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Risk of Factors Causing Delays in Road Construction Projects (Case Study on Road Project in South Sulawesi Province, Indonesia)

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Abstract. Project delays are a common occurrence in any construction project. Road constructions in South Sulawesi Province, Indonesia commonly are not resolved based on a predetermined time. Project delay will result in cost overruns which will reduce contractor profits and decline its corporate image. Therefore, a study is needed to identify the factors that cause project delays and determine the corrections that need to be made by making decisions based on the identification of various factors of delay. This paper aims to identify risk factors, determine the level of risk, and determine preventive measures against the dominant risk factors in road projects. The data were obtained through questionnaires and interviews. The Analytical Hierarchy Process (AHP) and the Risk Calculator are used to analyse the level of risk. The result reveals that the dominant risk factor causing road construction delay is less quality control followed by material delays and lack of coordination among project staff.

INTRODUCTION

Connectivity is needed to improve the economy, productivity and international competitiveness. To achieve this, it is necessary to develop infrastructure in the form of roads as an artery for the economy. Road infrastructure will increase the rate of logistics and encourage industrial growth. The development of road infrastructure in South Sulawesi Province has become the government's priority in order to support the acceleration of the economy. Therefore, to achieve the success of road project development, effective and efficient planning is needed. This relates to the method of determining the amount of the required budget, the design of infrastructure that considers environmental impacts, a good planning schedule, the availability of materials, and so on. However, the problems that occur in road project construction are not resolved based on a predetermined time, cost and quality.

This study aims to identify and analyze the level of risk of the factors causing road project delays. The research is expected to become a guideline for contractors to implement an optimal project management system to minimize problems that arise so that construction projects can be controlled and carried out according to planned time, cost and quality. Delays often occur in many construction projects. Construction delays are defined as time beyond the contract date on which all the parties agree to deliver the project to the customer [1]. The types of delays in a project fall into 3 categories [2]:

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a. Excusable Non-Compensable Delays, are act of god, force majeure, weather.
b. Excusable Compensable Delays, this delay is caused by the owner client, the contractor entitled to an extension of time and claims for delay.
c. Non-Excusable Delays, this delay is entirely the responsibility of the contractor, because the contractor extends the work implementation time so that it passes the agreed completion date, which actually causes the delay can be predicted and avoided by the contractor. Thus, the owner client can request monetary damages for the delay.

The causes of construction project delays include difficulties in obtaining construction materials, difficulties for contractors to receive monthly payments, contractor financial difficulties, deficiencies in contractor organizations, shortages in the owner's organization, lack of qualified workers, large amounts of added work, delays in design work, errors planning and scheduling, inadequate job site inspections, frequent job changes, shortages in equipment allocation, unrealistic contract duration by the owner, difficulty obtaining fuel, disagreement with contract clauses, difficulty obtaining construction permits, unpredictable weather conditions, disagreement with specifications, transportation difficulties, natural disaster, unexpected social events and others [3].

Several studies have been conducted on the causes of delays in construction projects. Chan and Kumaraswamy [4] surveyed potential delay factors in Hong Kong construction. Their study found five main factors, namely: poor management and supervision, unexpected site conditions, work variations, slow decision making, and client variations. Al-Momani [5] conducted survey of 130 projects which indicated that poor design, negligence of the owner, contract change orders, weather, site condition, late delivery, economic conditions, and increase in quantities are the principal causes of delay. Studies by Yogita [6] reveals that the main causes of construction delays attributed to contractors; they are improper planning, poor site management, inadequate experience, lack of material, labor supply, and lack of communication between parties. A similar study by Koq [7] who surveyed potential construction delays causes in Indonesia, Malaysia, Thailand, and Vietnam. He reveals that the main delay factors in Indonesia, Malaysia, Thailand, and Vietnam are attributed to contractors.

Risk is a potential event, which can be avoided or reduced as little as possible, so that the impact is at least as planned or that can be accepted within the tolerable limits, and does not significantly interfere with the targets that have been set. [8]. According to Kerzner [9], risk has three main elements, namely:
a. Event is situations that occur at a certain place during certain intervals.
b. Likelihood is a qualitative description of the probability or frequency.
c. Consequences is the result of an event, both quantitative and qualitative in the form of loss or damage

RESEARCH METHODOLOGY

The research methodology contained twenty-eight (28) causes of road construction delay that were identified through literature review and discussion with some experts who are involved in the construction industry. Further, a questionnaire was established in order to evaluate the importance, frequency of occurrence, and consequences of the identified causes.

Data were collected through a survey, analyzed by using Analytical Hierarchy Process (AHP) and risk calculator. The ranking of the risk level of the causes of delay were determined. Recommendations for reducing delays in road construction projects were highlighted in the results of the study.

Questionnaire Design

Data were obtained through a questionnaire. The questionnaire was divided into two main parts. Part I is related to the general information of the respondent. Respondents were further requested to answer questions by comparing statements and determine their importance. Part II contains the list of the identified causes of delay in the road construction project. These causes are classified into seven (7) groups according to the sources of delay: manpower, materials, design, project management, financial, project characteristic and external factors. Respondents were requested to answer questions by determining the frequency and consequences of the variables.

Data Collection

Data were gathered through a survey. Surveys were conducted in Makassar, Maros, Gowa, Takalar Pare-Pare and Palopo, A total of 64 respondents from 13 large contractors answered the questionnaire.

Data Analysis Approach

Data were collected through a survey then analyzed by using Analytical Hierarchy Process and risk calculator.

Analytical Hierarchy Process (AHP)

AHP helps to measure subjective and objective evaluation, providing an instrument for checking the consistency of evaluations and thereby reducing bias in measurement. The basic concept of AHP is the use of a pairwise comparison matrix to produce relative weights between criteria. The first step is to decompose the main objective into its constituent criterions. In this stage, the complex structure of the problem is divided into parts in a hierarchy. Its purpose is to define problems from general to specific. After the main factor according to the source of the delay has been identified, the next step is to make a pairwise comparison. One criterion will be compared with other criteria in terms of how important it is to the achievement of the goal. The relational scale used in pairwise comparison is presented in Table 1 [10]. Figure 1 shows the hierarchy of factors causing the delay based on the results of the decomposition. These causes are classified into seven (7) groups which are expressed as a criterion in AHP hierarchy.

TABLE 1. Analytical Hierarchy Process importance scale

For any pair of objectives i, j	
Score	Relative importance
1	Criteria i and j are of equal importance
3	Criteria i is weakly more important than j
5	Criteria i is strongly more important than j
7	Criteria i is very strongly more important than j
9	Criteria i is absolutely more important than j
Note: 2, 4, 6, 8 are intermediate values	

The pairwise comparison matrix is represented as:

$$A=\begin{bmatrix} w_1/w_1 & \cdots & w_1/w_n \\ \vdots & \vdots & \vdots \\ w_n/w_1 & \cdots & w_n/w_n \end{bmatrix}\times\begin{bmatrix} w_1 \\ \vdots \\ w_n \end{bmatrix}=n\begin{bmatrix} w_1 \\ \vdots \\ w_n \end{bmatrix} \tag{1}$$

where A is the comparison matrix, w is the eigenvector, and n is the dimension of the matrix. Consistency Index as a deviation or a degree of consistency is obtained using Eg. 2 and Consistency Ratio is calculated using Eq. 3.

$$CI=\frac{\lambda_{\max}-n}{n-1} \tag{2}$$

$$CR=\frac{CI}{RI} \tag{3}$$

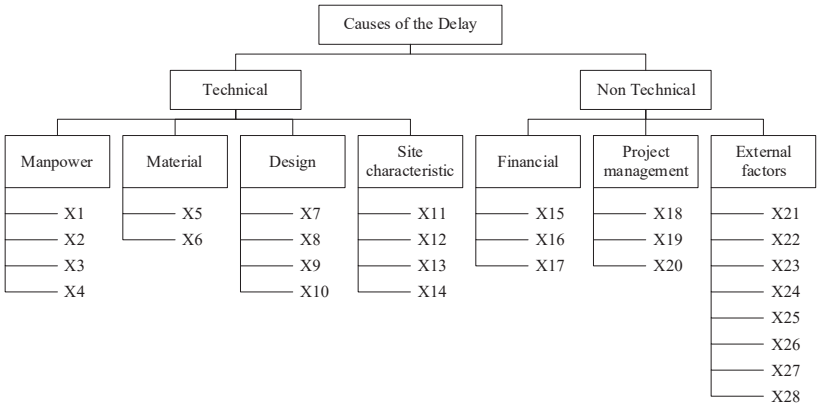

FIGURE 1. AHP hierarchy of goals and criterions

TABLE 2. Causes of the road project delay

X1	Worker skills
X2	Worker discipline
X3	Lack of worker motivation
X4	Lack of workers
X5	Late material
X6	Incompatible material
X7	Unclear specifications
X8	Delay in revised work drawings
X9	Design changes
X10	Process drawing approval requests by the owner
X11	Surface and underground conditions
X12	Workspace requirements
X13	Difficult traffic control
X14	Material storage area
X15	Bureaucracy to the owner is difficult
X16	Contractor's financial
X17	Material prices
X18	Poor planning and scheduling
X19	Lack of coordination among project staff
X20	Less quality control
X21	Changes to material specifications
X22	Rainfall intensity
X23	Work accident
X24	Delay in permission from the government
X25	Changes in regulations or political policies
X26	Natural disaster
X27	Workers strike
X28	Riot

Risk Calculator

The process of measuring risk is by estimating the frequency and consequence of the identified causes using Eq. 4.

$$RI = FI \times CI \tag{4}$$

where *RI* is risk index, *FI* is frequency index, and *CI* is consequence index. Formulas used to calculate frequency index and consequence index are expressed in Eq. 5 and Eq. 6.

$$FI = \frac{\sum_{0}^{4} a_i n_i}{4n} \tag{5}$$

$$CI = \frac{\sum_{0}^{4} b_i n_i}{4n} \tag{6}$$

where *a* is constant which expressing the score assigned to each frequency response (ranges from 1 for rare to 4 for probable), *b* is constant which expressing the score assigned to each consequence response (ranges from 1 for low to 4 for very high), and *n* is the frequency of each response.

Combined Risk Assessment Methodology

The obtained data were analysed through the AHP and risk calculator. The ranking of the factors causing the delay is measured by AHP, while the risk score for variables X1 to X28 is calculated using the risk calculator. The risk score obtained from the AHP synthesis is then categorized based on Table 3.

TABLE 3. Causes of the road project delay

Risk Score	Risk Category	Risk Respond
>0.7	High	top management must be involved in reducing risks
0.4 – 0.7	Medium	remedial steps are needed within a certain time
<0.4	Low	Remedial steps whenever possible

Flexural testing on material aims to determine the material's ability to accept Flexural loads as measured by the amount of energy required to bend the specimen until it breaks. This test is very useful for determining the flexibility of a material. This study is using the ASTM D790-02 standard [14]. The Flexural strength of a material can be calculated by the following equation: Results and Discussion

RESEARCH RESULTS AND FINDINGS

The results of AHP analysis from the technical point of view show that the material aspect is the factor causing the highest delay followed by design then manpower and site characteristics (Fig. 2). Whereas from a non-technical perspective, it shows that the aspect of project management is the factor causing the highest delay followed by financial and external factors as seen in Fig. 3.

FIGURE 2. Factors causing delays from technical point of view

FIGURE 3. Factors causing delays from non-technical point of view

Based on the AHP synthesis, it reveals that the largest risk factor causing project delay is less quality control (X20). Furthermore, other significant factors that influencing project delay which has adjacent weights, namely late of material (X5) and lack of coordination among project staff (X19). On the other hand, factors that are considered less significant to project delay are workspace requirement (X12) and material storage area (X14).

Less quality control is considered very risky causing delays in road projects because it can make the work have to be redone if the quality does not meet the requirements. This rework requires additional time which can affect the project schedule. In addition, material delays are also a risk factor for slowing project progress due to work interruptions

Based on the results of the ranking of risk categories, it is known that 1 variable has high risk category, 16 variables with medium risk category, and 10 variables have low risk category. Figure 4 shows the risk causes of project delays sorted from high risk to low risk.

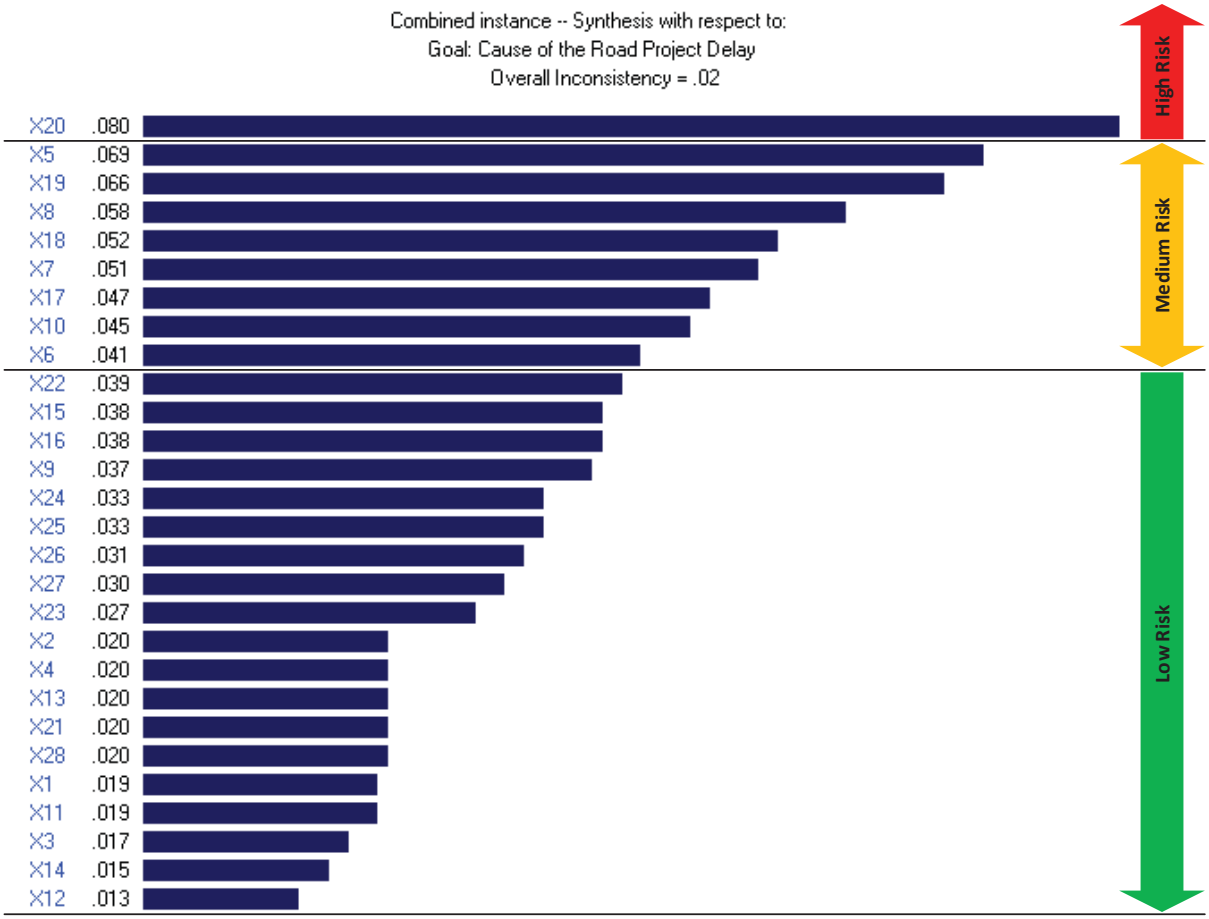

FIGURE 4. Factors causing delays from non-technical point of view

CONCLUSION

The dominant risk factor for road construction projects on time performance is less quality control followed by material delays and lack of coordination among project staff. Less quality control is measured very risky causing delays in road projects because if the quality does not meet the requirements thus contractor must do the rework and will affect the overall project schedule. Furthermore, material delays are also a risk factor for slowing project progress due to work interruptions

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