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RISK ANALYSIS AND RECOMMENDATIONS TO IMPROVE THE LOGISTICS COST PERFORMANCE OF THE EPC PROJECT AT REMOTE AREA

Ferdi Firdausy*[1]
Wisnu Isvara[2]
[1]*Civil Engineering Department, Faculty of Engineering, Universitas Indonesia*
[2]*Civil Engineering Department, Faculty of Engineering, Universitas Indonesia*
e-mail: ferdi.firdausy@ui.ac.id[1], wisnu.isvara1@ui.ac.id[2]
**Correspondence: ferdifirdausy@gmail.com*

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Abstract: The EPC and construction projects generally have a high level of complexity, and uncertainty. The changes that have occurred in the engineering, construction, control systems, and sub-logistics stages will impact logistics cost performance and finally affect the project margins, weak of project control, and high risk. The purpose of this study is to determine the variable risk that affects the performance of logistics costs, to obtain high-risk identification of engineering, construction, and system control variables that affect the performance of logistics costs and to determine the risk responses and recommendations to improve logistics cost performance on EPC projects in remote locations. Data was collected from literature studies, interviews with respondents, and experts. By 51 respondents' answers, the risk was identified are 30 factors in terms of the probabilities and impact. The method through descriptive analysis, validity & reliability testing, and qualitative risk analysis. Further, the follow-up of risk results would carry out through proactive and reactive mitigation. This research found 7% of the variables were extreme, and 93% were high-risk categories. Thus it indicates that all variables affect the logistics costs performance where the remote project locations are one of the main factors in increasing the logistics costs.

Keywords: *EPC project, engineering, construction, control system, logistic, remote location, cost performance.*

INTRODUCTION

The Engineering Procurement and Construction (EPC) project is a form of project management concept that delegates responsibility for design engineering activities, material/equipment procurement, and construction implementation to EPC contractors.

This research is important to study, according to the literature (He & Han, 2022) Identification and evaluation of logistics risks of overseas EPC projects are conducive to taking targeted measures to strengthen risk prevention, improve engineering construction safety, and increase corporate. Like it or not, both the supply chain and the EPC project process need to be planned properly. By using the proper methods, the cause of problems in EPC projects can be minimized so that the project can improve the logistic cost performance.

The questions in this research include: What are the risk variables that affect the performance of logistics costs? What is the high-risk identification of the components of the engineering, construction, and control systems that affect the logistics cost performance? What is the risk response and improvement strategy for the logistics cost control system in the EPC project at a risk-based remote area location?.

EPC projects are usually large and complex, Such projects can be found in many industry segments, including but not limited to industrial plants, oil, and gas, mining, power plants, or large infrastructure (Wagner, 2020; Ritche, 2019). Not a few EPC project locations are for oil & gas or industrial plant far from urban areas, far from tools and human resources.

The complexity of the EPC project has a relationship between one process and another. This has the potential to cause multiplier impacts if one of the processes undergoes a change in planning, scheduling, technical, quality, etc., which will affect the other functions, such as procurement, construction, and commissioning.

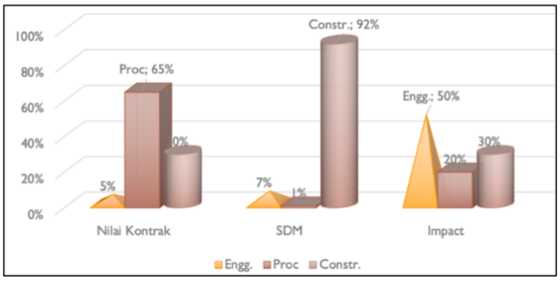

Figure 1. Impact of Engineering, Procurement and Construction on Project Performance
Source: Kamyar & Mojtahedi, 2019.

In this case, the researcher took the example of a case that occurred on the EPC Project in Indonesia, and from the contractor's point of view. The example project consist of the ferronickel project in East Halmahera, NCDT BP Tangguh, West Papua, Matindok project in Luwuk, Banggai Regency, Central Sulawesi Province, and etc.

Figure 2. Remote area project at Papua

The New Condensate and Diesel Tanks (NCDT) project is located at the BP Tangguh LNG site, in West Papua – Indonesia. The NCDT project was carried out to support existing COMPANY's facilities in the Tangguh LNG plant facilities to increase the capacity and efficiency of the Tangguh LNG plant.

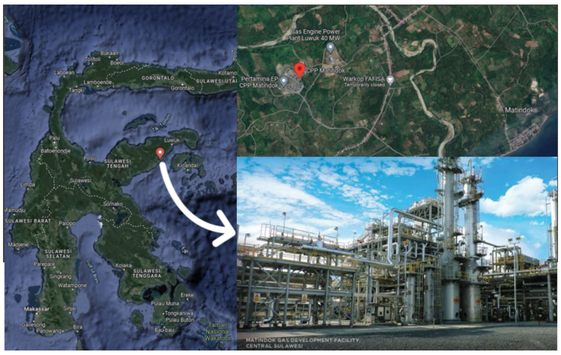

Figure 3. Remote area project location at Luwuk, Banggai District

The Production Facility at CPP Matindok is located in Nonong Village, in Banggai District, Central Sulawesi, Indonesia. The gas produced from the field still contains CO2, H2S, and Mercaptan compounds which need to be processed first at the Production Facility so that it becomes a gas product that meets the sales gas quality requirements.

Figure 4. Remote area project location at Halmahera, North Maluku

The Halmahera ferronickel plant development project known as (P3FH) project is located at Halmahera Island, North Maluku Province, Indonesia. The P3FH Project area mostly includes mining sites, ferronickel smelters, jetty, and town sites in two sub-districts at East Halmahera Regency, namely Maba District and Kota Maba District.

From the previous literature studies, the difference with the previous research has not yet found that changes in engineering, construction, control systems & sub-logistics are connected to the performance of logistics costs. Other's factor is the remote location itself, it's one of the influencing factors increasing the logistics costs in the EPC project. The variables will analyze through risk analysis, interview, and expert validation.

Research contribution to science is as the evaluation material for companies in implementing strategies for tenders in remote areas and in the long term to get better productivity, as input for the strategy and commercial preparation in the tender stage, and as the lesson learned for projects located in remote areas, they can take steps to prevent cost overruns and can help companies increase profits.

Cost Structure of EPC

Cost management is one of the most fundamental criteria in determining the success of an EPC project, so it must be managed and controlled throughout the project life cycle. Depending on the project type, the material costs can represent range from 30% to 70% of the total project (Donyavi, et al., 2009).

According to Indirect Construction

Costs (IDCC), The cost can represent 10-40% of the total project cost or more of the total construction project cost, depending partly on the type and nature of the project. Pulver also identified that the company's OH ranged between 8% and 15% of the total annual construction volume. As reported in the United States, OH companies generally account for 2.5% to 10% of the annual construction volume (Popescu, et al., 2003).

As general from the above description we can resume that:

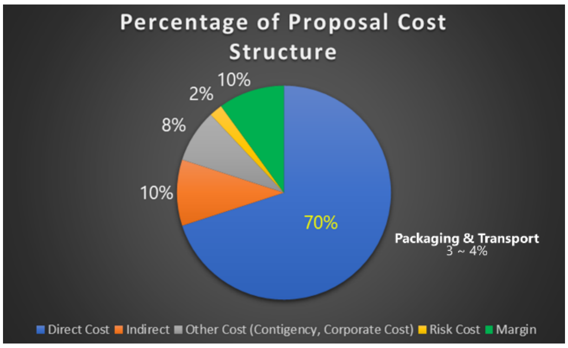

Figure 5. Proposal cost according to others literature

Logistic Problem on The Epc Project

One of the problems faced by this EPC project is related to the high cost of logistics. The amount of logistics costs is influenced by many factors, some of which are engineering, construction, logistics components, and project locations which are specificially located in remote areas.

Limited access to reach the project site has its problems for contractors because a large amount of construction support materials and tools must be provided on time, so a good strategy is needed to control logistics costs, especially for EPC projects in remote areas.

Projects that are located in remote areas have problems mainly due to the remoteness of the project itself where the schedule for shipping materials by sea transportation is not available all the time.

Some projects that experience problems from inappropriate engineering, logistics, and construction strategies will have a negative impact on the project quality and increase the logistics costs.

The geographical nature of Indonesia, which has many islands and an unequal population distribution, provides a potential challenge in building infrastructure and overcoming disparities between regions (Bahagia, et al., 2013).

One element of construction project resources that is very vital is material. One of the reasons for the many construction failures is the material logistics management process that is not optimal (Prahuhub, 2021).

The causes that generally occur as a result of an increase in logistics costs are:

- Engineering & construction projects located in remote areas, transportation difficulties for large equipment, on-site transportation conditions, loading, and warehousing operations bring great difficulties to EPC logistics operations (He & Han, 2022).
- Efficient construction site layout, which includes site geometry, size, and location of temporary facilities, it's an important aspect to consider at the initial planning stage, as it can significantly affect site transportation, Construction Logistics, and safety of construction workers (RazaviAlavi & AbouRizk, 2021).

- There was an interface problem between the contractor and the equipment supplier, client, material supplier, and subcontractor (Yang et al., 2019).

Factors Affecting The Logistic Cost

Project delays will impact extensions, and extensions will increase costs (Protocol, 2017). The KPMG's 2019, Annual global construction survey found that for 60% of companies, cost overruns and time were still the main challenges (KPMG, 2019). The problems are related to bad logistics and consume a lot of time and resources (Ekeskär, et al., 2016).

Poor logistics management can cause double handling of materials (Fearne, et al., 2006). Concern to the supply chain, the common problems were delivery reliability (Agapiou, et al., 1998a; Akintoye, et al., 2000), material flow planning (Bankvall, et al., 2010; Wickramatillake, et al., 2007).

Logistic Impact To The Overall Epc Project

The logistical problems in the EPC project will have an impact to:

- Additional costs due to sending materials to locations without prior notification will cause extra material handling and labor costs (Ying, Tookey, & Roberti, 2014).
- Many project delays and cost overruns are generally blamed on "logistic challenges" for example, the Papua New Guinea LNG project appears to have been delayed due to work stoppages and land access issues ($1.2 billion), plus poor logistics and weather conditions ($700 million) (Fournier, 2019).

Remote construction projects introduce many challenges that are not witnessed in urban locations if construction companies face supply problems in urban areas, then remote locations have the potential to get worse because construction projects are generally complex and require high-level management (Usman & Muhammad Ibrahim, 2015)

METHODS

The method that will be used by researchers is risk-based analysis. Then the data is processed qualitatively to get the level of risk. The risk level will be analyzed where the sub-variable items only have extreme and high-risk categories.

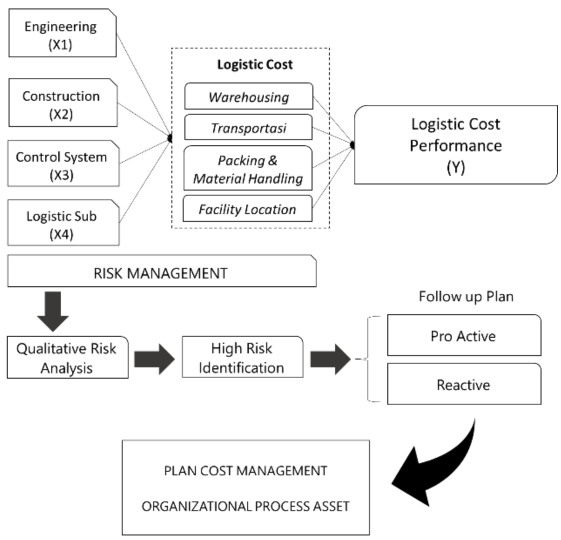

Figure 6. Research Operational Model

This method was chosen to see the relationship between the independent variables (X1, X2, X3, X4) and the dependent variable (Y).

To achieve the objectives of the research, The author conducted interviews and discussions with various respondents and experts. thus found there are 30 risk factors are consist of:

Table 1. Sub Variable Component of X

X1	Engineering
X1.1	Production Design
X1.2	Engineering Changes
X1.3	MTO
X1.4	Equipment / Material Changes
X1.5	Client Approval
X1.6	Site design
X1.7	Poor Engineering Design
X1.8	Lack of / Missing Interface
X2	Construction
X2.1	Site Condition
X2.2	Damage or poor quality of material
X2.3	Error of working method
X2.4	Equipment/Material not in accordance with the design
X2.5	Unrealistic design to execution
X2.6	Construction work activity
X2.7	Rework
X2.8	The influence of climate and weather that often changes
X2.9	Project Crash on a project which is indicated to be delay
X2.10	The site visit process is not carried out with the correct stages
X2.11	Lack of QC supervision
X2.12	There are internal and external requirements that are not considered in the planning stage
X2.13	Inappropriate construction strategies
X3	Control System
X3.1	Traditional reporting system
X3.2	Unintegrated system
X3.3	There is no performance index for logistics
X3.4	Late payments to vendors
X3.5	Incomprehensive logistics planning system
X4	Sub Logistic
X4.1	Warehouse
X4.2	Transportation
X4.3	Packing & Handling
X4.4	Facility Location

The research strategy will be divided according to the research questions, starting from the first strategy based on the first research question (RQ1), the second strategy based on the second research of RQ2, and the third strategy based on the third research of RQ3.

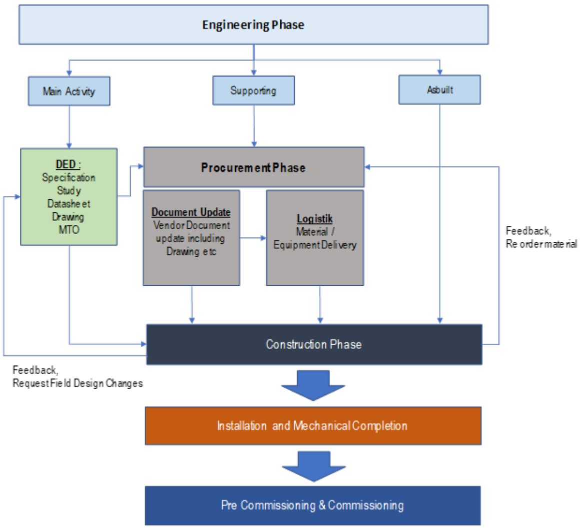

Figure 7. Relationship between engineering, procurement and construction on project life cycle

According to the first research of RQ1, obtaining the necessary data is through a literature study. The aim is to obtain parameters that influence each other through previous studies. In general, the literature study is used to get references that are appropriate or relevant to the problems raised.

The reference literature contains: From the indicator of variable X, does it affect the performance of logistics cost? The data analysis in stage 1 will use the Delphi technique, and the method is to obtain variables from valid references such as research journals, theses, and others.

To answer the second research of RQ2 a survey will be carried out by providing questions in the form of a questionnaire that will describe: What is the risk impact of variable X on the EPC project logistics process in remote areas? The criteria for respondents who will answer the questionnaire in the survey must have experience in EPC projects located in remote areas.

That applies equally to personnel positions in the engineering, construction, project control, and logistics departments. The purpose of the experience time specified by the author is that respondents are seen as having understood the work process in their respective fields and have a fairly good understanding of the interface between sections within the project management team.

At this stage, the author will validate the constituent variables and content through experts. The aim is to obtain relevant parameters or add variables that have not been listed. In addition, this validation is to obtain the exact definition of the "remote area" parameter so that respondents can easily understand appropriate project conditions. Criteria for experts who will become respondents in the research are experts from practitioners and experts from academics.

The author will validate the constituent variables and content through in-depth interviews (structured / semi-structured) and Expert Validation, the aims is to answer the third research of RQ3. In research, this questionnaire involved a total of 51 respondents. The respondent's background came from internal companies and was involved in the EPC project located in Indonesia with educational qualifications of 36 bachelor's degrees and 15 master's degrees.

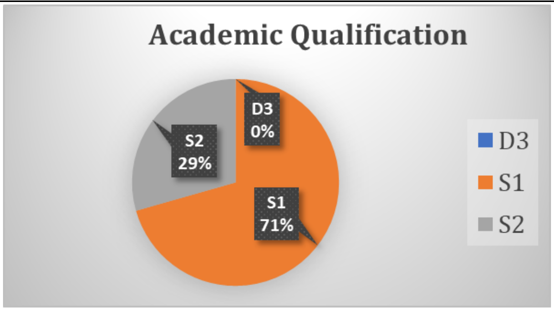

Figure 8. Academic Qualification

The survey results in figure 10 also show the experience of respondents over 5 and under 10 years by 49%, over 11 and under 15 years by 45%, over 16 and under 20 years by 4%, and over 20 years by 2%.

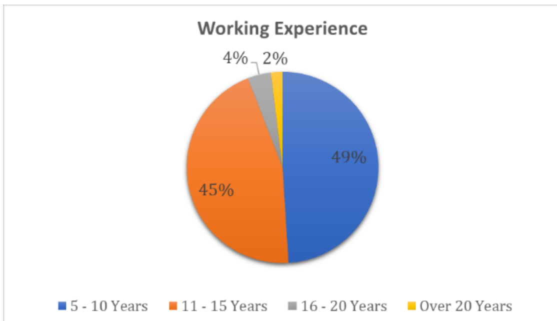

Figure 9. Working Experience

Validity And Reability Test

To measure the accuracy and consistency of the respondents' questionnaire answers, the validity and reliability tests were carried out by the author. The validity and reliability test were completed by the Pearson method and Cronbach's alpha.

Coefficient interval value:

Value of r calc > Value of r table

The Cronbach's alpha value used as a reference is:

If Value of cronbach's alpha > 0,7	Reliable
If Value of cronbach's alpha < 0,7	Not Reliable

Validity and reliability test for sub variable of X1 – Engineering, is obtained as follows:

Table 2. Variable X1. Engineering

Pearson Validity Test			
Variable	R Table 5%	R Calculated	Result
X1.1	0,281	0,77	Valid
X1.2	0,281	0,81	Valid
X1.3	0,281	0,79	Valid
X1.4	0,281	0,89	Valid
X1.5	0,281	0,84	Valid
X1.6	0,281	0,84	Valid
X1.7	0,281	0,85	Valid
X1.8	0,281	0,82	Valid

Varians Quantity	163,40
Total	1982,785714
Cronbach's Alpha Value	1,0
Cronbach's Alpha Value Reference	0,7
Result	Reliable

Validity and reliability test for sub variable of X2 – Construction, is obtained as follows:

Table 3. Variable X2. Construction

Variable	R Table 5%	R Calculated	Result
X2.1	0,281	0,83	Valid
X2.2	0,281	0,84	Valid
X2.3	0,281	0,83	Valid
X2.4	0,281	0,81	Valid
X2.5	0,281	0,83	Valid
X2.6	0,281	0,88	Valid
X2.7	0,281	0,86	Valid
X2.8	0,281	0,74	Valid
X2.9	0,281	0,80	Valid
X2.10	0,281	0,84	Valid
X2.11	0,281	0,82	Valid
X2.12	0,281	0,85	Valid
X2.13	0,281	0,87	Valid

Varians Quantity	280,05
Total	1430,307692
Cronbach's Alpha Value	0,9
Cronbach's Alpha Value Reference	0,7
Result	Reliable

Validity and reliability test for sub variable of X3 – Control System, is obtained as follows:

Table 4. Variable X3. System Control

Variable	R Table 5%	R Calculated	Result
X3.1	0,281	0,87	Valid
X3.2	0,281	0,91	Valid
X3.3	0,281	0,86	Valid
X3.4	0,281	0,89	Valid
X3.5	0,281	0,87	Valid

Varians Quantity	111,97
Total	1876,5
Cronbach's Alpha Value	1,2
Cronbach's Alpha Value Reference	0,7
Result	Reliable

Validity and reliability test for sub variable of Y1 – Sub Logistic, is obtained as follows:

Table 5. Variable Y1. Sub Logistic

Uji Validitas Pearson			
Variable	R Table 5%	R Calculated	Result
X4.1	0,281	0,90	Valid
X4.2	0,281	0,94	Valid
X4.3	0,281	0,93	Valid
X4.4	0,281	0,86	Valid

Varians Quantity	96,80
Total	618,25
Cronbach's Alpha Value	1,1
Cronbach's Alpha Value Reference	0,7
Result	Reliable

To analyze the risk level, a 4x4 heat map matrix will be used by the author. Where the matrix is the standard form given by the Company's author.

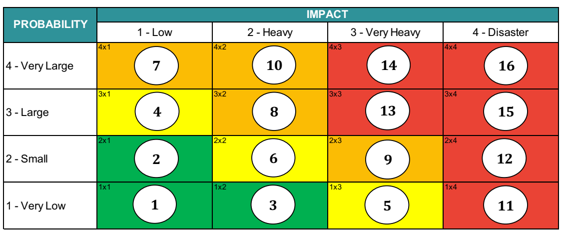

Figure 10. Risk Matrix

RESULTS

The results of a survey of 51 respondents showed that engineering, construction, control systems, and sub-logistics variables had an impact on cost performance. The questionnaires involved job levels from staff to project managers.

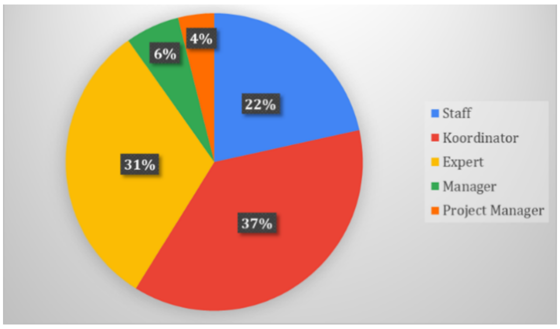

Figure 11. Job Level

Variable X1 has 8 sub-variables, where the questions given to respondents are asked to sort the frequency and impact values starting from those that have an effect to those that have less influence on the performance of logistics costs. The researcher used the criteria ideal score formula to obtain the risk level:

Table 6. Risk Categories for Engineering Sub-Variables

Variable & Sub Variable		%	RESULTS
X1	Engineering		
X1.1	Production Design	69,24	Extreme
X1.2	Engineering Changes	66,42	High
X1.3	MTO	70,83	Extreme
X1.4	Equipment / Material Changes	55,39	High
X1.5	Client Approval	64,71	High
X1.6	Site design	57,48	High
X1.7	Poor Engineering Design	65,81	High
X1.8	Lack of / Missing Interface	61,15	High

Variable X1.1 and variable X1.3 are sub-variables that fall into the extreme category with percentages of 69.24% and 70.83%. However, other sub-variables provide and show high-risk values.

For the construction variable - X2, it was shown in the table below that all sub-variables included in the high category have an impact on the performance of logistics costs.

Table 7. Risk Categories for Engineering Sub-Variables

Variable & Sub Variable		%	RESULTS
X2	Construction		
X2.1	Site Condition	61,15	High
X2.2	Damage or poor quality of material	54,41	High
X2.3	Error of working method	56,99	High
X2.4	Equipment/Material not in accordance with the design	50,37	High
X2.5	Unrealistic design to execution	45,96	High
X2.6	Construction work activity	55,76	High
X2.7	Rework	55,15	High
X2.8	The influence of climate and weather that often changes	49,88	High
X2.9	Project Crash on a project which is indicated to be delay	63,73	High
X2.10	The site visit process is not carried out with the correct stages	51,84	High
X2.11	Lack of QC supervision	53,19	High
X2.12	There are internal and external requirements that are not considered in the planning stage	54,66	High
X2.13	Inappropriate construction strategies	54,53	High

The smallest percentage shown in variable X2.5 is 45.96%, and the highest value is in variable X2.9 of 63.73%. The control system variable X3 has the smallest value in the X3.3 variable of 45.71%, and the highest value in the X3.4 variable is 58.09%.

Table 8. Risk Categories for Control System Sub-Variables

Variable & Sub Variable		%	RESULTS
X3	Control System		
X3.1	Traditional reporting system	46,32	High
X3.2	Unintegrated system	53,80	High
X3.3	There is no performance index for logistics	45,71	High
X3.4	Late payments to Vendors	58,09	High
X3.5	Incomprehensive logistics planning system	53,43	High

Meanwhile, the X4 sub-logistic variable has the smallest value in the X4.3 variable at 50.49% and the highest value in the X4.2

variable at 57.84%.

Table 9. Risk Categories for Sub Logistic Sub-Variables

Variable & Sub Variable		%	RESULTS
X4	**Sub Logistic**		
X4.1	Warehouse	54,66	High
X4.2	Transportation	50,49	High
X4.3	Packing & Handling	57,84	High
X4.4	Facility Location	55,27	High

Researchers also asked questions regarding whether each component of the sub-variables affects the sub-logistics variable such as warehouse, packing & handling, transportation, and facility location. The results answer from the 51 respondents is shown in the table below:

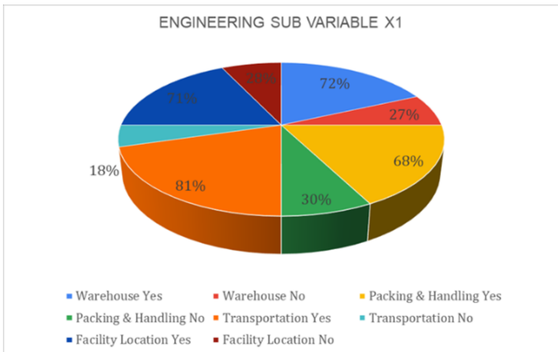

Figure 12. Summary of Respondents' answers to the influence of the variable Engineering components on the sub-logistics components

The picture above is related to the risk factor component of the engineering sub-variable which is dominated by high and extreme in line with the respondents' answers to the influence and impact on the logistics sub-variable, namely warehouse with a percentage of 72%, packing & handling 68%, transportation 81% and facility location 71%.

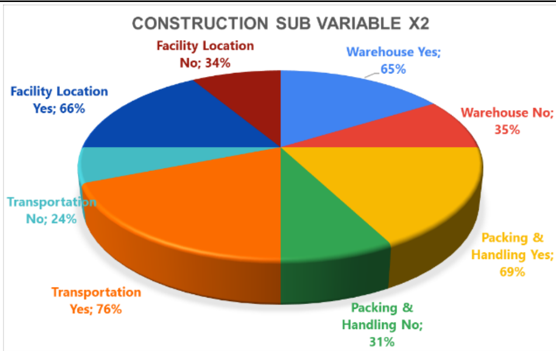

Figure 13. Summary of Respondents' answers to the influence of the variable Construction affected on sub-logistics components

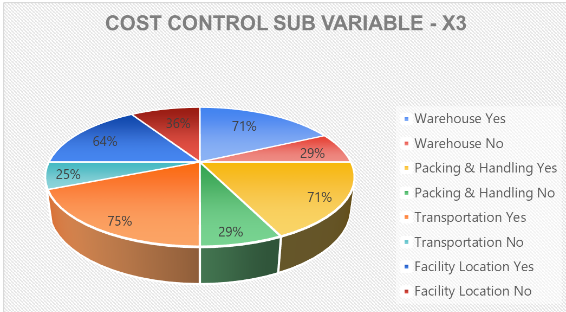

Figure 14. Summary of Respondents' answers to the influence of the variable Construction affected on sub-logistics components

According to respondent's answer that shown on figure 12, from the total question of sub variable X2 were affected transportation with percentage 76%. Same case with the variable X3 that shown on figure 13, cost control sub variable affected the transportation with percentage 75%.

DISCUSSION

The purpose of this research is to find out which sub-variables influence the logistics cost performance and has a major affected on the overall cost performance.

The final result of answers from respondents who have been involved in EPC projects located in remote areas that the general factors of the engineering, construction, and control system variables have major impacted the sub-logistics component and ultimately affect the performance of logistics costs.

This research intends to focus on the logistics links of EPC projects located at remote area specific in Indonesia, explore the risks of the EPC variables, sub logistics, and analyze by proactive and reactive follow up plan .

Several previous literatures mentioned several alternative solutions, including:

- To manage procurement risks, contractors have good interfaces with suppliers around the world, which enhances information sharing and efficient decision-making in handling equipment design, manufacturing, logistics, installation, and commissioning (Yang et al., 2019).
- In the case of EPC project uncertainty, the first solution is to estimate project completion time, optimize project resource investment, and conduct a project risk assessment (Ou-Yang & Chen, 2019)
- Research on project risks is very effective in making decisions to reduce the level of risk exposure of construction projects (Marle, 2020).
- Identifying the key factors of construction project logistics risks and taking effective measures will facilitate the smooth completion of construction projects and ensure the quality and safety of construction projects (He & Han, 2022).

After identifying risk variables items with extreme and high-risk values, The follow-up plan is carried out by proactive and reactive actions. Pro-active and reactive is conducted through discussions and interviews with respondents with at least 5 years of experience, with a minimum education level of S1, and experts.

The results of these follow-up actions become feedback for the company to face similar tenders to improve logistics cost performance which indirectly increases or maintains project margins according to the initial planning stages.

From the results of correspondence with the respondents and expert validation that the strategic plan of sub-variable engineering consists of;

SUB VARIABEL	
X1.1. Production Design	
RISK COST	
Cost overrun on logistics and construction	
RISK LEVEL	
Extreme	
FOLLOW UP PLAN	
Pro Active	- The organizational structure preparation before the kick off meeting with the project owner / when the contractor already declared as the winner.(*B) - Management decission related to project scope (for alternative design). (*B) - By using project lessons learned for similar tenders. (*E) - Verify the FEED document during the tender, if a dispute is found, it is necessary to submit a deviation list in the proposal, carry out with re-site survey or extend the survey period. (*E) - Verify conformity of manhours with engineering manpower during implementation. (*E) - Verify the suitability of the vendor schedule
Reactive	- CO/TQ submission related to cost & time. (*B) - Project management to consider an additional cost. (*B) - Additional manpower / MH engineering during a certain period. (*E) - Involvement of lead/ senior engineer (*E) - Join review and project visit to subcon fabrication place. (*E)

SUB VARIABEL	
X1.2 Engineering Changes	
RISK COST	
Cost overrun on logistics and construction	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- For project scopes with high complexity/lack of experience that will impact performance guarantees, it is recommended to join operations with other partners (JO) / KSO) to risk share or a third partner of engineering Subcon. (*B) - Involve lead / senior engineering in design and review documents, technical clarification with JO partners/vendor and licensor/package. (*E) - Conduct a technical query (TQ) if there is an unclear gray area/battery limit (BL). (*E) - Involve lead / senior engineering in the design & review of tender documents. (*E) - For the project key documents, it is recommended to carry out by internal discipline check (IDC) process. (*E) - By using project lessons learned for similar tenders. (*E)
Reactive	- Project management to consider an additional cost. (*B) - Re design including project specs, finding the short time of material delivery, and doing VA/VE which is minimum impact on another system. (*E) - Involvement of lead / senior engineer during design review. (*E) - for new project with an major issue recommended to use engineering third party. (*E)

SUB VARIABEL	
X1.3 MTO	
RISK COST	
Additional cost claims from 3rd parties, direct & indirect costs	
RISK LEVEL	
Extreme	
FOLLOW UP PLAN	
Pro Active	- Using allowances in the calculation of material take-off (MTO) of bulk materials. (*E) - The MTO calculation process for bulk material items needs to use integrated engineering software (*E) - Use of integrated material codification. (*E) - For vendor key documents such as drawings, datasheets, and equipment dimensions, it's mandatory and needs to be IDC processed. (*E) - Every construction work has a work package (WP) procedure. (*C)
Reactive	- Proposed substitution of materials / work methods modification that may have an impact on adding materials / standby equipment. (*E) - Re-order materials with consider the material delivery time, to avoid standby manpower of subcontractor & late payment. (*S) - Have a database of local resource including consumable materials by conducting surveys. (*P)

SUB VARIABEL	
X1.4 Equipment / Material Changes	
RISK COST	
Additional costs for packing, replacement of heavy equipment / material handling, & transportation	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- If not clearly mention on ITB document, mandatory to raise TQ during tender stage. (*E) - Every key document including vendor key document must be IDC to other function. (*E) - A joint review/constructability review is needed when progress achieves 30%, 60%, and 90% of the participant's need involves engineering, construction, key vendors, the operations team, and end users. (*E)
Reactive	- Involvement of lead / senior engineer during design review. (*E) - Involvement of construction expert for review of work method. (*C)

SUB VARIABEL	
X1.5 Client Approval	
RISK COST	
Additional cost of heavy equipment / material handling, warehouse & transportation	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- Project communication is needed between the project manager of the contractor and the project owner for the critical items / overdue document which is impact project delay. (*B) - Need notification from project management to project owner for every issue log which's impacts project delay. (*B) -Need to develop a project approval procedure, for the critical document project team must be conducted join the review, and use the digital system for document management. (*E) - The reminder process is carried out through a management meeting agreed upon via MoM, informing through analysis delays, using standard allowances, and project lessons
Reactive	- CO/TQ submission to project owner. (*B) - Join review with the project owner at the same place. (*E) - Propose the project delay notification and analysis to project owner . (*P)

SUB VARIABEL	
X1.6 Site design	
RISK COST	
Additional cost of heavy equipment / material	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- Use of standards from during site visits. (*E) - Involve lead / senior engineering in design and review documents,, Using project lesson learned / project database (*E) - Create logistic plan in to proposal document and make sure the PPC, SCM and Project manager already comprehend in to tender cost. (*S) - Create a plan for warehouse, laydown, fabrication, temporary office during tender
Reactive	- Involvement of lead / senior engineer during design review. (*E) - Involvement of construction expert. during design review. (*C) - Re site visit after project owner announce the winner. (*C) - Re soil investigation if the result is not match, the project team proposed TQ / CO. (*C)

SUB VARIABEL	
X1.7 Poor Engineering Design	
RISK COST	
Project delay, additional cost for purchase of materials, logistics	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- Agreed with management for use for MTO or cost allowance. (*B) - If not clearly mention on ITB document, mandatory to raise TQ during tender stage. (*E) - Doing re site visit when the project owner announce the winner. (*E) - Make a consortium partner to share risk or using engineering third party. (*E) - Use of integrated software such as 3D modelling or BIM software. (*E) - Using familiar international codes & standards. (*E) - By selecting qualified or using an experienced engineer during project execution, and
Reactive	- Re-verify of FEED documents during KOM with clients, and Involve Leads / Senior engineers. (*E) - Re design and Involve Lead / Senior engineer for the review / verification process. (*E) - Use of integration software such as 3D modeling / BIM. (*E) - Update on level 3 engineering procedures. (*E) - Re-order materials with consider the material delivery time, to avoid standby manpower of subcontractor & late payment. (*S) - Re site visit after project owner announce the

SUB VARIABEL	
X1.8 No / Missing Interface	
RISK COST	
Additional costs for warehouse rental, transportation, packing & handling, subcontracting manpower and delays in construction	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- For tenders with high complexity, it is necessary to plan an organizational structure that takes into account the existence of a project engineer/project interface. - IDC requires an interdisciplinary engineering team, and key doc agreement required IDC and involves licensor in constructibility review or involved on hazid-hazop study. (*E)
Reactive	- Add project engineer / project interface personnel or conduct intersection meetings. (*B) - Holding a joint review meeting with licensor / package vendors & additional manpower responsible for interfaces such as PE. (*E) - Involvement of lead / senior engineer during design review. (*E) - The competence selection of engineers who are involved in the project with criteria of similar project experiences, and conduct training for

Variable X1.1 and X1.3 became an extreme risk because there was a major gap/deviation between planning versus actual design. The example case is pipe rack route changes impacted to additional steel structure, foundation, re-design, etc. In other cases, changes in equipment capacity will cause additional cable capacity, tray, foundation, and accessories. Finally, the MTOs cannot be fixed and will be impacted in the procurement and construction stages. Because the project schedule is very tight, the project team usually makes partial purchase orders, delivery, packing handling, and transportation.

The follow-up and strategic plan for the construction sub-variable (X2) are consist of;

SUB VARIABEL	
X2.1 Site Condition	
RISK COST	
Delays in construction activity (increasing overhead manpower cost for cathup schedule), additional costs for standby equipment material handling, rental for heavy equipment	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- Calculating the risk cost into the tender proposal (*B) - Transportation procedures are required and become an attachment of the RFQ in this case the subcontractors / vendors will accommodated costs in bidding proposal. (*S) - During site visit need to be detail check. (*C) - Create construction execution plans, submitting TQ related to work areas, facilities and fabrications area that may be provided by the client. (*C) - Additional MTO / work method for access improvement. (*C)
Reactive	- Submit to the project owner for the CO process. (*P) - Additional engineering manhours caused by additional deliverable lists. (*E) - Conduct a re-site survey, if there is a change / gap from the original contract, it's subject to additional costs. (*C) - Additional of manpower, tools, equipment & construction. (*C) - Additional material for road access improvements to increase productivity. (*C)

SUB VARIABEL	
X2.2 Kerusakan atau kualitas material	
RISK COST	
Additional costs for repurchasing materials, transportation, packing & delays in construction work	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- Create packing & material handling procedures, shipping plan procedures. (*S) - Conduct pre inspection meeting / shop inspection. (*Q) - Create ITP procedures agreed upon with the owner. (*Q)
Reactive	- Additional manhours for re-ordering materials such as MR, MTO, drawing, datasheet, etc. (*E) - Additional manhours for re-orders, change of third-party logistics & re-inspection of the vendor manufacture. (*S) - Re-order materials with consider the material delivery time, to avoid standby subcon manpower / material handling. (*E) - Re FAT by remote / digital if needed

SUB VARIABLE	
X2.3 Improperly Working Method	
RISK COST	
Additional costs for repurchasing materials,	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- Required the IDC process, and joint review when constructability progress is 30%, 60% and 90%. (*E) - Additional construction experts are needed to review work methods. (*E) - Planning for training and reviewing the competence of construction or subcontractor evaluation. (*E) - A site survey is needed to identify local resource such as man power skills, tools, raw materials etc (*E)
Reactive	- Changing of work methods to be more effective and efficient requires additional Manpower, & Tools. (*C) - Need additional QC experts to review the work methods. (*Q)

SUB VARIABLE	
X2.4 Equipment/Material not in accordance with the design	
RISK COST	
Additional costs for purchasing materials, transportation, packing & delays in construction work	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- Required the IDC documents with related function. (*E) - When the material/equipment has been installed at site to involve or invite the relevant vendor to get advice. (*E) - Each material/equipment installation must be provided with typical drawings, tagging and shop drawings. (*E) - Involve the engineering experts to review documents. (*E) - Involve the construction experts to review documents. (*C)

Reactive	- Additional lead / senior engineer to review document design. (*E) - Additional material is carried out immediately via air freight or the fastest transportation to avoid manpower / equipment standby. (*S) - Additional costs for vendor supervision to ensure modifications align with performance guarantee. (*C)
SUB VARIABLE	
X2.5 Unrealistic design to execution	
RISK COST	
Construction delays (increasing overhead manpower cost for cathup schedule), costs for purchasing materials & logistics	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- Required the IDC documents with related function. (*E) - Required engineering software, for example 3D modeling. (*E) - Substitution of work methods/equipment modification. (*C) - Need vendor supervision during installation activity at site to minimize re work or missing part (*C)
Reactive	- Additional manhours for redesign of drawing. It is necessary to join review with the client if the design change is major. (*E) - Additional manhours for re-orders, third-party logistics & re-inspection of the vendor manufacture. (*S) - Additional work for Subcon and standby material handling. (*C) - Additional mandays rate for vendor supervision at site. (*C)
SUB VARIABLE	
X2.6 Construction work activity	
RISK COST	
Construction delays, costs for purchasing materials & logistics	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- Required control sheet for picking up material in the warehouse example cutting list, bulk material, etc (*C) - Involve construction experts to review vendor documents. (*C) - Using smartplan software for construction activity (example material will be installed in real time and easy to monitoring). (*C)
Reactive	- Looking for the best delivery time for material reorders to avoid standby manpower of subcontractors and material handling (*S) - Additional experts for vendors / subcontractors supervision to review. (*C) - Additional software to monitoring material installation as real time. (*C)
SUB VARIABLE	
X2.7 Rework	
RISK COST	
Construction delays (increasing overhead manpower cost for cathup schedule), costs for purchasing materials & logistics	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- Required control sheet for picking up material in the warehouse example cutting list, bulk material, etc (*C) - Involve construction experts to review vendor documents. (*C)
Reactive	- Looking for the best delivery time for material reorders to avoid standby manpower of subcontractors and material handling. (*S) - Additional experts for vendors / subcontractors supervision to review. (*C)
SUB VARIABLE	
X2.8 The influence of climate and weather that often changes	
RISK COST	
Construction delays (increasing overhead manpower cost for cathup schedule), costs for purchasing materials & logistics	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- Required work methods plan that adapt to weather conditions. (*C) '- Schedule planning involves the general condition of the work area so that work productivity can be adjusted. (*P) - Use of project lessons learned and databases of similar projects. (*P)
Reactive	- Adding supporting tools in case of a bad weather by tarpaulin, geotextile, platform, etc. (*S) - Additional fabrication/warehouse & supporting material in case of bad weather. (*C) - HSE notifications for events such as stopping working due to bad weather or use recording by CCTV. (*H)

SUB VARIABLE	
X2.9 Project Crash on a project which is indicated to be delay	
RISK COST	
Construction delays (increasing overhead manpower cost for cathup schedule), costs for purchasing materials & logistics	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- Local worker productivity analysis. (*C) - Organize regular training for local workers. (*C) '- Construction planning using project lesson learn / database, carried out in detail both strategy preparation, productivity, manpower planning, and use of tools. (*P) - Provide notification to the project owner if problems are found due to external factors. (*P)
Reactive	- Conducting an analysis of the productivity of the local worker & adding skilled workers from outside the region. (*C) - Additional scheduler for the construction team so that mitigation and delay analysis can become a work reference. (*P)

SUB VARIABLE	
X2.10 The site visit process is not carried out with the correct stages	
RISK COST	
Additional logistic cost	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- Conducting site visits according to the standard form, preparing the TQ during site visit and focus on critical part such as tie in, laydown, temp facility location, warehouse, and client regulation. - Required the expeditor / logistic team to participate in the site visit. (*C)
Reactive	- If possible the expeditor team is involved in the site visit process. (*S) - Extend the time to conduct site visits. (*C)

SUB VARIABLE	
X2.11 Lack of QC supervision	
RISK COST	
Additional logistic cost	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- Involve the engineering team to review ITP documents from related manufacturers. (*E)
Reactive	- Additional QC experts for supervision. (*Q)

SUB VARIABLE	
X2.12 Lack of QC supervision	
RISK COST	
Construction delays (increasing overhead manpower cost for cathup schedule)	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- During the site visit, the survey team identified work procedures, permits, safety aspects, and other local regulations. (*C)
Reactive	-Develop HSE procedures and become an attachment to the RFQ (*H)

SUB VARIABLE	
X2.13 Inappropriate construction strategies	
RISK COST	
Delays in construction (increasing overhead manpower cost for cathup schedule) and logistics costs	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- Required a planning and coordination between construction team, SCM and project control as periodically to ensure the material priority to be installed and delivered to site immediately. (*C)
Reactive	- Additional scheduler for the construction team, in order to make notification what is a priority from the material to be installed first. (*P)

Variable X2.1 and X2.9 are high-level risks because the site condition can not be predicted accurately. Even though the contractor already made the allowance/contingency in the planning stages but there was still a big gap due to the result of the soil investigation versus the ITB document. If the project faces a crash because of too many problems, The project team needs to prepare material handling / heavy equipment and tools from outside.

The follow-up and strategic plan for the control system sub-variable (X3) are consist of;

SUB VARIABLE	
X3.1 Traditional reporting system	
RISK COST	
Additional logistics cost	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- During planning, the engineering team provides an equipment list and needs the IDC to the construction and SCM team. - During clarification also involves the lead / senior engineer, and construction expert. (*E) - Control sheets from the SCM team are periodically carried out by IDC to project engineers, PPC and Construction. (*E)
Reactive	- Need an integration system software between contractor, subcontractors and suppliers (*S) - Requires a barcode system or use of RFID system for tracking material or placing materials. (*C)

SUB VARIABLE	
X3.2 Unintegrated system	
RISK COST	
Logistics costs (transportation costs, laydown/warehouse rental, ship demurrage & charter ships) & equipment rental for material handling	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- The IDC system is done through system/software integration.. (*E) - Vendor monitoring system is carried out through system/software integration. (*S) - If there is a design change in the field, the construction team must make a field design change (FDC) and inform to Engineering team. (*C)
Reactive	- Involvement of lead / senior engineer during design review. (*E) - Need an integration system software between contractor, subcontractors and suppliers. (*S) - If there is a backlog, it is necessary to convey information through a management meeting and its overdue. (*S) - PE / Project interface involvement is required to coordinate with related functions. (*S)

SUB VARIABLE	
X3.3 There is no performance index for logistics	
RISK COST	
Logistics cost planning for uncontrolled realization, and well monitored.	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- Create the KPIs during the vendor engineering design, fabrication, FAT inspection, and delivery to on-site material by involving dedicated personnel. (*S)
Reactive	- Create the KPIs during the vendor engineering design, fabrication, FAT inspection, and delivery to on-site material by using integrated system (*S)

SUB VARIABLE	
X3.4 Late payments to vendors	
RISK COST	
Additional logistics costs (transportation costs, laydown/warehouse rental, ship demurrage & charter ships)	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- An integration process is required through software/web base so all activity will be monitored online and avoid errors / missing. (*S) - Required strategy for terms of payment and clear requirements to the vendor during the final negotiation. (*S)
Reactive	- Make coordination with project management to create a strategy for payment priority. (*B)

SUB VARIABLE	
X3.5 Incomprehensive logistics planning system	
RISK COST	
Realization of logistics costs (transportation costs, laydown/warehouse rental, ship demurrage & charter ships)	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- During the site visit involves the expeditor creating a strategy, and making a logistics plan taking into account the location of the warehouse, shipping goods from overseas, and sea/land transportation. (*S) - Create shipping plans, lay down materials, and temporary facilities plans. (*S) - For high-risk shipments, use third party services up to MOS or become a vendor's scope. (*S) - Use an integrated system for communication between project management and make coordination between PPC, SCM, and Construction regularly. (*S)
Reactive	- Find alternative jetty to accelerate loading unloading material and using shipping independently (not using public transportation) (*S) - Conduct surveys to locations as independently to obtain data: land transportation. Heavy equipment, aggregate, query, warehouse, mess etc. (*S)

Variable X3.4 has a high-risk level than others because late payments to vendors or subcontractors make the activity will slow down and delivery equipment are not in line with the schedule. Delays in equipment delivery will make changes to the logistic plan and impact the cost.

The follow-up and strategic plan for the Sub Logistic sub-variable (X4) are consist of;

SUB VARIABLE	
X4.1 Warehouse	
RISK COST	
Construction delays, purchasing costs for materials, warehouse, packing handling and transportation	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- Integrated system planning, for example the use of CCTV connected via cellphone in real time. (*E) - Use of CCTV, & others technology such as QR code/RFID technology, or warehouse management system. (*S) - Create preservation procedures and construction strategy if laydown and warehouse capacity are limited.. (*C) - Separate the flammable materials by identifying them through the Material Safety Data Sheet (MSDS). (*C)
Reactive	- Required coordination with local residents for the security process through social programs. (*B) - Use of an integrated system. (*S) - Required coordination with vendors/suppliers related to the material preservation process. (*C) - Construction strategy by adding tools/manpower to speed up the material installation process with consider the first priority material coming to the site. (*C) - Add security officers or CCTV for areas that are not monitored. (*C)

SUB VARIABLE	
X4.2 Transportation	
RISK COST	
Construction delays, purchase costs for materials, warehouse, packing handling and transportation	
RISK LEVEL	
High	
FOLLOW UP PLAN	
Pro Active	- A strategic decision from the Project Manager by considering the schedule and impact delay.(*B) - Involvement of a lead/senior engineer is required for the design review process.. (*C) - Before shipping, it is necessary to carry out a Pre-Inspection to ensure that the packing handling and transportation are in proper condition. (*C) - Create a expediting plan, make coordination with vendors and the use of an integrated system. (*C) - Identification of the material/equipment arrangement on vessel and review the process of lifting and unloading material at the jetty can run smoothly, especially for materials/equipment that have large dimensions. (*C) - Make Coordination with the logistics to find out the shipping capacity. (*C) - Required management meeting for the activity to be carried out in the next 2 / 3 weeks. (*P) - Analyzing vendor schedules and logistics routes including roads, jetty, transportation, and permits mainly for the equipment that has large dimensions when access through remote locations. (*P)
Reactive	- Inspection is required before the material arrived at the site, including packing & handling, and transportation of the vehicle used. (*S) - Carry out the selection & evaluation of logistics transportation by assessment selection criteria. (*S) - Collaborate with suppliers/vendors regarding alternative routes and cooperate with the local police/transportation agency, for example, opening and closing main routes. (*S) - To minimize material damage, a supervision is required by the vendor/supplier for inspection of packing material. (*S) - If possible before the material delivery to site, it is necessary to place materials consolidated in one place, then use a transportation lease to send materials together. (*S) - Delegating and coordinating with generalship logistics related to material dimensions so that the unloading process can run smoothly. (*S) - Conduct a review of the material on-site. engineering drawings and involving construction experts. (*C) - Involvement of construction experts to review

Legend:

- (*B): Responsibility by BOD or Project Management
- (*E): By Engineering Team
- (*S): By Procurement or SCM
- (*C): By Construction team
- (*P): By PPC (Project Planning & Control) team
- (*Q): By Quality Control team
- (*H): By HSE (Health Safety & Environment) Team

Abbreviation:

- CO: Change Order
- FAT: Factory Acceptance Test
- IDC: Intern Discipline Check
- ITP: Inspection Test Plan
- JO: Joint Operation
- KOM: Kick off Meeting
- KPI: Key Performance Index
- MoM: minutes of meeting
- MOS: Material Onsite
- MTO: Material Take Off
- PE: Project Engineer
- PMS: Project Master Schedule
- RFQ: Request for Quotation
- SCM: Supply Chain Management
- SOW: Scope of Work
- SOS: Scope of Supply
- TQ: technical Query

CONCLUSIONS

From the presentation of the data above, it can be concluded several important notes from this paper, namely:

- The projects are located in remote areas, having good planning is mandatory because not all materials are available at the local site, especially since the materials are delivery from abroad. the plan includes a project execution plan, engineering execution plan, procurement execution plan (warehouse, delivery, and site facility location), construction execution plan, and project control execution plan.
- The use of digitalization and integration system for the implementation of EPC projects is vital to minimize problems

that occur in the engineering, procurement, control system and sub-logistics implementation processes.

- The use of lessons learned and project databases is very important to use as a basis for a proposal's budget plan.
- Being sharp in reviewing and finding disputes / deviations / battery limits / gray areas in invitation to bid (ITB) documents is one of the factors in project cost control.
- In the case of a tender for a plant that has a high level of difficulty or complexity, good and detailed planning is required, such as conducting a JO with an experienced company including SOW/SOS, using a third party in terms of engineering design, and conducting an ongoing training program.

From the description above, first, the results from one case study maybe still limited for generalization because all data is coming from an internal or single EPC company. Investigation of a multi number of projects on different companies may provide more evidence and comprehensive results. Second, the author did not include external factors as variables that affect the performance of logistics costs. This research also inline with the previous study, Where the recommendation is In the future, it would also be worthwhile to analyze any research related to the measurement of logistics costs in companies (Muha, 2019).

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