cronbach Alpha. Expected value > 0.6 for all constructs.

The table shows that composite reliability value for all construct, was above 0.7, indicating that they all met the criteria for discriminant validity. Moreover, the lowest value was 0.837. The reliability test was also strengthened by Cronbach's Alpha. It was concluded that the indicators used, which were the variables, had sufficient reliability (above 0.6) (Hussein, 2015) or were able to measure the construct. The AVE value on all variables met the criteria, as they were all more than 0.5.

2) Hypotheses analysis

After the estimated model meet the Outer Model criteria, the next step was to test the structural model/Inner model. In table 4, the composite reliability values for all constructs were above 0.7, which indicated that all the constructs in the estimated model met the discriminant validity criteria. Moreover, the lowest value was 0.837, and was in the X5 variable.

The reliability test was also strengthened by Cronbach's Alpha. It is concluded that the indicators used, which were the variables had sufficient reliability or were good enough (above 0.6) or were able to measure the construct.

The AVE value on all variables meet the criteria, which is more than 0.6 so, all of them was used for further testing.

Table 5. Hypothesis Test Results

Hypotheses	Variable	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	interpretation
H1	X1==>X3	0,490	0,497	0,070	6,964	0,000	confirmed
H2	X2 ==> X3	0,377	0,372	0,067	5,618	0,000	confirmed
H3	X3 ==> X4	0,674	0,675	0,057	11,856	0,000	confirmed
H4	X3 ==> X5	0,144	0,146	0,093	*1,550*	*0,122*	not confirmed
H5	X3 ==> X6	0,505	0,505	0,064	7,857	0,000	confirmed
H6	X4==>X5	0,477	0,480	0,091	5,229	0,000	confirmed
H7	X5 ==> X6	0,374	0,375	0,058	6,404	0,000	confirmed
H8	X4 ==>X7	0,201	0,201	0,052	3,868	0,000	confirmed
H9	X5 ==> X7	0,079	0,078	0,054	*1,457*	*0,146*	not confirmed
H10	X6 ==> X7	0,638	0,638	0,061	10,433	0,000	confirmed
H11	X7 ==> Y1	0,649	0,650	0,060	10,760	0,000	confirmed
H12	X7 ==> Y2	0,648	0,651	0,061	10,686	0,000	confirmed

In PLS, each relationship testing is carried out using a bootstrapping simulation of the sample. Moreover, they aim to minimize the problem of research data abnormalities. The test results obtained after using the bootstrapping method obtained an inner model diagram (Figure 2), which showed the relationship between the variables.

IV. RESULT

The overall analysis are shown in Table 5. Results show that there was a relationship between the location and WBS, with a T-statistic of 6,964 (> 1,96). Meanwhile, the original sample estimate value was 0,490, which is positive, and indicated that the relationship directly between the location and the WBS was positive. Therefore, hypothesis H1 in this study which stated that location affects WBS was proven.

In addition, the relationship between building height and WBS in the table was significant, with a T-statistic of 5,618 (> 1.96). The original sample estimate value of hypothesis 2 was 0.377, which is positive. It indicated that the relationship directly between the height of the building and the WBS was positive. Therefore, the H2 hypothesis in this study which stated that building height affects WBS was proven.

The evidence results showed that there was a relationship between WBS and work methods, with a T-statistic of 11.856(> 1.96). Meanwhile, the original sample estimate value was 0.674, which is positive, and indicates that the relationship direction between WBS and the work was positive. Therefore, the hypothesis H3 which stated that WBS affects work methods was proven.

For Hypothesis 4, it can be seen from the table that there was no relationship between WBS and risk, with a T-statistic of 1.550 (<1.96). Meanwhile, the original sample estimate value was 0.144, which is positive, and indicates that the relationship direction between WBS and risk was positive. Thus, hypothesis H4, which stated that WBS affects risk was not proven.

For hypothesis 5, it can be seen in the table that the relationship between work methods and risk was significant with a T-statistic of 7.857 (> 1.96). Meanwhile, the original sample estimate value was 0.505, which is positive, and indicated that the relationship between work methods and risk was positive. Therefore the hypothesis H5 which stated that work breakdown structure affects control system was proven.

For hypothesis 6, it can be seen in the table that the relationship between work methods and risk was significant with a T-statistic of 5.229 (> 1.96). Meanwhile, the original sample estimate value was 0.477, which is positive, and indicated that the relationship between work methods and risk was positive. Therefore the hypothesis H6 which stated that work methods affects risk was proven.

Likewise, hypothesis 7, in the table above, showed that there was a relationship between risk and the control system, with a T-statistic of 6.404 (> 1.96). The original sample estimate value was 0.374, which is positive, and indicates that the relationship direction between risk and the control system was positive. Thus this hypothesis, which states that risk affects the control system was proven.

A similar result was obtained when proving hypothesis 8, which showed that the relationship between work methods and programs was significant, with a T-statistic of 3.868 (> 1.96). The original sample estimate value was 0.201, which is positive, and indicates that the relationship directly between the work method and the program was positive. Therefore, this hypothesis which stated that work methods affect the program was proven.

In proving hypothesis 9, the results showed that there was no relationship between risk and the program, with a T-statistic of 1.457 (<1.96). The original sample estimate value was 0.079, which is positive, and indicates that the relationship directly between the location and the WBS was positive. Thus the hypothesis H9 which stated that risk affects the program was not proven.

In proving hypothesis 10, the results showed that the relationship between the control system and the program was significant, with a T-statistic of 10.433 (> 1.96). The original sample estimate value was 0.638, which is positive, and indicates that the relationship direction p between the control system and the program was positive. Therefore the hypothesis H10, stated that the control system affects the program was proven.

From the next hypothesis, it can be seen that there was a relationship between the program and general costs, with a T-statistic of 10.760 (> 1.96). Moreover, the original sample estimate value was 0.649, which was positive, and indicates that the relationship directly between the program and general costs was positive. Therefore, the hypothesis H11, which stated that the program affects general costs was proven. Likewise in hypothesis 12, the results showed that there was a relationship between the program and special costs, with T-statistic of 10.686 (> 1.96). Meanwhile, the original sample estimate value was 0.648, which is positive, and indicates that the relationship directly between the program and special costs was positive. Thus, the hypothesis H12, which stated that the program affects special costs was proven.

V. DISCUSSION

The SMartPLS 3.0 analysis were interpreted, from 12 hypotheses, of which 10 were proven to have a direct relationship with variables, while 2 were not proven to have a direct relationship with variables. Furthermore, the location of the construction area of the tall building was shown to affect WBS. This result is similar to that obtained by Mahampang [31], which showed that WBS is planned according to the complexity of the conditions at the construction location. Allan stated that the soil stability conditions, land investigations results, and any obstacles on the ground in each location need to be identified [16]. Therefore, the work scope contained in the WBS should adjust to these conditions. Likewise, for buildings taller than 5 floors, an elevator needs to be provided, which will affect the building construction work scope as stated in the WBS [8]. The results also show that WBS had a direct effect on the choice of work method. Therefore, hypothesis 3 was proven to be true.

Hadwiansyah stated in a research that the WBS is based on several factors including, the flat-bed work package, the description of the job, the persons in charge of the work, and the reference documents [6]. Meanwhile, this is in accordance with Ministry regulation that the work methods need to contain the work scope, job description, and work stages [3].

The results indicate that the scope of WBS does not affect risk. Meanwhile, risk level is influenced by the nature of the work,, budget ceiling, the number of workers, equipment type, work methods, and high technology [3]. Although the nature of a work is seen from the work scope, this study proves that it does not directly affect job risk.

The working method in construction work, especially in the construction of flats consists of mechanical and conventional parts, and is proven to have a direct effect on the risk level. Meanwhile, risks of hazard in construction work are assessed by calculating the impact frequency and severity [3], for which controls are determined. Risk greatly affects the control system, and this was also stated by Apriadi in a research. The control level in the control system will be selected based on the type or risk level to be faced [7].

In addition to affecting the risk level in a job, the work method was proven to also affect the safety program. Likewise, the control systems were also been shown to have a direct influence on safety programs. Hazard control in a construction project is contained in a safety plan document, in the form of a safety program. Meanwhile, this program consists of 9/nine components [3], and is divided into 2/two major groups in regards to in construction safety costs, namely general and specific costs.

VI. CONCLUSION

The aim of this study is to analyze the factors affecting the construction safety costs of the rusunawa vertical residential building project by the PWH Ministry, and the results showed that there are 9 factors directly affecting construction safety costs.

From the results of the analysis of factors affecting the cost of construction safety of vertical residential building in Indonesia, the following recommendations are obtained:

1. For the Government: The policy for calculating construction safety costs, especially in the vertical residential development project, needs to take into account the factors of location, building height, WBS, work methods, risks, control systems, programs, general costs and special costs.
2. For Universities, construction safety associations and training agency: there are several variables that have a strong and strong influence in determining the amount of SMKK costs for the construction of a flat, these can be used as input for the preparation of teaching materials for both training and lectures.
3. For contractors: Calculation of the amount of construction costs in the vertical residential development project must take into account the factors that influence it.

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