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RISK RELATED TO HEAVY EQUIPMENT PRODUCTIVITY ON THE ROAD CONSTRUCTION PROJECT IN PALU CITY

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ABSTRACT

Heavy equipment is a vital resource in road construction projects. To determine the level of efficiency and effectiveness of heavy equipment, a quantity is needed which is expressed by the productivity of the tool. There are several risks related to machine productivity that can affect time, cost, and quality. The purpose of the study was to identify, assess, and manage risks related to heavy equipment productivity and to determine the effect of these risks on cost, time, and quality in road construction projects in Palu City. The method used is primary data collection through interviews and questionnaires as research instruments. Data analysis used descriptive statistics and assessment of risk acceptability. The results showed that 21 risks were included in the undesirable risk category with a percentage of 88%, so the action taken for these risks was to reduce risk to an acceptable level by making improvements within a certain period and 3 risks that are included in the acceptable risk category with a percentage of 12%, then the actions taken for these risks are to make improvements whenever possible because these risks do not have a large impact and are still within acceptable limits. Of the 24 risks, there is 1 risk that has a significant impact on time with a percentage of 100%, 4 risks that have a significant impact on costs with a percentage of 100%, and 1 risk that has a significant impact on quality with a percentage of 79 %.

Keywords: risk, heavy equipment, productivity, road construction.

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1. INTRODUCTION

Risks can arise at every stage of construction, both at the planning, procurement, implementation, and operational stages and risks can arise from the owner, planner, implementer, or the user community. To be able to minimize the risks that occur, it is necessary to identify, analyze, and handle the possible risks that will occur. Risk management is the process of identifying, measuring, and ascertaining risks and developing strategies to manage these risks. A risk management system is used within an organization or company which is a process or series of activities that are carried out continuously, to control the possibility of risks arising that bring consequences to the organization or company concerned [1].

At the implementation stage of a road construction project, several risks may occur, especially those related to heavy equipment productivity. The risks that occur can affect the cost performance, time, and quality of construction projects. To minimize the occurrence of time delays, cost overruns, and incompatibility with the quality of implementation, the risks that may arise need to be managed properly. Therefore, this study aims to identify, assess, and manage risks associated with heavy equipment productivity and the effect of these risks on cost, time, and quality performance. So that the construction project targets, namely the right cost, time, and quality are achieved.

2. LITERATURE REVIEW

2.1 Productivity of Construction Heavy Equipment

According to [2], the productivity of heavy equipment in reality in the field is not the same when compared to the ideal condition of the equipment due to certain things such as topography, operator expertise, operation, and maintenance of the equipment. The productivity per hour of the tool that must be taken into account in planning is the standard productivity of the tool under ideal conditions multiplied by a factor called work efficiency. It is difficult to determine the value of work efficiency precisely, but based on experiences, it can be determined that work efficiency is close to reality. The effectiveness of the tool works depends on several things, namely: the ability of the operator who uses the tool, the selection and maintenance of the tool, the planning and arrangement of the location of the tool, the topography and volume of work, weather conditions and the method of implementing the tool.

2.2 Risks Related to Heavy Equipment Productivity

Risk identification related to the productivity of heavy equipment in the implementation of road construction projects (Table-1) is carried out by clearly knowing the source of the risk, the event, and the effect of the risk. Broadly speaking, the risk identification stage is detailing the risks that exist to a detailed level and then determining their significance (potential) and their causes, through a survey program and investigation of existing problems. These detailed risks are then classified. To overcome the difficulties in identifying risks, several methods can be used, including compiling a risk checklist, interviews with key personnel (experts) involved, and brain storming.

Table-1. Identification of risks related to heavy equipment productivity.

Number	Risk Type	Source
I	Equipment	
1	Damage to heavy equipment during project implementation	[3]
2	Damage to heavy equipment due to lack of heavy equipment maintenance	[4]
3	The existence of damaged and unused heavy equipment due to the lack of availability of spare parts for heavy equipment	[5]
4	The number of heavy equipment is less so work productivity is not optimal	[6]
II	Labor	
5	The work carried out by the contractor is not to the technical specifications regarding the number of heavy equipment tracks	[7]
6	Delay in the mobilization of heavy equipment	[7]
7	Delays in work due to lack of experience of heavy equipment operators	[3]
8	Delays in work due to lack of experience in heavy equipment mechanics	[3]
9	Heavy equipment operator under load	[5]
10	Operator falls from heavy equipment	[5]
11	There are heavy equipment operators who do not wear personal protective equipment (PPE) when working	[7]
III	Material	
12	Delay of Material production	[7]
13	Delays in work due to unmet material requirements so that heavy equipment does not operate	[6]
IV	Construction Method	
14	Improper use of heavy equipment work methods so work is delayed	[8]
15	The occurrence of work delays due to low productivity of heavy equipment	[7]
16	Lack of quality of heavy equipment work due to not following instructions from the field supervisor	[7]
V	Field Condition	
17	Heavy equipment delays due to traffic density around the project	[7]
18	The occurrence of damage to project facilities such as heavy equipment	[7]
19	Site conditions of extreme projects make heavy equipment difficult to operate	[4]
20	Damage to roads around the project due to being passed by heavy equipment	[7]
VI	Weather	
21	Heavy equipment work is hampered due to rain	[7]
22	The occurrence of landslides at the project site which has an impact on the use of heavy equipment	[1]
23	There was a flood at the project site so the heavy equipment could not operate	[1]
VII	Economy	
24	An increase in the price of fuel oil during the implementation of the work that has an impact on the use of heavy equipment	[7]

3. RESEARCH METHOD

Primary data was collected through interviews and questionnaires as well as construction project site surveys, while secondary data was obtained from relevant agencies, namely contractors, consultants, and project owners. The data that has been obtained were analyzed using descriptive statistics and the Assessment of Risk Acceptability. The table for the Assessment of Risk Acceptability is presented in Table-2.

Table-2. Assessment of risk acceptability.

Assessment of Risk Acceptability					
Consequences	**Catastrophic**	**Critical**	**Serious**	**Marinal**	**Negligible**
Likelihood/	(5)	(4)	(3)	(2)	(1)
Frequent (5)	Unacceptable	Unacceptable	Unacceptable	Undesirable	Undesirable
	(25)	(20)	(15)	(10)	(5)
Probable (4)	Unacceptable	Unacceptable	Undesirable	Undesirable	Acceptable
	(20)	(16)	(12)	(8)	(4)
Occasional (3)	Unacceptable	Undesirable	Undesirable	Undesirable	Acceptable
	(15)	(12)	(9)	(6)	(3)
Remote (2)	Undesirable	Undesirable	Undesirable	Acceptable	Negligible
	(10)	(8)	(6)	(4)	(2)
Improbable (1)	Undesirable	Acceptable	Acceptable	Negligible	Negligible
	(5)	(4)	(3)	(2)	(1)

(Source: [7])

The level of risk acceptance can be described as follows:

1. Unacceptable, the risk is not accepted, risk avoidance or risk transfer
2. Undesirable, the risk that is not expected and must be reduced (risk reduction)
3. Acceptable, the risk is acceptable
4. Negligible, the risk can be ignored

4. RESULTS AND DISCUSSIONS

4.1 Characteristics of Respondents

19 respondents have the latest educational background S1 with the highest percentage of 68%. Work experience 1-5 years with the highest percentage of 53%. The status of respondents in construction projects is Contractor with the largest percentage of 74%.

4.2 Reliability and Validity Test

The results of reliability testing are presented in Table-3.

Table-3. Reliability Statistics.

Reliability Statistics	
Cronbach's Alpha	N of Items
0,936	24

The results of testing the reliability of Cronbach's alpha index are very satisfying because the resulting index is 0.936 which this value into the range of Cronbach's alpha values of 0.81 to 1.00 which means it is very reliable.

From the results of validity testing, it can be concluded that all the variables contained in the research instrument are declared valid with the results of the calculation of r count > r table.

4.3 Risk Assessment and Acceptance

Risk assessment using a Likert scale which is formulated as a result of multiplying the frequency scale (likelihood) with the consequences scale (consequences). The level of risk acceptance (risk acceptability) depends on the results of the multiplication of probability (likelihood) with consequences, taking into account the level of risk acceptance based on the risk acceptance scale according to Table-2. The assessment and acceptance of risks related to productivity in road construction projects are presented in Table-4.

Table-4. Risk Acceptance.

No	Risk Type	Risk Value	Risk Acceptance
I	Equipment		
1	Damage to heavy equipment during project implementation	10	Undesirable
2	Damage to heavy equipment due to lack of heavy equipment maintenance	8	Undesirable
3	The existence of damaged and unused heavy equipment due to the lack of availability of spare parts for heavy equipment	5	Acceptable
4	The number of heavy equipment is less so work productivity is not optimal	8	Undesirable
II	Labor		
5	The work carried out by the contractor is not to the technical specifications regarding the number of heavy equipment tracks.	5	Undesirable
6	Delay in the mobilization of heavy equipment	7	Undesirable
7	Delays in work due to lack of experience of heavy equipment operators	7	Undesirable
8	Delays in work due to lack of experience in heavy equipment mechanics	6	Undesirable
9	Heavy equipment operator under load	5	Acceptable
10	Operator falls from heavy equipment	4	Acceptable
11	There are heavy equipment operators who do not wear personal protective equipment (PPE) when working	7	Undesirable
III	Material		
12	Delay of Material production	8	Undesirable
13	Delays in work due to unmet material requirements so that heavy equipment does not operate	9	Undesirable
IV	Construction Method		
14	Improper use of heavy equipment work methods so work is delayed	6	Undesirable
15	The occurrence of work delays due to low productivity of heavy equipment	9	Undesirable
16	Lack of quality of heavy equipment work due to not following instructions from the field supervisor	7	Undesirable
V	Field Condition		
17	Heavy equipment delays due to traffic density around the project	13	Undesirable
18	The occurrence of damage to project facilities such as heavy equipment	11	Undesirable
19	Site conditions of extreme projects make heavy equipment difficult to operate	7	Undesirable
20	Damage to roads around the projects due to being passed by heavy equipment	6	Undesirable
VI	Weather		
21	Heavy equipment work is hampered due to rain	11	Undesirable
22	The occurrence of landslides at the project site which has an impact on the use of heavy equipment	7	Undesirable
23	There was a flood at the project site so the heavy equipment could not operate	7	Undesirable
VII	Economy		
24	An increase in the price of fuel oil during the implementation of the work that has an impact on the use of heavy equipment	9	Undesirable

Table-5. Percentage of risk acceptance.

Risk Acceptance	%
Undesirable	88
Acceptable	12

From Table-5 the results of risk acceptance show the undesirable risk category with a percentage of 88% and the acceptable risk category with a percentage of 12%. The risk with the largest value is the delay in heavy equipment due to traffic density around the project with a risk value of 13 included in the undesirable risk category, while the risk with the smallest value is the operator falling from the heavy equipment with a risk value of 4 including into the category of acceptable risk.

4.4 Risk Handling

After the risks are identified, the strategy of risk response planning or the handling of each risk can be seen which is presented in table 6 as follows:

Table-6. Strategy of risk response planning.

Number	Risk Type	Handling
I	Equipment	
1	Damage to heavy equipment during project implementation	Periodical daily inspection of equipment, repairing damaged heavy equipment, increasing the number of heavy equipment
2	Damage to heavy equipment due to a lack of heavy equipment maintenance	Periodic maintenance of heavy equipment
3	The existence of damaged and unused heavy equipment due to the lack of availability of spare parts for heavy equipment	Bringing spare parts from outside the city and abroad
4	The number of heavy equipment is less so work productivity is not optimal.	Rent or increase the number of heavy equipment
II	Labor	
5	The work carried out by the contractor is not to the technical specifications regarding the number of heavy equipment tracks.	Controlling each work item such as the number of heavy equipment passes to conform to the technical specifications contained in the contract
6	Delay in the mobilization of heavy equipment	Site survey to ensure availability and access of heavy equipment in the project site area
7	Delays in work due to lack of experience of heavy equipment operators	Reliable and trained heavy equipment operator who already has an operator's license
8	Delays in work due to lack of experience in heavy equipment mechanics	Bring in reliable and trained mechanics
9	Heavy equipment operator under load	Implementation of OHSMS (Occupational Health and Safety Management System), conduct safety induction (training on occupational safety and health) before doing work, conduct toolbox talk (discussion on safety issues) to ensure workers use Personal Protective Equipment (PPE)
10	Operator falls from heavy equipment	Implementation of OHSMS (Occupational Health and Safety Management System), conduct safety induction (training on occupational safety and health) before doing work, conduct toolbox talk (discussion on safety issues) to ensure workers use Personal Protective Equipment (PPE)
11	There are heavy equipment operators who do not wear personal protective equipment (PPE) when working	Implementation of OHSMS (Occupational Health and Safety Management System), conduct safety induction (training on occupational safety and health) before doing work, conduct toolbox talk (discussion on safety issues) to ensure workers use Personal Protective Equipment (PPE)
III	Material	
12	Delay of Material production	Controlling material supply and material production so that they can be used on time
13	Delays in work due to unmet material requirements so that heavy equipment does not operate	Make a material schedule to control the fulfillment of work materials
IV	Construction Method	

14	Improper use of heavy equipment work methods so work is delayed.	Approve work methods for consultants before work starts
15	The occurrence of work delays due to low productivity of heavy equipment	Reviewing work methods, increasing the number of machines, and ensuring daily machine hours are achieved
16	Lack of quality of heavy equipment work due to not following instructions from the field supervisor	Maximize the role of quality control to ensure the quality of work
V	Field Condition	
17	Heavy equipment delays due to traffic density around the project.	Avoiding busy roads, making traffic safety management plans, Temporarily closing roads, and making alternative routes with the help of security-related parties
18	The occurrence of damage to project facilities such as heavy equipment	Placing workers on guard at the project site
19	Site conditions of extreme projects make heavy equipment difficult to operate	Site survey before starting work to determine preliminary work to facilitate work due to extreme locations and submit it to the owner, using a reliable and experienced operator
20	Damage to roads around the project due to being passed by heavy equipment	Develop working methods of heavy equipment so as not to damage existing roads, such as using a board when the excavator passes on the road
VI	Weather	
21	Heavy equipment work is hampered due to rain	Maximizing the use of heavy equipment when it is not raining, having rainfall data for the last few years to compile a schedule of work items that are disrupted due to rain
22	The occurrence of landslides at the project site which has an impact on the use of heavy equipment	Internal training on disaster management, emergency response training
23	There was a flood at the project site so the heavy equipment could not operate	Internal training on disaster management, emergency response training
VII	Economy	
24	An increase in the price of fuel oil during the implementation of the work that has an impact on the use of heavy equipment	Before making an offer, you must know and calculate the fluctuating price of materials so that they can be submitted to the owner, using unused reserve costs that are intended for unexpected events.

4.5 Impact of Risk on Cost, Time, and Quality

Risks that have a significant impact on costs are the destruction of project facilities such as heavy equipment with a percentage of 100%, risks that have a significant impact on time, namely delays in work due to unmet material requirements so that heavy equipment does not operate, work delays due to low productivity of heavy equipment, delays in heavy equipment due to traffic density around the project, extreme project site conditions so that heavy equipment is difficult to operate, and heavy equipment work delays due to rain with a percentage of 100%, then some risks have an impact which is quite significant to the quality, namely the work carried out by the contractor is not by the technical specifications related to the number of heavy equipment tracks with a percentage of 79%.

5. CONCLUSIONS

From the description that has been stated, the following conclusions can be drawn:

a) Identified 24 risks related to the productivity of heavy equipment in the implementation of road construction projects in the city of Palu. Based on the risk analysis, 21 risks were categorized as undesirable, and 3 risks were categorized as acceptable.
b) From the results of risk acceptance, it is found that the risk category is not expected (undesirable) with a percentage of 88%, then the action taken for that risk is to reduce risk (risk reduction) to an acceptable level by making improvements within a certain period, while the risk category is acceptable (acceptable) with a percentage of 12%, then the action taken for that risk is to make improvements whenever possible because the risk does not have a large impact and is still within acceptable limits.
c) Of the 24 identified risks, there was 1 risk, namely the occurrence of damage to project facilities such as heavy equipment) which has a significant impact on time with a percentage of 100%, 5 risks, namely work delays due to unmet material requirements so that heavy equipment does not operate, the occurrence of work delays due to low productivity of heavy equipment, delays in heavy equipment due to traffic density around the project, extreme project site

conditions so that heavy equipment is difficult to operate, and delays in heavy equipment work due to rain which has a significant impact on costs by the percentage was 100% and 1 risk was that the work carried out by the contractor is not by the technical specifications related to the number of heavy equipment tracks that have a significant impact on quality with a percentage of 79%.

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