Management Analysis Journal 14 (4) (2025)

http://maj.unnes.ac.id

THE DESIGN OF PROJECT RISK MANAGEMENT TO MITIGATE PROJECT DELAY IN ONSHORE CONSTRUCTION INDUSTRY (A CASE STUDY OF A SHORE PROTECTION PROJECT)

Firdaus Yusri Muhammad[1]✉, Gatot Yudoko[2], Muhammad Hanafi[3]

[1,2,3]School of Business and Management, Institute of Technology Bandung, Indonesia

Article Information

History of article:
Accepted 08 October 2025
Approved 13 November 2025
Published 01 December 2025

Keywords:
Project Delay, Current Reality Tree, Future Reality Tree, Project Risk Management

Abstract

This study research focuses on a three-month delay in a shore protection project undertaken by PT Sabar Sejahtera, which resulted in financial, time, and opportunity losses. Electricity is essential for human life and can be generated in various ways; therefore, the construction of power plants must be well planned. Effective project planning helps manage resources and schedules, while poor planning can lead to project delays. This study aims to identify the root causes of the delay, propose solutions and mitigation plans, and develop a lessons learned register. A mixed-method approach was employed, including focus group discussions and Risk Priority Number (RPN) analysis. The Current Reality Tree identified two main root causes: systematic errors during the tendering and planning stages and the absence of a mitigation plan. The Future Reality Tree demonstrated that involving multiple departments and correcting systematic errors could prevent similar issues in future projects. To manage project risks, this study applied the PMBOK 6th Edition project risk management framework, covering risk identification through monitoring. The lessons learned register highlights the importance of early planning, appropriate working methods, and a comprehensive risk mitigation plan. The company is encouraged to adopt this approach in future projects.

✉correspondence Address:
Jl. Ganesa No.10, Lb. Siliwangi, Kecamatan Coblong, Kota Bandung, Jawa Barat 40132
E-mail: firdaus.yusri99@gmail.com

e-ISSN 2502-1451

INTRODUCTION

Electricity is one of the core utility for human being. These utility can be obtaining through various method such as, coal. The total power generation in Indonesia is still dominated by fossil fuels, reaching 62,399 MW (ESDM, 2021). The need for electrical energy in Indonesia is expected to continue to increase in the future. Power plants in Indonesia must be planned carefully to anticipate the increase in the need for electrical energy. Planning a construction for coal power plant is complicated due to coal power plant have many critical part that require precision in constructing such as, boiler and cooling water pipe. Therefore, require precise project planning in construction this. Project planning is a very crucial stage in project management that aims to organize, direct, and manage resources, schedules, and tasks effectively so that the project can be completed according to the goals, budget, and time that have been determined.

Project Management have triple constraint to create a successful project which is, scope, schedule, and cost. Scope is the work for the project that will be cover, time is how long will the project take to complete, and cost is how much cost for the project and what resource are needed (Schwalbe, 2017). But, some project may suffer from project delays due to various reasons such as, bad planning and scheduling, Inefficient Resource Management, and Delay in Procurement of Materials or Equipment. Project delays have negative effect on the project in terms of performance, time, and cost (Goyal et al. 2023). according to Carvalho et al. (2021) delay in construction project cause by 4 major factors which is management, manpower management, project management, and management of climatic conditions. Whereas, according to Viles et al. (2019), there are 3 main problems that represent 80% of the causes, which is problem that occur during execution, administrative problem, and labor conflicts. Thus, project planning requires precise and exact project planning to avoid this project delays.

PT Sabar Sejahtera is an onshore construction company that founded by experienced professionals. PT Sabar Sejahtera have finished project across Indonesia such as, CW pipe 2 x 1000 MW at Batang coal power plant, and many others. PT Sabar Sejahtera in CW pipe 2 x 1000 MW project have many activities, such as, and shore protection. PT. Sabar Sejahtera suffer major losses in financial aspect due to project delay in completing the shore protection project. Shore protection project is started at November 2022 and planned to finish at April 2023, but due to the project delay the project is finished at July 2023. These 3 month's delay impacted in major financial loss to PT. Sabar Sejahtera due to different contract type which is the lump sum contract. In this contract. all project costs, including labor, materials, and overhead, are specified in a fixed amount. Thus, makes PT. Sabar Sejahtera suffer a catastrophic loss. Shore protection project is valued at Rp. 53.310.069.750.

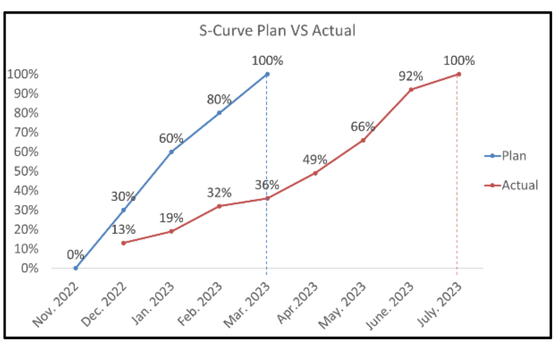

Figure 1. Difference S-curve between plan and actual

Based on the plan shore protection project will be finished by 5 months until April 2023. But, in the project realization there are delays that happen in shore protection project that affecting delaying the completion of the project. Figure 1 shows a huge difference of S-Curve between the plan and the actual from shore protection project. The first difference is the starting time of project; the actual project is starting at December while it is planned to start at November.

This late starting time of the project affecting low productivity in the first stage of the project. Besides that, the actual project also run into several problem as it is shown that the project plan is complete at march while the actual only have 36% project completed in march These shore protection construction delay impact in financial losses, time losses and even opportunity losses for PT Sabar Sejahtera. This delay may affect by many factors, thus needed in depth analysis for this problem and providing the solution for this project delay problem and mitigation plan is needed to prevent this project delay case will happen in future project or other project. Besides that, lessons learned register also needed for a describing the effects, suggestions, and steps for comparable future situations.

METHOD

Table 1. Mapping Objectives

Objectives	Methods	Tools
Root Causes of Shore Protection Project	Qualitative	Group discussion
Propose Solution and Mitigation Plan	Qualitative & Quantitative	Group discussion & Risk Management Framework
Lessons Learned Registers	Qualitative	Group discussion

This research is conducted using a mixed method of quantitative and qualitative research. Qualitative method that is used in this research is group discussion with PT Sabar Sejahtera stakeholders and people that heavily involve in shore protection project. This group discussion will collect detailed information about the project delay in the shore protection project and allowing to explore the complex interaction that happen in project through discussion. Quantitative method that is used in this research is the mitigation plan that conduct by risk management framework method to provide step by step approach to assess and mitigate the risk. This risk management framework will identify the risk, analyze the risk, develop mitigation plan, and develop the implementation plan for PT Sabar Sejahtera project.

The risk management framework will be the second topic discussion in the group discussion with author presenting the risk management framework to participant and discuss about the risk management framework. Besides that, the quantitative analysis in this research will be done by failure mode and effect analysis that applied to asses improvement steps on the more general development method is applied by conducting a risk assessment using three critical stages, the severity with an evaluation of the level of impact of the problem, occurrence by analyzing how often the cause of errors occurs and detection by researching the ability of the product or process control to detect the cause of the problem or failure mode (Velasquez, et al., 2021). Failure mode and effect analysis in this research give score severity (S), likelihood (L), and inability to detect (D) of each potential risk that have been discussed in the group discussion. The scoring is done by discussion in the group discussion for each potential risk.

The scoring will be 1 to 10-point score (Liu, et al., 2013). After scoring of severity, likelihood, and inability to detect for each potential risk, will conduct calculation of risk priority number by multiplying severity, likelihood, and inability to detect of each potential risk. By calculating the risk priority number, each potential risk will have different score based on their priority with the highest score meaning have highest priority and lowest score have lowest priority. Data analysis conduct through analyzing group discussion MoM and transcript for the the first and third objective, while for the second objective which is propose solution and mitigation plan the data analysis is based on discussion interaction, group discussion MOM, and project risk management framework. Then, conduct a data validation by sharing the findings into group discussion participant in order to confirm the accuracy and to enhance the credibility.

RESULT AND DISCUSSION

Root Causes Analysis

Root cause analysis in this research is done by qualitative research by conducting group discussion with PT Sabar Sejahtera stakeholder that heavily involved in shore protection project. Group discussion that conduct with PT Sabar Sejahtera stakeholder is discussing the root cause of project delay in shore protection project from all aspect that involve in shore protection project, and the main root cause of project delay. Besides that, the group discussion also discusses the relation between each root cause from the main root cause. The root causes analysis is done by analyzing current reality tree. current reality tree (CRT) is a statement of the underlying core problem and the symptoms that arise from it (Dettmer, 1997) or in other words, Current reality tree is use for identifying and analyzing root cause problem of the project delay in shore protection project from different aspect.

Based on the group discussion with PT Sabar Sejahtera, there are 13 root causes that result to project delay of shore protection project which is, Inexperienced workers and project lead that handle the shore protection project, workers lack of rest hour, heavy machineries often break down during work, inappropriate machine availability for work, delay in supplying material to project area, material quality is not up to standard, not fixed work sequence in shore protection project, changing work method in the middle of project, delay of procurement in material and equipment, material and equipment different from the one that requested, wrong choice of contract management vendor, weather forecast error, systematic error at tender and planning stage. this systematic error includes in lack of mitigation plan that provide by PT Sabar Sejahtera. This become a domino effect of the project delay shore protection project.

The current reality tree is use to show a cause and effect of each root cause problem that create an undesirable effect. Based on the current reality tree on figure 2, show The main root cause problem is systematic error in tender and planning stage impacting to wrong choice of contract management vendor and miss budget plan when tendering and execution. Besides that, there are others main root cause problem to this delay which is lack of mitigation plan thath affecting to miss budget plan when tendering and execution. Both of this problem resulting in miss man-hour, machine, material, and others budget plan. This problem first impact to tight machinery budget plan and there is no forecast for machinery for the shore protection project that resulting in supply chain department late to procure the machine due to finding the lowest price vendor and no guidance's or standards for the machinery that need to come to project area. Both of this problem resulting two of the same result which is heavy machine often breaks down during works (UDE 3) and inappropriate machine availability for work (UDE 4).

Due to this heavy machine problem and inappropriate machine availability, PT Sabar Sejahtera experience lack of trust from their main contractor that resulted in not fixed work sequence in shore protection project (UDE 7) and PT Sabar Sejahtera main contractor often change the work method in the middle of project (UDE 8). This problem resulting in project delay in shore protection project. In Conclusion, In conclusion, the main root cause that creating many domino effect in this project delay at shore protection project by PT Sabar Sejahtera is systematic error at tender and planning stage and lack of mitigation plan. Therefore, author propose solution to tackle this systematic error problem and mitigation plan for PT Sabar Sejahtera future project to mitigate risk that can happen in PT Sabar Sejahtera future project.

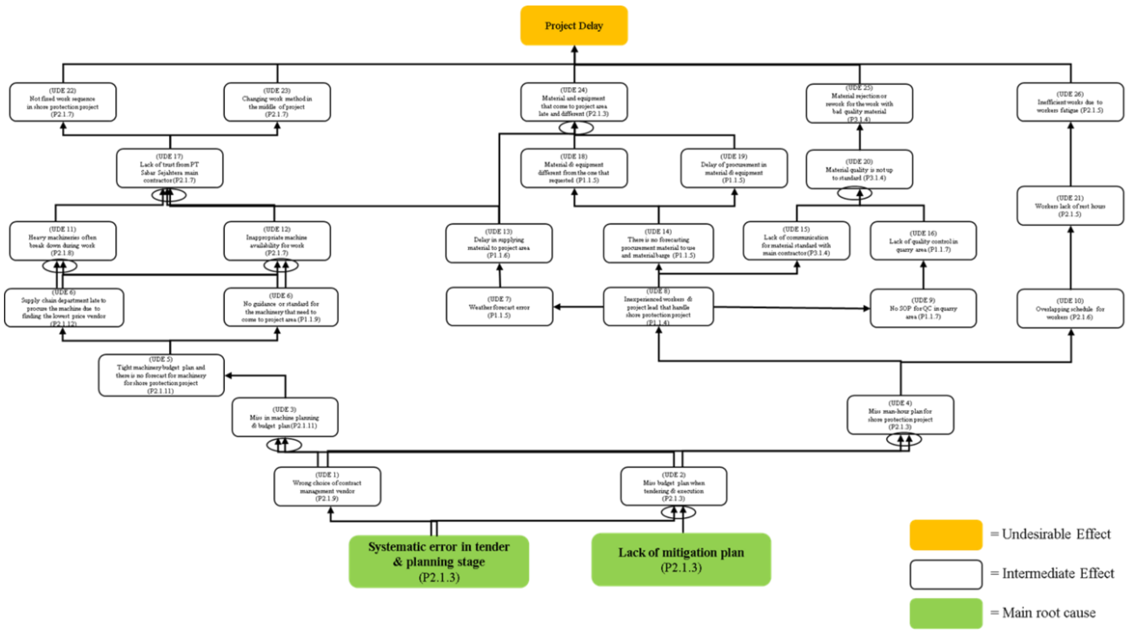

Figure 2. Current Reality Tree of Project Delay in Shore Protection Project

Propose Solution

Propose solution in this research is done by qualitative research by conducting group discussion with PT Sabar Sejahtera stakeholder that heavily involved in shore protection project. group discussion that conduct with PT Sabar Sejahtera stakeholder is discussing the solution for the main root cause of the shore protection project delay which is systematic error in tender and planning stage of shore protection project. This propose solution is present in the form of future reality tree.

Future Reality Tree (FRT) is a visual logic-based tool that shows how a group of suggested remedies (referred to as injections) can have a positive impact on a system by removing fundamental issues and accomplishing desired results (Goldrat's, 1994). Based on the group discussion there are 2 major solutions to the systematic error at tender and planning stage of shore protection project. The first solution is system creation during tender and planning that can result in having more realistic project schedule and budget plan for their project. This can lead to procurement of the material and machine according to time and needs (P2.2.1). The second solution is involving various departments during tender that result to inputs from technical, field, financial, and procurement is more accurate.

This can lead to project contract and works are adapted from work actual conditions of the projects (P2.2.1). both of this solution lead to no change of work method in the middle of project. Thus, the fields work has no disruption and can finish the work on time. (P1.2.2). the visualization of the positive ripple effect from the solution shown in Figure 3 below.

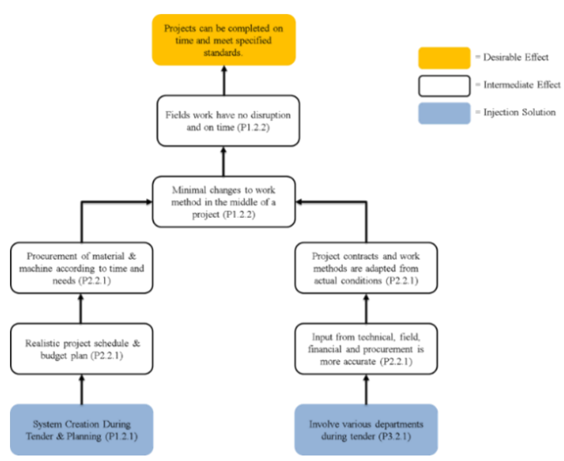

Figure 3. Future Reality Tree of Project Delay in Shore Protection Project

Mitigation Plan

This research also proposes mitigation plan for project delay at PT Sabar Sejahtera for the main root cause problem lack of mitigation plan. This mitigation plan is based on the proect risk management framework from PMBOK 6th edition. This mitigation plan done by qualitative research by conducting group discussion with PT Sabar Sejahtera stakeholder to discuss the potential risk for PT Sabar Sejahtera future project and quantitative to calculate the risk priority number for each potential risks.

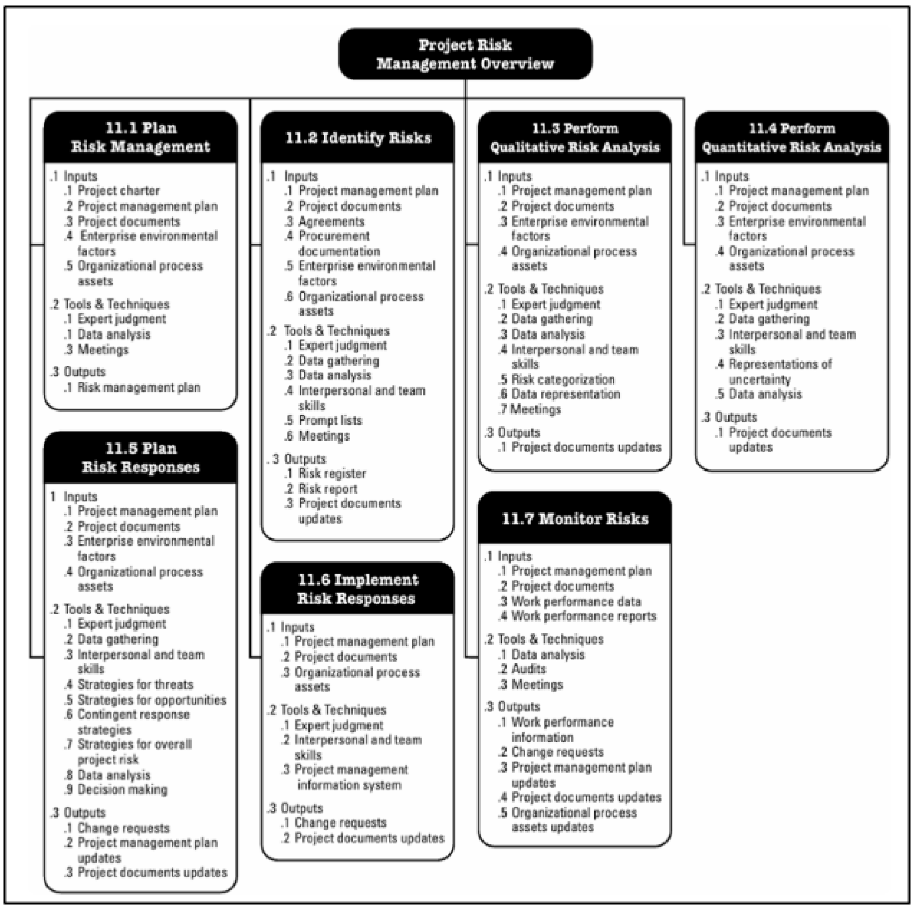

Figure 4. Project Risk Management Overview from PMBOK 6th Edition

Risk management framework in this research is based on the PMBOK 6th edition that consists of 7 steps. The first step is plan risk management, which aims to define how to conduct risk management activities for PT Sabar Sejahtera future project. The second step is identify risks, which is the process of identifying project potential risks for PT Sabar Sejahtera future project. The third step is perform qualitative risk analysis, which prioritizes each project potential risk for future analysis by assessing its severity, likelihood of occurrence, and inability to detect.

The fourth step is perform quantitative risk analysis, which numerically analyzes the combined effect of each project potential risk of PT Sabar Sejahtera future project. The fifth step is plan risk responses, which determines the actions to be taken if risks are triggered, develops response options, and agrees on actions to address each potential project risk. The sixth step is implement risk responses, which determines and plans the implementation of the risk response plan.

The seventh step is monitor risks, which determines the monitoring method for the implementation of risk response plans. In this research, plan risk management is defined as the process of determining how to conduct risk management activities for PT Sabar Sejahtera future project. The key benefit of the plan risk management process is that it ensures the degree, type, and visibility of risk management for each potential project risk in PT Sabar Sejahtera future project.

Table 2. Plan Risk Management

No.	Process	Tools & Techniques	Outputs
1	Identify Risks	Group discussion	List of potential risk PT Sabar Sejahtera future project
2	Perform Qualitative Risk Analysis	FMEA & group discussion	Score for each potential risk in FMEA
3	Perform Quantitative Risk Analysis	FMEA (Risk priority number)	Risk priority number (RPN) for each potential risks
4	Plan Risk Response	Strategies for overall project risk	Impact, action on trigger, and response plan for each potential risks

5	Implement Risk Response	Implementation plan	Action steps, resource needed, and timeline to implement the plan
6	Monitor Risks	Monitor risks plan	Monitoring activity, frequency, tool, and threshold for monitoring the implementation

Identify risks is a step to identify potential risks for PT Sabar Sejahtera future project. The potential risks are discussed in a group discussion conducted by the author with stakeholders of PT Sabar Sejahtera.

The first identified risk is low working productivity in the project due to inexperienced workers (P1). Another potential risk is an increase in the work accident rate caused by worker fatigue (P2). In addition, broken machineries may lead to work delays and increased maintenance costs (P3), while limited machine availability may result in high idle time during the project (P4).

Material-related risks were also identified. These include miscalculation of the quantity of materials required (P5) and the possibility that materials do not meet technical standards or final inspection requirements due to low quality materials (P6). Furthermore, overlapping activities, slow adaptation during project execution, and waste of time and money may occur due to unfixed and changing work sequences (P7).

Procurement-related risks include delays in starting the project due to procurement delays (P8). There is also a risk of rework and reduced quality of results when materials or equipment do not meet the required specifications (P9). Finally, delays in project work may occur due to inaccurate weather forecasts (P10).

After finishing the discussion about the potential risk and potential cause, author conduct quantitative and quantitative risk analysis by using failure mode and effect analysis (FMEA) that apply scoring model to identify, estimate, and prioritize, and evaluate risk of possible failure in shore protection project in order to list each potential risk with risk priority number (RPN) and risk prioritization. Here are the qualitative and quantitative risk analysis.

Table 3. Qualitative & Quantitative Risks Analysis

No.	**Tools & Techniques**	**FMEA**				**Output**	
		Potential Risk	**S**	**L**	**D**	**RPN**	**Priority**
1	FMEA & Group Discussion	P10	7	7	10	490	1
2		P2	10	5	5	250	2
3		P6	8	4	7	224	3
4		P9	9	2	8	144	4
5		P5	5	3	8	120	5
6		P3	7	7	2	98	6
7		P8	5	5	2	50	7
8		P1	9	5	1	45	8
9		P4	6	7	1	42	9
10		P7	7	2	2	28	10

From the qualitative and quantitative risks analysis above, the highest priority risks are P10 - Delay of work due to wrong weather forecast with 490 RPN, P2 - Increase in work accident rate due to worker's fatigue with 250 RPN, and P6 - Does not meet technical standards or does not meet final inspection standards due to low quality material with 224 RPN.

Plan risk response in this research is determining each potential risks impact, deciding the action if the risk is trigger, and the response plan for the risks for PT Sabar Sejahtera future project. This risk response plan that shown in Table 4 also include action on trigger for each risk that show an immediate action taken when risk indication begins to appear. Action on trigger have a reactive nature that respond to the situation. Action on trigger have a purpose to control the impact of the risk. Besides action on trigger, plan risk response also includes response plan. response plan is a mitigation strategies or a prepare plan before the risk occurs. Response plan have a proactive nature that prevent or reduce the likelihood/impact of the risk. Response plan have a purpose for prevent the risk from occurring or minimizing the impact in the project.

Table 4. Plan Risks Response

Risk	Impact	S	L	D	RPN	Action on Trigger	Responsibility	Response Plan
Delay of work due to wrong weather forecast (P10)	Rework or re-planning the work and postponed shipment material	7	7	10	490	Emergency stop for outside work and evacuate material barge to safe area & re-evaluate project schedule	Operation department	Use the latest weather forecast system and do not plan work at monsoon season
Increase in work accident rate due to workers fatigue (P2)	Work accident and stop work in project area	10	5	5	250	Provide additional rest periods and implement worker rotation	Operation & HSE department	Use proper manpower plan and set maximum working hours
Does not meet technical standards or does not meet final inspection standards due to low quality material (P6)	Rework and changing material (time loss & financial loss)	8	4	7	224	Postpone use of material and conduct additional material inspection	Operation & Material supply department	Tightening of quarry material selection and seek supervision & approvals since quarry
Rework and decrease quality result due to material/equipment not according specifications (P9)	Waste of time and money	9	2	8	144	Hold work until materials meet specifications, if work already done dismantle and reassemble the work	Operation, Material supply, & Supply chain department	Conduct feasibility study and cross-check technical specification before delivery
Miscalculation of quantity of material (P5)	Material out of stock for discharging work and stop work due to waiting more material	5	3	8	120	Emergency material supply from the nearest quarry	Operation & Material supply department	Re-verify material volumes in material requirement planning, seek supervision and approval since quarry, and collaborate with survey departments to calculate the material at quarry
Increase work delay and increase maintenance cost due to broken machineries (P3)	Downtime and extra cost for repair machineries	7	7	2	98	Call a mechanic to do a quick repair on the machineries	Operation & Supply chain department	Conduct routine machine inspections and prepare standby spare units
Delay in starting the project due to delay in procurement (P8)	Delay in starting the project	5	5	2	50	Contact alternative vendor	Operation & Supply chain department	Create forecasts for procurement planning with time buffers in the schedules and backup vendor contracts

Low working productivity in project due to inexperienced worker (P1)	Longer working time to finish and irregularities in work implementation (inefficient work & loss of time)	9	5	1	45	Conduct weekly/daily performance evaluations	Operation & HR department	Implement clear employee recruitment SOPs and provide technical training before the project starts
High idle time in project due to machine availability (P4)	Disruption in project schedule	6	7	1	42	Adaptation of work methods to existing machines and reschedule the machine	Operation & Supply chain department	Create proper forecast for equipment planning
Overlapping activities, slow adaptation in project, and waste of time and money due to not fixed and changing work sequence (P7)	Field worker confusion and decrease project efficiencies	7	2	2	28	Re-evaluate project weekly schedule	Operation department	Conduct feasibility study and finalize the work sequence and method before the project starts

Implement risk response is determining the implementation plan of the response plan for each potential risks. This implementation includes action plan that can be done by PT Sabar Sejahtera project team, departments responsibility, what resource needed to implement the risk response, what method to monitor the implementation plan, timeline of the implementation, and a measure of implementation success indicator. Implementation risk response that in Table 5 is shown a detailed action steps, responsibility, resources needed, monitoring method, timeline, and success indicator for each risk. Implementation above show a proactive measure for each risk and monitoring method that continuous and measurable, that connected to the success indicators for each risks.

Table 5. Implement Risks Response

Risk	**Action Steps**	**Responsibility**	**Resources Needed**	**Monitoring Method**	**Timeline**	**Success Indicator**
P10 - Weather forecast	Avoid major work in the monsoon season; Use high tech and the latest forecasting weather system	Operation department	Weather application system and SOP for evacuation plan	Daily weather log and weekly evaluation	During project planning & execution (weekly updates)	Work is not delayed >1 day due to weather
P2 - Fatigue	Create a work shift plan with appropriate working hours; Weekly evaluation of worker's working hours and fatigue	Operation & HSE department	Work shift schedules, fatigue work hour evaluation forms, and health checklists	Weekly HSE report	First week of project execution	There are no work accidents due to fatigue
P6 - Material quality	Additional quality control; Material inspection since quarry	Operation & Material supply department	Material inspection team, SOP for material quality control, and	Material inspection report	Before shipping the materials	100% of materials pass technical standards

			inspection form			
P9 - Specification mismatch	Technical verification of material/equipment; Conduct initial testing of materials/equipment	Operation, Material supply, & Supply chain department	Material/equipment checking form and technical SOP for inspection	Validation of material/equipment shipping documents	D-7 before material/equipment use	No rework due to specification errors
P5 - Miscalculation material	Verification of material requirements by survey; Technical material approval	Operation & Material supply department	Project BoQ data, SOP for material quantity control, and survey team	Cross-check plan vs realization	D-30 to D-7 of project	Material volume difference <5% from estimation
P3 - Broken machine	Schedule regular equipment inspections; Prepare spare machines and spare parts	Operation & Supply chain department	Machine checklist form, spare parts & spare units, and technician	Machine inspection report	Every 2 weeks	No idle time >2 hours due to equipment failure
P8 - Procurement delay	Create procurement forecast; Prepare alternative vendors	Operation & Supply chain department	Alternative vendor list and procurement timeline	Procurement progress report	Before project starts	100% procurements are on time
P1 - Inexperienced workers	Create recruitment SOP; Conduct pre-project technical training	Operation & HR department	Recruitment SOP, training modules, and experienced trainers	Recruitment evaluation and training evaluation	Pre-construction (D-30 project starts)	90% of workers pass training & productivity increases by 10%
P4 - Machine availability	Create initial equipment plan; Rearrange work methods according to available machine	Operation & Supply chain department	Data on available machines and alternative methods	Checklist of machine readiness	Pre-construction	0% schedule disruption due to machine availability
P7 - Not fixed & changing work method	Conduct feasibility study; Finalize work sequence & work method	Operation department	Project schedule, work method simulation, and field briefing	Weekly coordination meeting	Pre-construction	Work is in sequence and there is no overlapping work

Monitor Risks is monitor each implementation response plan for each potential risks that can be shown by monitor risks plan. Monitor risks plan includes the monitoring activity for each risk, the tools for the monitoring, frequency of the monitoring, responsibility departments, the threshold for risk, and the action if the risk exceed the threshold. Monitor risks plan in Table 6 shown monitoring activity to monitor the implementation plan and to monitor the risks. Besides that, monitor risks plan also includes the monitoring tools that required for the monitoring activity and the frequency of the monitoring (weekly, daily, or every batch). This monitor risks plan is systematic and threshold-based so there is a clear limit to trigger an action.

Table 6. Monitor Risks Plan

Risk	Monitoring Activity	Monitoring Tools	Frequency	Responsibility	Threshold	Action if exceed
P10 - Weather forecast	Monitor weather conditions to see if they are in accordance with the weather forecast and adjust the schedule	Daily weather log and weekly report	Daily and weekly	Operation department	Work is delay >1 day due to weather	Re-evaluate project schedule and re-plan work
P2 - Fatigue	Monitoring worker fatigue and worker working hours	HSE fatigue checklist and worker shift log	Weekly	Operation & HSE department	>12 hours work/day or reports of increased fatigue	Change work shifts or add workers
P6 - Material quality	Material quality check before sending to project area	Material inspection report	Every batch of material delivery	Operation & Material supply department	Material failed technical test >5%	Change quarry or improve inspection procedures
P9 - Specification mismatch	Verification of compatibility to material or machine specifications	Material ordering and delivery documents & machine inspection documents	Before the material/machine is used	Operation, Material supply, & Supply chain department	Rework occurred due to specifications >1 time	Postpone the use of materials/machines and order materials/machines that meet the specifications
P5 - Miscalculation material	Compare planned vs actual material usage	Survey log and BoQ tracker	Weekly	Operation & Material supply department	Material volume difference >5% from estimation	Material estimation audit and material stock adjustment
P3 - Broken machine	Monitoring inspection results and equipment damage reports	Machine inspection log	Every 2 weeks	Operation & Supply chain department	Idle >2 hours due to equipment failure	Call a technician and have backup machine ready
P8 - Procurement delay	Monitoring procurement progress and alternative vendors	Procurement progress report	Weekly	Operation & Supply chain department	Item arrived >1 day later than scheduled	Follow up with relevant vendors, contact backup vendors and revise project schedule
P1 - Inexperienced workers	Evaluate training and monitor project productivity	Training records and performance logs	Weekly	Operation & HR department	Project productivity < target 80%	Retraining or rotation of worker tasks
P4 - Machine availability	Check the readiness of the equipment according to the work schedule	Checklist of machine readiness	Weekly	Operation & Supply chain department	>1 machine not available when needed	Use alternative methods
P7 - Not fixed & changing work method	Monitor and evaluate field work method & sequence	Weekly coordination meeting	Weekly	Operation department	Work is not according to sequence or there is overlapping work	Sequence revision & re-coordination

Lessons Learned Register

Lessons learned register from the project delay in shore protection project is discussed at third section of the group discussion. The lessons learned register is discussed with PT Sabar Sejahtera stakeholders is related to project delay main root cause and project delay solution. The lessons learned register is for PT Sabar Sejahtera in managing future project. The first lesson learned from this project delay is correction of the systematic error, starting from the business plan design. This lesson learned occurs due to systematic error in tender and planning is the main root cause of project delay in shore protection project, therefore for future project PT Sabar Sejahtera needs to build a correction of those systematic error. The second lesson learned of this project delay is the importance of work method and instruction, and project preparation. This lesson learned occurs due to lack of preparation that in shore protection project that result in project delay that result in overlapping schedule, lack of adaptation, and decrease in productivity creating a domino effect to others. Therefore, for managing future project PT Sabar Sejahtera need to have a rigid preparation, work method, and work instruction that based on realistic project plan to complete the project on time. The third lesson learned of this project delay is the importance of mitigation plan. In shore protection project there is no mitigation plan to mitigate any risk, therefore the risk can only be overcome not prevent. This lack of mitigation plan also results in slow respond of risk problem and not systematic solution for the risk. Therefore, in this research author provide mitigation plan for PT Sabar Sejahtera future project through risk management framework that based on the PMBOK 6th edition.

Implementation Plan

Based on the current reality tree above, there are some UDE that can be map in the risk management framework from PMBOK. By mapping the UDE to PMBOK framework has a number of strategic and operational uses in project management, particularly to prevent, respond to and control risks that cause project delays or quality/cost losses. With this mapping, each UDE can be immediately directed to the appropriate PMBOK process stage which can prevent impulsive reactions or missteps because the team knows where in the process the issue should be addressed. Mapping for each UDE in the PMBOK framework shown in Table 7.

Table 7. Root Causes VS PMBOK Framework

Root Causes	Plan	Identify	Qualitative Risk Analysis	Quantitative Risk Analysis	Plan Risk Response	Implement Risk Response	Monitor Risks
1	UDE 22: Not fixed worked sequence in shore protection project	UDE 8: Inexperienced workers & project lead	UDE 11: Heavy machineries often breaks down	UDE 20: Material quality is not up to standard	UDE 11: Heavy machineries often breaks down	UDE 8: Inexperienced workers & project lead	UDE 21: Workers lack of rest houre
2	UDE 23: Changing work method in the middle of project	UDE 21: Workers lack of rest houre	UDE 23: Changing work method in the middle of project		UDE 12: Inappropriate machine availability	UDE 12: Inappropriate machine availability	UDE 20: Material quality is not up to standard
3		UDE 13: Delay in supplying material to project area			UDE 13: Delay in supplying material to project area	UDE 19: Delay of procurement in material & equipment	
4		UDE 22: Not fixed worked sequence in shore protection project			UDE 19: Delay of procurement in material & equipment		

5		UDE 23: Changing work method in the middle of project			UDE 7: Weather forecast error		
6		UDE 7: Weather forecast error					
Mapping Summary	2	6	2	1	5	3	2

After mapping each UDE in the PMBOK framework, then continue with determining the potential risk, mitigation plan, and responsibility based on the project risk management framework. This mapping has important uses in strengthening project risk planning and control. This determination of each potential risk, mitigation plan, and responsibility ensuring all risks are addressed throughout the risk cycle. risks are not only identified, but also responded to and monitored systematically.

Table 8. Implementation Plan at Plan Risk Management & Identify Risks

PMBOK Framework	Root Causes	Risk Potential	Risk Mitigation	Remarks
Plan Risk Management	UDE 22: Not fixed worked sequence in shore protection project	P7. Overlapping activities, slow adaptation in project, and waste of time and money due to not fixed and changing work sequence	M7. Conduct feasibility study and finalize the work sequence and method before the project starts	Operation Departments
Plan Risk Management	UDE 23: Changing work method in the middle of project	P7. Overlapping activities, slow adaptation in project, and waste of time and money due to not fixed and changing work sequence	M7. Conduct feasibility study and finalize the work sequence and method before the project starts	Operation Departments
Identify Risks	UDE 8: Inexperienced workers & project lead	P1. Low working productivity in project due to inexperienced worker	M1. Implement clear employee recruitment SOPs and provide technical training before the project starts	Operation & HR Department
Identify Risks	UDE 21: Workers lack of rest hours	P2. Increase in work accident rate due to worker's fatigue	M2. Use proper manpower plan and set maximum working hours	Operation & HSE Departments
Identify Risks	UDE 13: Delay in supplying material to project area	P5. Miscalculation of quantity material	M5. Re-verify material volumes in material requirement planning, seek supervision and approval since quarry, and collaborate with survey departments to calculate the material at quarry	Operation & Material Supply Department
Identify Risks	UDE 22: Not fixed worked sequence in shore protection project	P7. Overlapping activities, slow adaptation in project, and waste of time and money due to not fixed and changing work sequence	M7. Conduct feasibility study and finalize the work sequence and method before the project starts	Operation Departments

Identify Risks	UDE 23: Changing work method in the middle of project	P7. Overlapping activities, slow adaptation in project, and waste of time and money due to not fixed and changing work sequence	M7. Conduct feasibility study and finalize the work sequence and method before the project starts	Operation Departments
Identify Risks	UDE 7: Weather forecast error	P10. Delay of work due to wrong weather forecast	M10. Use the latest weather forecast system and do not plan work at monsoon season	Operation Departments

Table 9. Implementation Plan at Qualitative & Quantitative Risk Analysis

PMBOK Framework	Root Causes	Risk Potential	Risk Mitigation	Remarks
Perform Qualitative Risk Analysis	UDE 11: Heavy machineries often breaks down	P3. Increase work delay and increase maintenance cost due to broken machineries	M3. Conduct routine machine inspections and prepare standby spare units	Operation & Supply Chain Department
Perform Qualitative Risk Analysis	UDE 23: Changing work method in the middle of project	P7. Overlapping activities, slow adaptation in project, and waste of time and money due to not fixed and changing work sequence	M7. Conduct feasibility study and finalize the work sequence and method before the project starts	Operation Departments
Perform Quantitative Risk Analysis	UDE 20: Material quality is not up to standard	P6. Does not meet technical standards or does not meet final inspection standards due to low quality material	M6. Tightening of quarry material selection and seek supervision & approval since quarry	Operation & Material Supply Department

Table 10. Implementation Plan Plan Risk Response, Implement Risk Response, and Monitor Risks

PMBOK Framework	Root Causes	Risk Potential	Risk Mitigation	Remarks
Plan Risk Response	UDE 11: Heavy machineries often breaks down	P3. Increase work delay and increase maintenance cost due to broken machineries	M3. Conduct routine machine inspections and prepare standby spare units	Operation & Supply Chain Department
Plan Risk Response	UDE 12: Inappropriate machine availability	P4. High idle time in project due to machine availability	M4. Create proper forecast for equipment planning	Operation & Supply Chain Department
Plan Risk Response	UDE 13: Delay in supplying material to project area	P5. Miscalculation of quantity material	M5. Re-verify material volumes in material requirement planning, seek supervision and approval since quarry, and collaborate with survey departments to calculate the material at quarry	Operation & Material Supply Department
Plan Risk Response	UDE 19: Delay of procurement in material & equipment	P8. Delay in starting the project due to delay in procurement & material	M8. Create forecasts for procurement planning with time buffers in the schedules and backup vendor contracts	Operation & Supply Chain Departments
Plan Risk Response	UDE 7: Weather forecast error	P10. Delay of work due to wrong weather forecast	M10. Use the latest weather forecast system and do not plan work at monsoon season	Operation Departments

Implement Risk Response	UDE 8: Inexperienced workers & project lead	P1. Low working productivity in project due to inexperienced worker	M1. Implement clear employee recruitment SOPs and provide technical training before the project starts	Operation Departments
Implement Risk Response	UDE 12: Inappropriate machine availability	P4. High idle time in project due to machine availability	M4. Create proper forecast for equipment planning	Operation & Supply Chain Department
Implement Risk Response	UDE 19: Delay of procurement in material & equipment	P8. Delay in starting the project due to delay in procurement & material	M8. Create forecasts for procurement planning with time buffers in the schedules and backup vendor contracts	Operation & Supply Chain Departments
Monitor Risks	UDE 21: Workers lack of rest hours	P2. Increase in work accident rate due to workers' fatigue	M2. Use proper manpower plan and set maximum working hours	Operation & HSE Departments
Monitor Risks	UDE 20: Material quality is not up to standard	P6. Does not meet technical standards or does not meet final inspection standards due to low quality material	M6. Tightening of quarry material selection and seek supervision & approval since quarry	Operation & Material Supply Department

This mapping is a visual and analytical tool that links field issues with the professional risk management approach (PMBOK), ensuring that every project risk is not only recorded, but also acted upon in a planned and systematic manner. The potential risk for each UDE is coded with P and the mitigation plan for each UDE is coded with M. implementation timeline for each risk management framework process with assumption project will start at august next year can be shown in Gantt chart below:

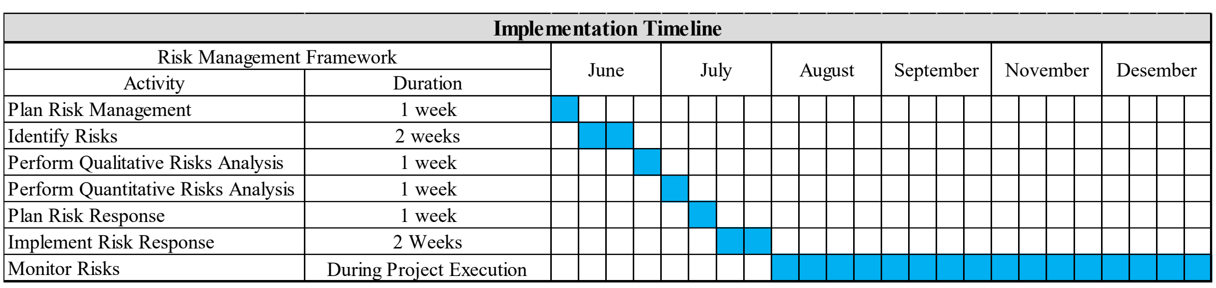

Figure 5. Implementation Timeline

CONCLUSION AND RECOMMENDATION

After conducting group discussion with PT Sabar Sejahtera with shore protection project coordinator, director of operation PT Sabar Sejahtera, and president director of PT Sabar Sejahtera and conducting data analysis with current reality tree to find the main root cause of project delay, there are 2 main root causes in this project delay problem, which is systematic error at tender and planning stage and lack of mitigation plan. Both of this main root causes creating a domino effect as shown in figure of current reality tree at data analysis above to undeseriable effect (UDE) that result in project delay at shore protection project. This Systematic error have a solution that already discussed with PT Sabar Sejahtera stakeholder at the group discussion.

The solution for this main root cause is system creation during tender and planning, and involve various departments during tender. Both of this solution will create a positive ripple effect that can tackle the systematic error problem. This lack of mitigation plan can be tackle using the project risk management framework that already shown above. By implementing this risk management framework including planning risk management, identify risks, perform qualitative risk analysis, perform quantitative risk analysis, plan risk response, implement risk response, and monitor risks PT Sabar Sejahtera can mitigate the risk for future project by implementation plan shown in Implementation Plan that show each UDE in the project risk management process. By implementing this implementation PT Sabar Sejahtera can ensure that every project risk is not only recorded, but also acted upon in a planned and systematic manner.

The lessons learned register from this shore protection project delay is for PT Sabar Sejahtera managing future project and it is discussed with

PT Sabar Sejahtera stakeholder at the group discussion. The first lesson learned is to build a correction of those systematic error. The correction will be starting from the business plan design, budget plan for the project, project scheduling, project contract, project planning, and many others. The second lesson learned is the importance of work method & instruction, and project preparation as project preparation is one of the most essentials part of project and the work method & instruction are one of the crucial part in project as it is act as guidance's of the activity. The third lesson learned is the importance of mitigation plan. In shore protection project there is no mitigation plan to mitigate any risk, therefore the risk can only be overcome not prevent. This lack of mitigation plan also results in slow respond of risk problem and not systematic solution for the risk.

The recommendations for PT Sabar Sejahtera and future research include implementing the risk management framework in PT Sabar Sejahtera future projects to minimize the possibility of project delays. The risk management framework should also be adapted to the specific conditions of each project, as land and marine projects may require different risk mitigation approaches.

In addition, PT Sabar Sejahtera is recommended to utilize digital tools to digitalize project estimation budget plans, project scheduling, and project management monitoring. The use of these tools can support technical functions, help keep future projects on track, and reduce the risk of delays during project execution.

For future research, data collection methods can be expanded through questionnaires distributed to field project teams and interviews conducted with project managers and project engineers. Furthermore, root cause analysis can be performed using different tools, such as swim lane diagrams and five why analysis, to provide broader insights into project risk management.

REFERENCES

Carvalho, A. B., Maués, L. M. F., De Sá Moreira, F., & Reis, C. J. L. (2021). Study on the factors of delay in construction works. *Ambiente Construído, 21*(3), 27–46.

Dettmer, H. W. (1997). *Goldratt's theory of constraints: A systems approach to continuous improvement*. ASQ Quality Press.

ESDM. (2021). *Konferensi pers perkembangan dan arah kebijakan subsektor ketenagalistrikan*. https://gatrik.esdm.go.id/assets/uploads/download_index/files/44abb-210604-bahan-konferensi-pers-media.pdf

Goldratt, E. M. (1994). *It's not luck*. North River Press.

Goyal, A., & Razdan, R. (2023). To study the delay to construction projects: Cause, effect and measures to reduce. *International Journal of Research Publication and Reviews, 6*, 115–126.

Project Management Institute. (2013). *A guide to the project management body of knowledge (PMBOK® guide)* (5th ed.). Project Management Institute.

Project Management Institute. (2017). *A guide to the project management body of knowledge (PMBOK® guide)* (6th ed.). Project Management Institute.

Project Management Institute. (2021). *A guide to the project management body of knowledge (PMBOK® guide)* (7th ed.). Project Management Institute.

Schwalbe, K. (2017). *An introduction to project management* (6th ed.). Schwalbe Publishing.

Velasquez, D., Carhuamaca, S., & Farje, J. (2021). Risks management model integrating the analysis mode and failure effects within the Last Planner System to improve the time of real estate construction projects. In *2021 Congreso Internacional de Innovación y Tendencias en Ingeniería (CONIITI)* (pp. 1–6). IEEE.

Viles, E., Rudeli, N. C., & Santilli, A. (2019). Causes of delay in construction projects: A quantitative analysis. *Engineering, Construction and Architectural Management, 27*(4), 917–935.