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Risk Management Rework and Repair Implementation Phase in Building Project to Improve Project Quality Performances

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***Abstract*—** *The infrastructure development project is one of the facilities and infrastructures to support the economic sector. For that function and quality of the building must be in accordance with existing specifications. However in reality, at the time of construction, many found the quality of work results that are not in accordance with what is required. Often found differences between planning and implementation in the field result in the work of Rework and Repair. Rework and Repair works is some work that is hard to expect and avoid. The work is closely related to the cost and quality of the project or the performance and productivity of the contractor. Based on the results of the foreman's SPK, it was found that the concrete work items were the largest cost of Rework and Repair of all existing Rework and Repair costs. The contribution of the cost of Rework and Repair to the work of concrete work items in the three projects reached 40-70% of the total cost of the whole. In addition, based on the SEM-PLS calculation method, it was found that the quality management system and Rework and Repair work contributed 61.4% of the project's quality performance. For the biggest effect of quality performance comes from the work of Rework and Repair of 0.738, which means that the work of Rework and Repair has a positive influence on quality performance so as to make the quality better.*

***Keywords*—** *Project Performances, Risk BreakDown Structure, SEM-PLS.*

I. INTRODUCTION

The infrastructure development project is also one of the facilities and infrastructures to support the economic sector. For that function and quality of the building must be in accordance with existing specifications. This is related to quality, cost and time as a reference in construction activities. However in reality, at the time of construction, many found the quality of work results that are not in accordance with what is required. This causes a mismatch between planning and consequences in the area that can be caused by different factors, along with the application of irrelevant implementation methods and insignificantly problem solving. Often found the difference between planning and implementation in the field resulted in the work of rework and repair.

Rework and repair works is a work that is hard to expect and avoid. The work is closely related to the cost and quality of the project or the performance and productivity of the contractor. In this case the application of ISO 9001: 2015 where quality management aims to achieve project quality requirements at the first job without repetition (to do right things right the first time). The application of ISO 9001: 2015 is also expected to be an indicator for improving the quality of the project in order to reduce the work of rework and repair and repair. The impact caused in terms of costs where the average cost incurred to correct quality problems is 12.4% of the contract value. Even found costs due to quality failure reaching 25% (Winata, 2005). From the explanation above, there is a need for project risk management to reduce the level of repair and rework work. In this study, risk evaluation and management will be carried out in repair and rework work to improve project performance.

II. THEORETICAL BASIS

A. Repair and Rework

In this study, the researcher found some definitions of rework and repair, those are:

1. According to Measurement Sub-Committee (2002) repeat work is activity in the field that must be completed more than once in the field or eliminate previous work that has been done where there is no change request from the project owner before the work is done. Eliminating the previous job means that the work has been realized in the field and needed time in the removal process
2. According to Construction Industry Institute (CII) (2001) defines rework and repair as doing work on the field more than once or activities that eliminate the work that has been done before

However, this understanding is still unclear so it needs to be given limits on what includes rework and repair and which are not. According to Feyek et al (2003) the following are some things that do not include rework and repair

1. Changes in the scope of the initial work that has no effect on the work already done
2. Design changes or errors that do not affect work in the field
3. Fabrication errors corrected at off-site
4. The off-site modular fabrication error that is corrected off-site is the same as the fabrication error corrected at offsite, except that this is a bigger matter. On-site fabrication errors but do not directly affect activities in the field (repaired without interfering with the construction activities).

B. Risk Management

Risk Management Project is an integral part of the process that aims to identify potential risks associated with the project and respond to those risks. The purpose of risk management is

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to prevent or minimize the effects that are not good due to unexpected events through avoiding risks or preparing risks related to those risks (Santoso, 2008). In general, risk management is defined as the process, identifying, measuring and ensuring risk and developing strategies to manage those risks. In this case risk management will involve processes, methods and techniques that help project managers.

C. Risk Analysis

Risk analysis is a series of processes carried out with the aim of understanding the significance of the consequences that will pose a risk, both individually and portfolio to the continuity of the project. According to PMBOK 5rd edition (2013) Grouping risks based on root causes or based on categories that are considered important can help increase the effectiveness of risk mitigation. In this analysis the risks that require rapid handling must be handled more quickly. Indicators can be from the level of risk, symptoms, and signs of danger. After the quantitative analysis is carried out, the results obtained from the analysis are in the form of a priority list of project risks, risk categorization, a list of short-term risks, a list of additional risks and mitigation. In Risk Breakdown Structure (RBS), risk is generally divided into four levels starting from level zero, which are risky programs. Furthermore,from level one, it is further divided into more specific sub risks such as risks from management, project implementation and external risks. At level two the risks at level one are further divided into more specific risks. For instance, the implementation of projects at level one is further divided into the planning, work contract and construction stages. At level three, the risks in level two are detailed again into more specific risks, such as at level two, the plan details the risks, namely public responses, the objectives and benefits of the project, project permits and many others.

To sort the risk resulting from multiplication between frequency scale and impact arranged from the largest to the smallest. To determine the level of importance of risk (importance level) can use the equation as below (Zhi, 1995):

Level of Interest risk = Frequency Scale x Impact

D. Struqtural Equation Modelling

According to Ghozali & Fuad (2008: 3), structural equation models (Structural Equation Modeling) is a second generation multivariate analysis technique that allows researchers to examine the relationship between complex variables both recursive and nonrecursive to obtain a comprehensive picture of the overall model. In general, there are two known as types of SEM, namely Covariance Based Structural Equation Modeling (CB-SEM) developed by Joreskog and Partial Least Square Structural Equation Modeling (PLS-SEM) developed by Wold. Many researchers use CB-SEM to see the effect of an exogenous latent variable on endogenous latent variables, using a large number of samples. Therefore, in this study PLS-SEM will be used to see the effect of an exogenous latent variable on endogenous latent variables using smaller amounts of data

E. Partial Least Square (PLS) Analysis

SEM using PLS consists of three components, namely structural models, measurement models and weighting schemes. This third part is a special feature of SEM with PLS and does not exist on covariant-based SEM. SEM using PLS only allows the relationship model between recursive (sarah) variables only. This is the same as the path analysis model (path analysis) is not the same as covariant based SEM that allows also the occurrence of non-recursive (reciprocal) relationships. One example The basic concept of the research will be presented in Figure 1.

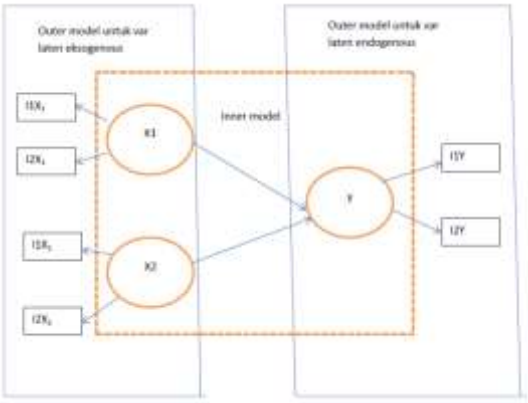

Fig. 1. PLS SEM Model

F. Variablepresented in SEM – PLS

1. Reflexive model

In PLS SEM there are two kinds of relationships between indicators and latent variables, namely the reflexive model and the formative model. Reflective models reflect that each indicator is a measurement of errors imposed on latent variables. The direction of cause and effect is from latent variables to indicators so indicator indicators are reflections of variations from latent variables (Henseler, Ringle & Sinkovicks, 2009). Thus changes in latent variables are expected to cause changes in all indicators. Examples of relationship models reflexive like the Figure 2 as below.

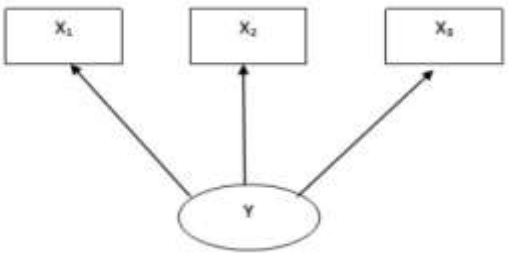

Fig. 2. Reflexive Model
(The latent variable Y is measured by X block which consists of 3 indicators X1, X2 and X3 reflectively)

2. Formative model

While the formative relationship model is a causal relationship originating from indicators leading to latent variables. This can happen if a latent variable is defined as a combination of indicators. Thus the changes that occur in the indicators will be reflected in changes in latent variables. A clear example in this model is the marketing mix as a latent

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variable formed by indicators of promotion, product, price and distribution. An example of a formative relationship model as indicate in the following.

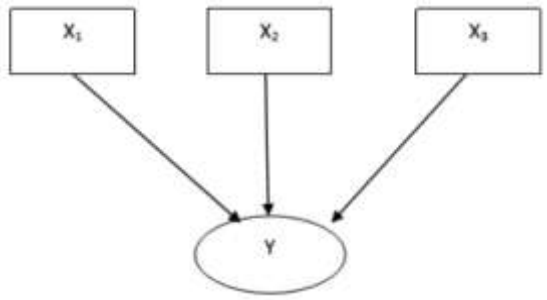

Fig. 3. Formative Model
(The latent variable Y is measured by X block which consists of 3 indicators X1, X2 and X3 formatively)

G. *Flow of the SEM-PLS Algorithm*

In this study, Data analysis and structural equation modeling are used PLS software, are as follows (Ghazali, 2006):

1. Designing a Structural Model (Inner Model). Structural models describe the relationship between latent variables based on substantive theory. The design of the structural model of relations between latent variables is based on the formulation of the problem or research hypothesis
2. Designing a Measurement Model (Outer Model). The Measurement Model defines how each indicator block is related to its latent variables. The design of the measurement model determines the nature of the indicators of each latent variable, whether it is reflexive model or formative model, based on the operational definition of the variable
3. Estimates: Weight, Path Coefficient, and Loading parameter estimation method (estimation) in PLS are least square methods. The calculation process is done by iteration, where the iteration will stop if convergent conditions have been reached. Estimation.
4. Evaluate Goodness of Fit. The Goodness of Fit Model is measured using R2 dependent latent variables with the same interpretation as regression. Q2 predictive relevance for structural models measures how well the observational value is generated by the model and also its parameter estimates.
5. Hypothesis Testing (Resampling Bootstraping)

III. Research Method

A. *Thinking Framewok*

Based on the background of the study, problem formulation and literature review in the previous discussion, the relevant research framework can be described. This makes it easy to get the right research process to get answers to questions in the formulation of the problem. To improve the quality performance and to reduce unexpected expenditure on building construction projects, in-depth studies need to be conducted. The risks that occur at the project implementation stage are identified first, then carried out an analysis and make a solution on how to manage these risks. In addition, recommendations are also needed to be taken. Thus, it is expected that targets to improve quality performance and reduce additional costs at the stage of implementation of building projects can be achieved.

The project review in this study has three projects with building types and functions that are typical or almost the same. There are two methods that used in this research, namely RBS and SEM-PLS.

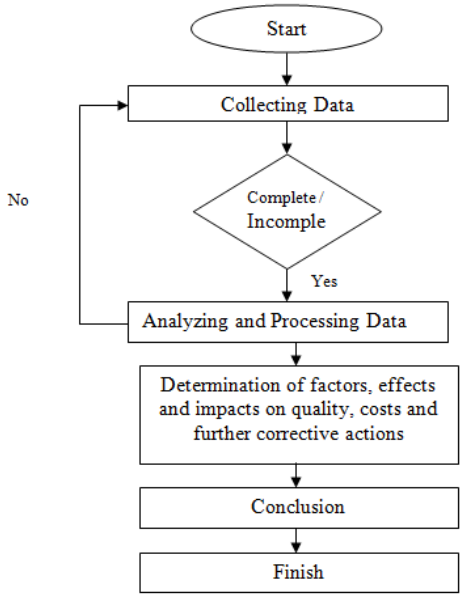

Fig. 4. Basic Concept

B. *Instrument Testing*

In this study, the validity of the construct instrument will be used based on expert opinion. The number of experts used in the test of construct validity is at least 3 experts who already has scope or expertise in their field. After that, the questionnaire tests are conducted.(Sugiono, 2016).

In the study, the reliability test used the Cronbach Alpha method. The coefficient of Alpha Cronbach ranges from 0 to 1, for values less than 0.6 in general the instrument is considered unreliable.

IV. Results and Discussion

A. *Recapitulation the Cost of Repair and Rework*

There are 3 types of projects which are reviewed in this study, where all three are based on functions and areas for factories and warehouses. Given that building projects have a higher complexity of work when it is compared to road projects, so the risks to work items are much higher. Broadly speaking, the results of the analysis carried out on the three projects are known that the most dominant work items and affect the cost of repair and rework are concrete work items, especially concrete. The work is much influenced by various factors as detailed in the subchapters of each project. Factor conditions and coordination in the field related to the order of work, the weight of each job and related to the drawing of a reference to the fieldwork work that is less detailed becomes a major influence on the existence of labor. Meanwhile, the casting process is also one of the obstacles where the casting time carried out every day from night to morning makes the

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productivity and efficiency of the survey team become more optimally related to the level of building structure. Here is a detailed table of the cost of repair and rework of each project

TABLE 1. *Repair* and *Rework* Cost

Projwct	Structure	Finishing	Total
MD-2281	Rp. 202.522.852,82	Rp. 40.994.074,05	Rp. 243.516.927
MD-2306	Rp. 272.128.235	Rp. 64.894.205	Rp. 337.022.402
MD-2259	Rp. 102.427.501,74	Rp. 32.478.119,69	Rp. 134.905.621

B. Risk Identification

RBS is used as an effort to categorize each risk. RBS is grouping risks into a logical, systematic and structured composition of risk hierarchies. Risk categorization is based on the value of the Risk Factor. Risk factors derived from the equation of risk factors are defined as the multiplication of the magnitude of the impact and probability of the occurrence of the risk. In this study, the Risk Breakdown Structure method is divided into 4 levels starting from level 0, namely when implementing the project, then level 1 is the work of *Rework and Repair*. For level 2, it is further divided into more specific sub risks of *Rework and Repair*, which are into 2 types of structural work and finishing. At level 3, the risks in level 2 are detailed again to be more specific risks such as at level 2 related to sub-sub-work finishing and structure that is about design, material, tools, managerial, resources, implementation methods and environment.

RBS has been recognized as a useful tool for structuring risk processes, and has been included in the risk determination standard. The project review is divided into 7 indicators of the assessment of *Repair* and *Rework* work that are related to design, managerial, material, human resources, implementation methods, tools and environment. The following is a table of results of finishing risk level and structure in the table as follows:

- *Structure*

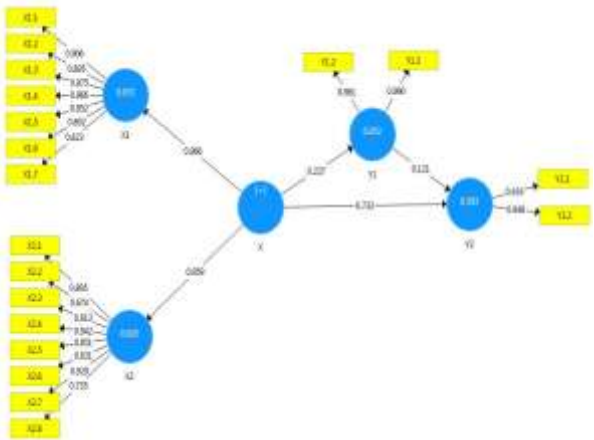
Level 0	Level 1	Level 2	Level 3	Level 4	Dampal	Frekuens	Tingkat Resik
					a	b	a x b
Project Implementation	Rework and Repair Implementation phase	Structure Work	Desain	Design changes during implementation	5	4	20
			Managerial	Lack of project teamwork	4	4	16
				Division of tasks and authority is not clear	4	4	16
			Material	The material used is not according to specifications	5	5	25
				Material arrivals late	5	5	25
			Human Resources	Availability of Experts	5	5	25
				Supervisory personnel are incompetent	5	5	25
			Implementation Method	Product failure due to improper working methods	4	5	20
				Failure to implement work methods is not in accordance with the plan or procedure	4	5	20
			Tool	The amount of equipment is inadequate / not in accordance with the specified productivity	5	4	20
			Environment	The weather is not good	3	3	9
				Difficult Field Conditions	3	3	9

- *Finishing*

Level 0	Level 1	Level 2	Level 3	Level 4	Dampal	Frekuens	Tingkat Resik
					a	b	a x b
Project Implementation	Rework and Repair Implementation phase	Finishing Works	Desain	Poor planning (unclear details	5	5	25
				Poor planning Slow revising images and redistributing (unclear details)	5	5	25
			Managerial	Lack of project teamwork	5	4	20
				Lack of coordination in the field	4	5	20
			Material	The material used is not according to specifications	4	3	12
				Material arrivals late	4	3	12
			Human and Resources	Work scope	4	5	20
				Supervisory personnel are incompetent	4	5	20
			Method	Failure to implement work methods is not in ac	4	4	16
			Tool	The amount of equipment is inadequate / not in accordance with the specified productivity	4	3	12
			Owner	Change by request	5	5	25
			Enviroment	The weather is not good	4	4	16

C. SEM-PLS Analysis

The stages of statistical analysis are used to see the effect between variables that are functional and realized in mathematical models. In the SEM-PLS method the variables are divided into two, Exogenous Variables (free) and Variable Endogen (bound). Exogenous variables are independent variables where these variables are variables that influence or cause changes in the dependent variable. While the dependent variable or endogenous variable is a variable whose value depends on other variables. Path diagram analysis as seen in Figure explains that the structure and finishing work is an exogenous variable (free) where the value of the variable will affect the endogenous variable (bound) or the value of repair and rework work. Here is a path diagram image



1. Measurement Model (Outer Model)

- Convergent validity 1st order is intended to determine whether or not the indicator is valid in measuring dimensions or variables

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	Struktur Work	Finishing Work	ISO	Quality Performance
X1.1	**0,906**	0,477	0,208	0,404
X1.2	**0,895**	0,642	0,220	0,588
X1.3	**0,975**	0,784	0,228	0,598
X1.4	**0,966**	0,740	0,249	0,555
X1.5	**0,952**	0,760	0,264	0,685
X1.6	**0,892**	0,671	0,250	0,471
X1.7	**0,823**	0,615	0,364	0,377
X2.1	0,863	**0,895**	0,339	0,814
X2.2	0,689	**0,674**	0,109	0,634
X2.3	0,583	**0,913**	0,102	0,558
X2.4	0,796	**0,942**	0,212	0,753
X2.5	0,591	**0,851**	-0,040	0,664
X2.6	0,627	**0,631**	-0,013	0,627
X2.7	0,826	**0,929**	0,253	0,754
X2.8	0,820	**0,735**	0,300	0,753
Y1.1	0,180	0,071	**0,990**	0,125
Y1.9	0,249	0,095	**0,961**	0,152
Y2.1	0,558	0,653	0,482	**0,935**
Y2.2	0,635	0,801	0,122	**0,948**

The results indicate that the factor loading value that occurs is greater than 0.6.

- Convergent Validity 2nd order, Each dimension in measuring variable shown by the loading factor

Variable	Dimension	Loading Factor	Standard Error	T Statistics
Rework and Repair	Structure Works	0.966	0.007	138.026
	Finishing Works	0.959	0.011	85.386

- Realibility Testing

Variable	Dimension	Composite Reliability	Cronbachs Alpha
Pekerjaan Rework dan Repaired	Structure Works	0,974	0,968
	Finishing Works	0,945	0,931
Quality Management System		0,975	0,953
Quality Performance		0.940	0,872

From these results the most significant on material indicators, where the material structure work is the most representative indicator while the finishing work is the smallest value. It happened because there are not many work items such as when finishing work in the structural work. Hence, there are not much proportional to the volume on each work item. Furthermore, this value can also be correlated with the findings of field SPK where the main repair and rework work is considered as concrete work.

2. Structural Model (Inner Model)

- *Goodness of Fit Model*

Variable	R^2
Quality Management System	0.052
Quality Performance	0.593
$Q^2 = 1 – (1 – R_1^2) (1 – R_2^2)$ $Q^2 = 1 – (1 – 0.052) (1 – 0.593) = 0.614$	

Q-Square predictive relevance (Q2) Project quality performance variables are worth 0.614 or 61.4%. This means that the diversity of project quality performance variables can be explained by the overall model of 61.4%, or in other words the contribution of rework and repair work and the overall quality management system to the project quality performance variables of 61.4%, while the rest is 39.6 % is the contribution of other variables not discussed in this study

- Hypothesis Testing : Direct Effect

Eksogen	Endogen	Path Coefficient	Standard Error	T Statistics
Rework and repair	Quality Management System	0.227	0.049	5.280
Rework and repair	Quality Performance	0.733	0.044	16.311
Quality Management System	Quality Performance	0.121	0.053	2.122

The analysis results is based on the table above that indicates variables that have the greatest total coefficient on *Rework and Repair* work is the project quality performance with a total effect of 0.738. Thus the work of *Rework and Repair* is the most influential variable or has the most dominant influence on project quality performance.

V. CONCLUSION

1. The results of the recapitulation based on existing SPK, found that of the three projects the most dominant work items experienced repair and rework work were on concrete work consisting of decrepit work items, concrete chipping and grouting.
2. Analysis is carried out based on the risk breakdown structure method on structural work and finishing. The results of the analysis of factors that affect the repair and rework work are not much different. The variables that have the most dominant risk level are:
   a. Structural Work: Design, material and resources
   b. Finishing Work: Design and perception of the owner
3. The results of the analysis were conducted based on the SEM-PLS method. The biggest contribution value to improving quality performance is on repair and rework work of 0.733 or 59.3%. The better the quality management system, the better the quality performance of the project and the more intensive the work of rework and repair causes the quality performance of the project to be better.

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