

# Risk Analysis of Project Construction Delay of Spazio Tower - 2 Surabaya

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**Abstract:-**Spazio Tower 2 is a building construction developed in Surabaya using Top Down Construction Method. The method is selected in order to streamline the processing time, due to fulfil stake holder requirements. However, in practice there are definitely a project delay risks. Therefore the Spazio Tower project stake holders need a good risk management to get the desired results. This paper reports a study isto identify the risks involved in the construction of Spazio Tower 2 Surabaya and to prepare some management actions needed to response the identified risks. Identification of the risk was conducting by using Risk Breakdown Structure. Some expert were involved to assess the level of the risks. Priority of the risk was analyzed by mean of the Risk Priority Number. Risk Mapping was also outlined in order to show the risk classification. Finally, several planned actions are prepared with respect to respond each identified risks. Further analysis of the risks was also studied by using Analytical Network Process to anticipate the present of correlation among the risks. The result shows that some of the risks are interconnected and feedback systematically.

**Keywords:-**Risk Analysis;Construction Project; Building; Analytical Network Process; Top Down construction Method.

## I. INTRODUCTION

Surabaya has a large and potential property market. As the second largest city in the eastern business center of Indonesia, the needs of society and the business world towards property products are increasing. Looking at the positive statistics of Surabaya's economic growth, PT Intiland Development Tbk. takes a strategic action. The leading developer with more than 40 years of experience develops Spazio Tower, an office building with a new concept, in the premium business area of West Surabaya.

The challenge in this Spazio Tower 2 Surabaya project is the existence of five basement floors and using Top Down Construction Method in the construction work. This five basement is the deepest basement in Surabaya today. The Top Down Construction Method is chosen because this method has a more rigorous working time, ie basement and top floor workmanship are materialized at the same time.

Anticipating the likelihood that the construction delay risk will occur in the remaining time of Spazio Tower 2 Surabaya development project, it is useful to implement the construction risk management. This research seeks to perform risk management on the implementation of Spazio Tower 2 Surabaya Project so it is expected that this project can be completed on schedule and give maximum benefit for various parties.

Risk identification is performed using Risk Breakdown Structure (RBS). Weight risk analysis using ANP. ANP method is used in this research because the existing data have relationship between one element criteria with the others and relation relationship between criteria with their sub-criteria. Having obtained the dominant risk with ANP, then looking for alternative priority solutions and the right policy strategy, recommendations are given appropriately and optimal.

## II. LITERATURE REVIEW

### A. Risk Management

Strategies against negative risks by Project Management Institute (2008) are as follows:

- Avoid, risk is usually should be avoided if the level of risk that occurs in the category very high (very high) and the action / response needed to level the risk is very difficult
- Transfer, the risk is transferred to another party to take over responsibility.
- Reduce (mitigation), reduce the impact of the risk occurrence to the acceptable levels of risk.
- Accept, it is done because it is less likely to reduce the threat or there is no appropriate strategy to lower the risk level, so have to accept the risk.

### B. Risk Breakdown Structure

Risk Breakdown Structure (RBS) is a risk grouping within a hierarchical composition of organizational risk that is logical, systematic, and structured manner according to the organization or project structure. This stage of risk

identification results in the form of a risk list, which is a component of the overall risk management plan.

*C. Validity Test*

Validity indicates the extent to which a measuring instrument can measure what it wants to measure (Singarimbun and Effendi, 2006). A valid instrument is a measuring instrument for obtaining valid data and can measure what it wants to measure. The steps in testing the validity are:

- Define operationally the concept to be measured.
- Prepare a questionnaire containing the variable to be measured and its alternative answers.
- Conducting a trialtest on a number of respondents. It is highly recommended that the number of respondents to test at least 30 people.
- Calculate the correlation between each statement with the total score using product moment correlation formula, the formula as follows:

$$r_{Tes} = \frac{n\left(\sum_{h=1}^n X_h Y_h\right) - \left(\sum_{h=1}^n X_h\right) \left(\sum_{h=1}^n Y_h\right)}{\sqrt{\left[n\sum_{h=1}^n X_h^2 - \left(\sum_{h=1}^n X_h\right)^2\right] \left[n\sum_{h=1}^n Y_h^2 - \left(\sum_{h=1}^n Y_h\right)^2\right]}}$$

Where:

$r_{Tes}$  = Product moment correlation coefficient

$n$  = Number of samples

$X_h$  = Scores of items per respondent

$Y_h$  = Total score of each respondent

If  $r_{Tes} > r_{tabel}$  with degrees of freedom  $(n-2)$ , then the item is invalid and cannot be used further as a measuring instrument in the questionnaire. Also when it is negative, indicates that the item is contrary to another statement which means the statement is inconsistent with another statement (Singarimbun and Effendi, 2006)

*D. Reliability Test*

In this research the method used to calculate reliability index is internal consistency method. The reliability index can be represented by the Cronbach Alpha value of the following formula:

Cronbach Alpha =

$$r_{Test} = \left[ \frac{p}{p-1} \right] \left[ 1 - \frac{\sum_{b=1}^p \sigma_b^2}{\sigma_t^2} \right]$$

Where:

$p$  = Number of questions

$\sum \sigma_b^2$  = The number of variance items

$\sigma_t^2$  = Total variance

According Sugiyono (2007), reliability correlation coefficient is determined based on the following criteria:

- a. Between 0.00 to 0.199 = very low; b. Between 0.200 to

- 0.399 = low; c. Between 0.400 to 0.599 = medium; d. Bbetween 0.600 to 0.799 = high; and e. Between 0.800 to 1.000 = very high.

*E. Rank Spearman Correlation Analysis*

Rank Spearman correlation analysis is an analysis used to determine the relationship or linkage between two variables measured at least in ordinal. Each observation can be ranked based on X and Y variables according to the order of the score from the lowest to the highest.

*F. Analysis of the Impact and Intensity of Risk*

Hussein (2011) in his book explains that the probability value is the value of the possibility of the occurrence of risk, while the value of the impact is the value of the compensation of risk occurrence. Williams (1993), describes an approach developed using two criteria that are important for measuring risk:

- Probability, is the possibility of an undesirable event.
- Impact, is the level of influence or size of impact on other activities if undesired activity occurs. The risk level is the multiplication of Probability and Impact scores obtained from respondents (Well-Stam et al, 2004). Risk and un-wanted event opportunity values are the multiplication of Probability scores and consequences, the threat to negative or threat posed by the respondents (Hillson 2002)

To measure risk, it is usually use the formula:  $R = P \times I$

Where:  $R$  = risk level ;  $P$  = probability of occurrence of risk;

$I$  = Level of impact of the risk that occurred

Stages of risk analysis are used to determine the level of risk and risk of each esophagus. The method used in determining the level of riskis by using probability impact grid which can be achieved from thequantitiverisk matrix.

*G. ANP*

An ANP is a multi-criteria assessment method for astructureddecision and an analysis that has the ability to measure the consistency of judgment and flexibility in the choice of sub-criteria level. This method is a new approach of qualitative methods which is a further development of the previous method of Analytical Hierarchy Process (AHP) (Tanjung and Devi, 2013). The benefits of ANP are to assure consistency of pairwise comparisons, reduce the decision-making subjectivity, and provide a clear structure of the problem. (Saaty, 2008).

In a system with N components consisting of elements which will give effect to each other, it can be denoted that the component C number N is denoted by  $Ch$  where  $h = 1, 2, 3, \dots N$ . The elements belonging to the component will be symbolized by  $eh_1, eh_2, \dots, ehn$ . In general, the relationship of interest between elements within the network with other elements in the network can be represented following supermatrics, as follows

$$W = \begin{matrix} C_1 & C_2 & \dots & C_N \\ \begin{matrix} e_{11} \\ e_{12} \\ \vdots \\ e_{1N} \end{matrix} & \begin{matrix} e_{21} \\ e_{22} \\ \vdots \\ e_{2N} \end{matrix} & \dots & \begin{matrix} e_{N1} \\ e_{N2} \\ \vdots \\ e_{NN} \end{matrix} \\ \begin{bmatrix} W_{11} & W_{12} & \dots & W_{1N} \\ W_{21} & W_{22} & \dots & W_{2N} \\ \vdots & \vdots & \dots & \vdots \\ W_{N1} & W_{N2} & \dots & W_{NN} \end{bmatrix} \end{matrix}$$

The  $W_{ij}$  form in supermatrix is called the supermatrix block and is followed by the following matrix

$$W = \begin{bmatrix} W_{i_1}^{(1)} & W_{i_1}^{(2)} & \dots & W_{i_1}^{(n)} \\ W_{i_2}^{(1)} & W_{i_2}^{(2)} & \dots & W_{i_2}^{(n)} \\ \vdots & \vdots & \dots & \vdots \\ W_{i_{n_1}}^{(1)} & W_{i_{n_1}}^{(2)} & \dots & W_{i_{n_1}}^{(n)} \end{bmatrix}$$

To obtain a priority sequence between elements of a component or level, the value of the comparison matrix is searched for its eigenvector value. For the next eigenvector

value inserted into the spermatix. If from spermatix multiplied by the matrix itself to obtain a stable weight will be obtained steady state matrix.

Comparison consistency level is determined by measuring the Consistency Index CI, which is the average value of the entire criterion n, and n is the number of matrix of criteria comparison.

$$CI = \frac{\lambda_{maks} - n}{n - 1}$$

$\lambda_{maks}$  = The maximum eygen value of the matched matrix of  $n \times n \times n$  = Matrix size / number of items compared

Comparison matrix is acceptable if N value of Consistency Ratio  $\leq 0.1$ . The four main steps in a simpler ANP are as follows:

- Develop a Decision Model Structure
- Match Comparison Matrices of Interrelated Variables Count the Super matrix
- Weight the Interest from Clusters and Nodes

### III. METHODOLOGY

In this study the stages of the research is as shown in the Figure 1:

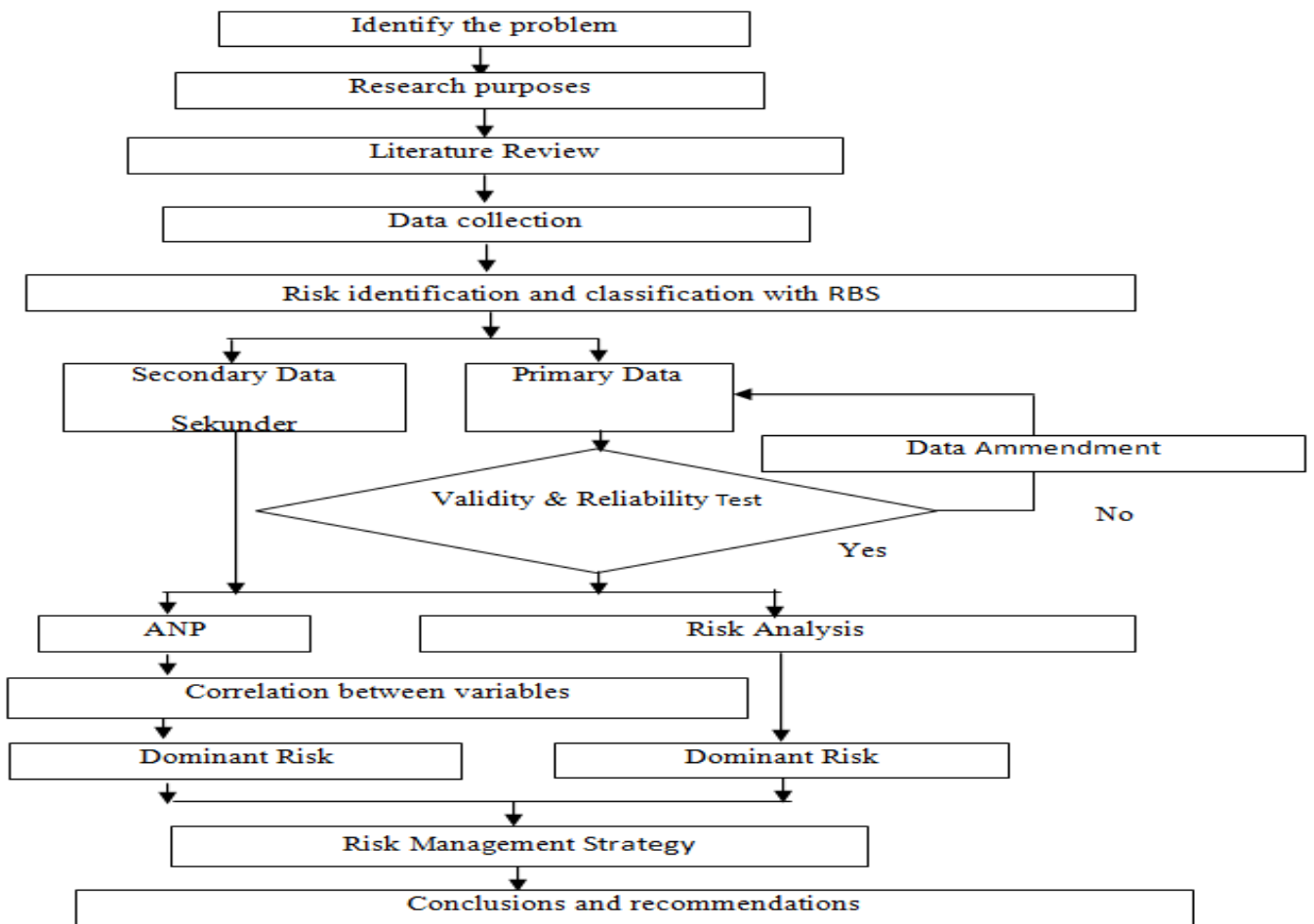


Fig. 1: Flow Chart of Research Methodology

This research is a case study on the Spazio Tower 2 Surabaya project development conducted by PT Tatamulia Nusantara Indah. Population in this research is personnel of expert staff from PT. Tatamulia Nusantara Indah who is doing the construction project

Determination of the sample using purposive sampling which is non probability sampling, the sample in this study determined by the researchers with the consideration that the sample can provide accurate information. The limitations in this sample determination are the personnel directly involved in the Spazio Tower 2 Surabaya Project and have a recent a diploma education.

The number of respondents becomes unimportant, since the most important person who is competent in the field is the selected respondent. Therefore, the criteria of respondents in this study is part of top management perception, knowing the situation / problem of all Spazio Tower 2 Surabaya Project and working in the field at least 5 years. Two experts who will become the respondents in this research are a Project Manager and a Chief Engineer at the Spazio Tower 2 Surabaya project which certainly has a responsibility on all the problems that exist in the project and has experience in the field for more than fifteen years and responsible in formulating and planning in management and giving input to the project leader in his decision making in project.

For the categorization of each risk, this study uses the RBS. The objective is to obtain a risk pooling in a logical, systematic, and structured hierarchical composition of risk in accordance with the project structure. Risk identification stage can be done by collecting information and checklist analysis. The risks in this project can be categorized by source, affected area, or other category. Risk grouped by categories that are considered important or based on the root of the problem can help improve the effectiveness of risk mitigation.

This research uses ANP analysis tool. In ANP, consistency is an important criterion for generating valid answers. Weakness in concentration can result in consistency of judgments that have no relevance to the real world. To maintain consistency must compare several elements in the matrix (not more than 7). This result is to ensure the level of consistency and validity, one needs to compare about 7 elements in each matrix. Therefore, to maintain consistency of the analysis results, the variables used in this study are not more than 7.

The risks involved in the construction of the Spazio Tower 2 Surabaya Project are linked, as well as between risk and sub-risk. Therefore, in the present study the network analysis process (ANP) is used to establish the dominant risks in the Spazio Tower 2 Surabaya project. Data that has been collected will then be calculated risk index, then analyzed by using ANP method to further develop the response plan Risk on risks that have a sufficiently dominant

level of risk. ANP data processing method is done using Super Decision software version 2.0.6.

Through the ANP method is expected to know the overall influence of all elements. Next, all criteria will be arranged and prioritized in a hierarchical or control network structure, then comparisons and syntheses to obtain the priority order of this set of criteria. Risk ranking determines the dominant risk of all risk items. This stage is derived from the criteria weighted ranking in each risk group in the ANP model through super decision software 2.0.6. Mapping Risk based on the level of influence and impact based on respondents' description (questionnaire results) by mapping based on three categories namely high, moderate, And low. Furthermore, only risks belonging to the high category are analyzed for their handling measures. Risk grouping into high, medium, and low categories is done by calculating the cumulative percentage of the limiting value of each risk, if the cumulative value of the percentage has exceeded 50%, it is included in the high risk category.

Furthermore, through ANP we can see the relationship between these risk groups. Of these risk groups can be seen the most dominant group of risks. Pairwise comparison for various criteria can only be considered with subjectivity. Therefore, the accuracy of the results depends on the knowledge of experts in the area of concern under study.

The risk management strategy focuses on the dominant risk, the high risk category among the risk groups, and the greatest risk in each risk group (variable). The identification of the dominant risk in each risk group is obtained from the risk ranking stage through the ANP model. The risk management strategy at this stage is obtained through depth interviews with experts and study literature. The result will then be concluded to get the dominant risk handling of Spazio Tower 2 Surabaya project development so it is expected that the construction can be completed on time and can be used as a study for the development of similar projects using Top Down method.

#### IV. RESULT

Opportunity for the occurrence of risk can arise at every stage of construction. Included in the development project Spazio Tower 2 Surabaya. The risks to be faced in the project are more severe because the project work only within a certain timeframe and does not recur. Therefore, it is necessary to risk management to look at the risks faced and the impact of those risks on the objectives of the activity. Furthermore, it can be planned solutions to minimize the impact of these risks so as to support the realization of the objectives of the activity.

Respondents in this case who are experts select the variables that are most influential or significant in the project Spazio tower 2 Surabaya. At this stage the experts conduct information collection and checklist analysis. The process of gathering information using study literature and expert adjustment.

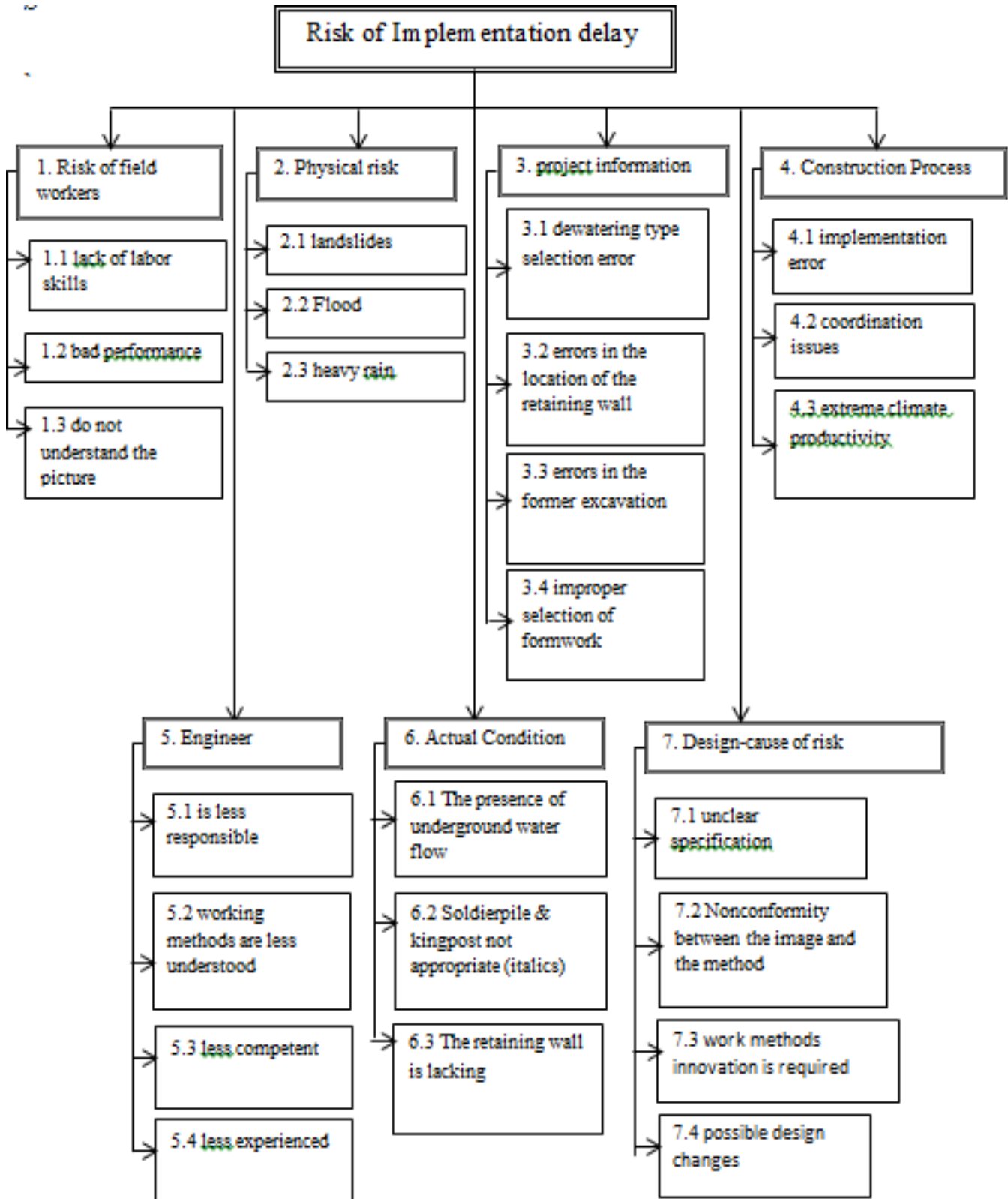


Fig. 2: Risk Breakdown Structure Scheme

The result of the instrument test (questionnaire) of the Intensity x impact survey shows all items in each valid and reliable variable. The test result through SpSSpogam with N = 30, r critical = 0.3610 is presented in the following table with.

Variable	Indicator	Validity		Reliability	
		R Test		Cronbach Alpha	
		value		value	Category
1. Risk of field workers	1.1 lack of labor skills	0.8	ok	0.88	Vey height
	1.2 bad performance	0.58	ok		
	1.3 do not understand the picture	0.87	ok		
2. Physical risk	2.1 landslides	0.67	ok	0.84	Very height
	2.2 Flood	0.85	ok		
	2.3 heavy rain	0.68	ok		
3. project information	3.1 dewatering type selection error	0.66	ok	0.83	Very height
	3.2 errors in the location of the retaining wall	0.78	ok		
	3.3 errors in the former excavation	0.61	ok		
	3.4 improper selection of formwork	0.68	ok		
4. Construction Process	4.1 implementation error	0.36	ok	0.63	height
	4.2 coordination issues	0.43	ok		
	4.3 extreme climate productivity	0.62	ok		
5. Engineer	5.1 is less responsible	0.37	ok	0.78	height
	5.2 working methods are less understood	0.72	ok		
	5.3 less competent	0.77	ok		
	5.4 less experienced	0.56	ok		
6. Actual Condition	6.1 The presence of underground water flow	0.40	ok	0.74	height
	6.2 Soldierpile& kingpost not appropriate (italics)	0.71	ok		
	6.3 The retaining wall is lacking	0.62	ok		
7. Design-cause of risk	7.2 Nonconformity between the image and the method	0.40	ok	0.65	height
	7.3 work methods innovation is required	0.55	ok		
	7.4 possible design changes	0.51	ok		

Table -1: The Results of the Survey Data of the Impact of Intensity X Are Valid

Stages of risk analysis are used to determine the risk level of each risk. The method used in determining the level of risk is to use probability impact grid which can be achieved from the quantitative risk matrix. - Hess Corporation as shown in table-2.



			Impact				
			insignificant	minor	moderate	major	cataspropic
			1	2	3	4	5
Possibility	very high	5					
	high	4					
	medium	3			1.1;1.2;1.3;2.2 ;3.2;3.3;4.1;4. 3;5.1;5.2;5.3;5 .4;7.1;7.3	2.1;2.3;4. 2;6.1;6.2; 6.3;7.4	
	low	2			3.1;7.2		
	Very low	1					

Sumber: – [hess](#) Cooperation

Table 2: Hess Risk Level Determination Matrix

Once the relationship between risks is identified, the next step is to develop an ANP model in Superdecision software that will be used to process the data in this research. The ANP model in Superdecision software can be seen in Figure 3 below:

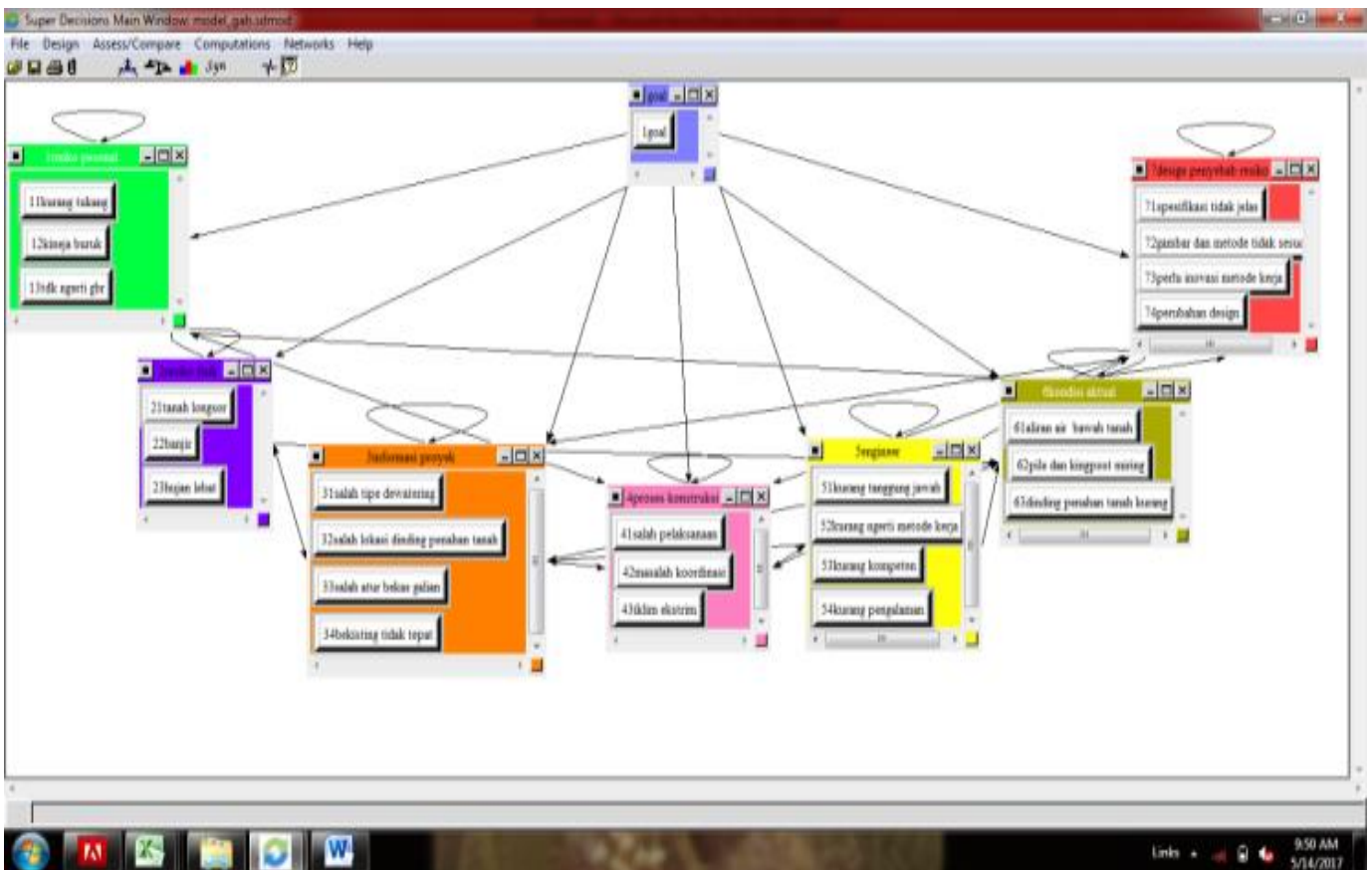


Fig. 3: ANP Model

In this ANP model, risk weighting analysis is divided into two parts, namely weighted all risk analysis and risk weighting analysis based on risk group. The following are risks that are ranked based on their weight, pairwise comparison, and the weight of the relationship between risks.

Name	Normalized By Cluster	Limiting	Persentase	Kumulatif
4.1 implementation error	1.00	0.26	25.80	25.80
6.2 Soldierpile & kingpost not appropriate (italics)	0.74	0.26	25.80	51.60
7.2 Nonconformity between the image and the method	0.40	0.13	12.53	64.13
7.4 possible design changes	0.40	0.12	12.42	76.55
6.1 The presence of underground water flow	0.26	0.09	8.88	85.43
7.3 work methods innovation is required	0.19	0.06	5.99	91.42
3.1 dewatering type selection error	0.35	0.03	2.72	94.14
3.2 errors in the location of the retaining wall	0.34	0.03	2.60	96.74
3.3 errors in the former excavation	0.25	0.02	1.94	98.69
2.1 landslides	1.00	0.01	0.87	99.56
3.4 improper selection of formwork	0.06	0.00	0.44	100.00
1.1 lack of labor skills	-	-	-	100.00
1.2 bad performance	-	-	-	100.00
1.3 do not understand the picture	-	-	-	100.00
2.2 Flood	-	-	-	100.00
2.3 heavy rain	-	-	-	100.00
4.2 coordination issues	-	-	-	100.00
4.3 extreme climate productivity	-	-	-	100.00
5.1 is less responsible	-	-	-	100.00
5.2 working methods are less understood	-	-	-	100.00
5.3 less competent	-	-	-	100.00
5.4 less experienced	-	-	-	100.00

Table 3: Priority Risk Weight

Through the table above can be seen the ranking of 24 risks on the implementation of the project Spazio Tower 2 Surabaya. Furthermore, only the high category risk that will be analyzed the action handling. Risk grouping into high, medium, and low categories is done by calculating the cumulative percentage of the limiting value of each risk. The risks are sorted from that has the largest limit value, then the value of the limit is censored. Furthermore, the cumulative percentage is calculated, the risk of the high category is the first cumulative 50 percent risk.

The risk rankings used in this analysis are those based on limiting, not on the basis of normalized by cluster. This is because limiting is the end result of the overall ratio of risk, whereas normalized by cluster is not the end result of risk priority, but a risk comparison based on the number of sub-criteria in the cluster.

Based on the limit value of the matrix limit above the risk of entering the high category (the first 50 percent cumulatively) is the risk of implementation error and the



risk of oblique pile and kingpost (actual condition not according to plan), each weighing 0.258021. The risk of improper misconduct is in the risk group of the construction process, whereas the risk of oblique piles and kingpost (actual conditions not in accordance with the plan) are in the actual risk group. On the other hand, other risks are a risk that does not significantly affect the model.

Incorrect risk of implementation is the development stage that is not in accordance with the expected results. If seen in relation to other risks, quite a lot of other risks that cause mismanagement, such as bad performance risk, the risk of not understanding the image, the risk of dewatering type selection error, the risk of coordination problems also leads to the risk of mismanagement. The risk of actual conditions that are not in accordance with the plan, for example soldier pile does not fit the plan, kingpost tilt. Because some things are difficult to make what has been planned is difficult to materialize, one of them is the field in the field beyond estimates, such as difficult field access. If seen in relation to other risks, quite a lot of other risks are caused by the risk of actual conditions that are not in accordance with the plan, for example the risk of nonconformity between the image and method, the risk of innovation required work methods, and the risk of possible design changes.

## V. RISK MANAGEMENT

Not all risks will be analyzed risk management strategies. In this study, only the dominant risk (high category) to be analyzed risk responses. This risk response is a recommendation from experts obtained through depth interview. The risk management recommendations are as follows:

- Physical Risk: protection of tarpaulin and shortener on the slope to avoid water entering the soil that could be the added burden of the soil, and make a ground-resistant ground wall soldier pile.
- Risk handling of implementation: The handling of these risks can be done by always evaluating the methods implemented, this is accompanied by a method of improvement that is tailored to the field conditions and desired target goals.
- Risk handling of actual conditions that are not as planned: Anticipate the existing conditions with the method of improvement / kantigensi plan and pengapangan of engineering team, initiated the project (especially the foundation) in good season.
- Coordination problem handling risk: In the implementation of regular meetings can be done every month, every week, or every day.
- Risk handling The presence of underground water flow: Handling these risks can be done by implementing dewatering and localizing wastewater. In performing dewatering sufficient equipment is required in reducing the flow of underground water
- Risk handling The retaining wall is less: In re-engagement should also be added an additional burden from the outside that can hit the existing wall.

- Risk handling Possible design changes :In conducting periodic meetings there must be a consultant who is in charge of the project area and the condition of the project area.

## VI. CONCLUSIONS

This section contains research conclusions and suggestions on what can be done next by the concerned parties.

Based on the analysis above, it can be concluded as follows:

- In the implementation of the Spazio Tower 2 Surabaya project development, RBS has identified seven risk groups with 24 risks. Furthermore, through ANP it is known that Physical Risk group is the dominant risk group. This risk group consists of risk of landslide, flood, and heavy rain.
- Taking into account the relationship between risks, the dominant risk in this project is the risk of improper implementation and the risk of actual conditions unlike the plan.
- The identified Risks should be treated using the recommendation from the expert that is:
  - Physical risk is handled by making a retaining wall, tarpaulin protection and a shortcrete.
  - Incorrect risk of implementation is addressed by preparing strategic methods, providing training for implementers and tightening evaluation.
  - The actual condition risks are dealt with by minimizing the resources of experts and always contingency plan and the accompaniment of the engineering team.
  - Coordination problem risks by means of regular meetings
  - Risk The existence of underground water flow By implementing dewatering and localizing waste water
  - Risk Retaining wall is less By way of counting the need and strength of the structure.
  - The risk of possible design changes by means of making periodic design meetings.

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