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A Practical Recovery Strategy for Delayed Construction Project: Insights from a Geothermal Cooling Tower Case

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Abstract. Project delays in construction often lead to significant financial consequences, particularly in terms of penalties specified in the project contract. This study addresses the cost-efficiency consideration behind the decision to implement project crashing through overtime, as opposed to accepting the penalty due to project delay. The research uses a case study of a geothermal power plant renovation project in Indonesia, which faced a ten-week delay caused by external factors. The study compares the penalty potential with the total cost of project crashing calculated. The results reveal that accelerating activities on the critical path only costs 17.02% of the potential penalty if no corrective actions are taken. This analysis emphasizes the importance of financial trade-offs in project decision-making and highlights that project crashing, when planned and executed properly, is a rational and cost-efficient strategy to recover from delays, provided it does not compromise project quality and scope. The study contributes to understanding the financial implications of project acceleration and offers insights for managers considering delay recovery strategies.

Keywords: Cost efficiency, project crashing, project management, construction

INTRODUCTION

The demand for electricity in Indonesia has continuously increased with the growth of public activity and the adoption of technologies such as Electric Vehicles (EVs). In 2020, national electricity consumption reached 242.113 GWh, with the household sector as the largest contributor, indicating that most daily activities require electricity (RUPTL PT PLN, 2023) (Al Irsyad et al., 2018; Arnaz, 2018; Romadhoni & Akhmad, 2020). However, around 58% of electricity in Indonesia is still generated by coal power plants, which not only causes environmental risks but also faces the looming issue of resource scarcity over time (Burke & Kurniawati, 2018; McNeil et al., 2019; Nainggolan, 2023; Windarta et al., 2018).

As part of the national transition to cleaner energy, the Indonesian government promotes the utilization of geothermal power plants, which have a generation capacity of 28.5 GWh, distributed across the country (Goswami et al., 2023; Himri et al., 2022; Shankar et al., 2020; Suo et al., 2021). PT GSE is one of the geothermal power plants in Indonesia, located in West Java, and is currently executing a project to replace the cooling tower structure, which has suffered a decline in structural integrity after over two decades of operation. This project, called Project X, is being executed by PT XYZ as the main EPC contractor, involving a structural replacement to enhance its integrity.

During execution, Project X faced significant delays, exposing PT XYZ to the risk of contract penalties and reputational damage. To address these losses, project crashing is being implemented to accelerate the project activities by adding overtime to tasks included in the critical path. This research examines the effectiveness of crashing through overtime by comparing the total additional crashing costs with the potential penalties due to delays. The study was conducted during the Unit – 1 construction phase, using the Precedence Diagramming Method (PDM) and interviews with stakeholders to gather expert judgment (Bansal, 2023; Hajdu, 2015; Isaac & Hajdu, 2016; Ljiljanić et al., 2022; Wiest, 1981).

Previous research has extensively examined project delays and their impacts on construction projects, particularly regarding financial consequences such as penalties. For instance, Alvanis et al. (2024) explore the significant role of coal in Indonesia's energy mix, highlighting the associated environmental risks and resource scarcity. However, while they address the broader implications of energy generation and sustainability, their study lacks a focus on financial management strategies, such as project crashing, that can mitigate delays in critical infrastructure projects like geothermal power plants. Furthermore, the study by RUPTL PT PLN (2023) reports on national electricity consumption patterns, emphasizing the growing demand for electricity due to technological advancements such as Electric Vehicles (EVs), but it does not provide insight into how such increases in demand may affect construction timelines and the penalties associated with energy infrastructure projects.

The objective of this study is to assess the effectiveness of project crashing through overtime in mitigating the risks of contract penalties caused by project delays, specifically in the case of geothermal power plant renovation. By comparing the additional crashing costs with the potential penalties, this study aims to provide valuable insights into how project managers can make informed decisions on cost-effective delay recovery strategies. The findings are expected to contribute to the development of better project management practices, especially in large infrastructure projects, and provide useful guidelines for decision-makers on the feasibility of using project crashing to minimize financial losses while ensuring timely project completion.

MATERIALS AND METHODS

This research is conducted using a mixed-method approach, incorporating both qualitative and quantitative data collection and analysis. Qualitative data collection and analysis were conducted through interviews with the project's key personnel, while the quantitative method will involve calculating the progress gap, determining the critical path, and calculating overtime costs by utilizing the project contract, project WBS, and project S-Curve as the foundation. The research flow will be as follows:

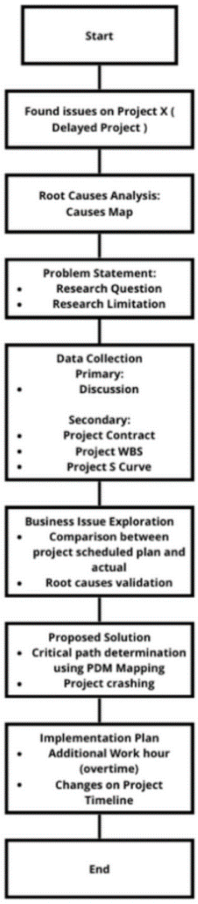

Figure 1. Research Method

The research will conduct a root cause analysis using a causes map. After the main causes have been determined, the next step is to collect data by conducting interviews and obtaining secondary data from the company. Following that, business issue exploration will be carried out by comparing the actual progress with the planned progress to determine the progress gap. Once the progress gap has been identified, the next step is to determine the critical path of the work sequences. Ultimately, project crashing will be conducted to calculate the overtime needed to crash the project.

Conceptual Framework

The conceptual framework utilized in this research is adapted from the Organizational State Transition via Project from PMBOK 7th Edition, as shown below:

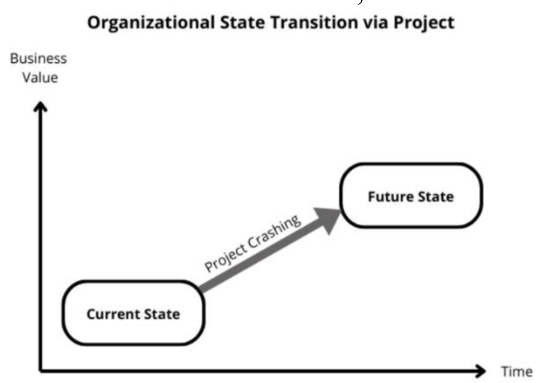

Figure 2. Conceptual Framework

The purpose of this conceptual framework is to achieve the expected future state, which is in this research is to bring back the progress to be aligned with the planned schedule, from the current state which is in this research is project delay using project crashing as the main methodology.

RESULTS AND DISCUSSION

By conducting the interviews with project's key person, the duration of the crash expected for activities can be determined. But due to the constraint of prohibition to conducting activity in the confined space, not all of the activities will be crashed. Another consideration to crash the activities is from the value of Cost per Unit Time, where only the activities with the lowest value of Cost per Unit Time will be conducted. Below shown the list of activities along with the value of the Cost per Unit Time:

Table 1. Cost per Unit Time per Activity

Activity	Description	Cost per Unit Time (IDR/Day)
1	Set up Scaffolding	-
2	Shutdown	-
3	Dismantle Cable Tray & Instrument	Rp 9,953,891
4	Remove Fan, Motor & Equipment	Rp 12,506,513
5	Remove Header, Distribution Pipe & Fill Pack, Drift Eliminator	Rp 12,131,951
6	Remove Wooden Structure	Rp 20,844,189
7	Install FRP Structure & Inspection	Rp 13,293,096
8	Install New Top Deck Platform	Rp 16,675,351
9	Install New Partition Wall, Cladding & Drift Eliminator	Rp 19,422,146
10	Install New Fan, Motor & Equipment	Rp 35,168,186
11	Fan Motor Alignment	Rp 13,114,570
12	Install New Header, Distribution Pipe & Fill Pack, Drift Eliminator	Rp 21,834,268
13	Install Cable Tray & Instrument	Rp 14,208,262
14	Megger Cable Test	Rp 6,635,927
15	Startup	-
16	Final Inspection & Commissioning	Rp 10,867,192

Source: processed data

Due to the restriction of working in the confined space and the needs to crash the project for 10 weeks, these activities will be sorted to fulfil those requirements. Below shown the list of activities which has been sorted:

Table 2. Sorted Activities

Activity	Description	Cost per Unit Time (IDR)	Crashing Cost per Cell per Day (IDR)	Total Crashing Cost for 4 Cells (IDR)
14	Megger Cable Test	Rp 6,635,927	Rp 829,491	Rp 6,635,927
3	Dismantle Cable Tray & Instrument	Rp 9,953,891	Rp 1,658,982	Rp 39,815,564
16	Final Inspection & Commissioning	Rp 10,867,192	Rp 1,086,719	Rp 21,734,385

Activity	Description	Cost per Unit Time (IDR)	Crashing Cost per Cell per Day (IDR)	Total Crashing Cost for 4 Cells (IDR)
5	Remove Header, Distribution Pipe & Fill Pack, Drift Eliminator	Rp 12,131,951	Rp 1,733,136	Rp 36,395,852
4	Remove Fan, Motor & Equipment	Rp 12,506,513	Rp 1,389,613	Rp 25,013,027
11	Fan Motor Alignment	Rp 13,114,570	Rp 468,377	Rp 13,114,570
7	Install FRP Structure & Inspection	Rp 13,293,096	Rp 1,007,053	Rp 66,465,478
13	Install Cable Tray & Instrument	Rp 14,208,262	Rp 1,014,876	Rp 28,416,524
8	Install New Top Deck Platform	Rp 16,675,351	Rp 1,389,613	Rp 33,350,703
9	Install New Partition Wall, Cladding & Drift Eliminator	Rp 19,422,146	Rp 728,330	Rp 58,266,438
10	Install New Fan, Motor & Equipment	Rp 35,168,186	Rp 1,352,623	Rp 70,336,373

Source: processed data

The sorted activities which have been sorted above fulfil the needs to crashed the project for 12 weeks, which exceeds the needs of 10 weeks itself. Based on the calculation conducted, the overtime cost required for crash the project for 12 weeks is Rp 399,544,839 which only take 17,02% from the potential losses of there are no corrective action. The activities for each cell also reduced from initially is 121 days to 99 days. After the crashing has been conducted, there are no changes in the critical path for the activity sequences. Below shown the Gannt Chart before the project has been conducted and after the project crashing has been conducted.

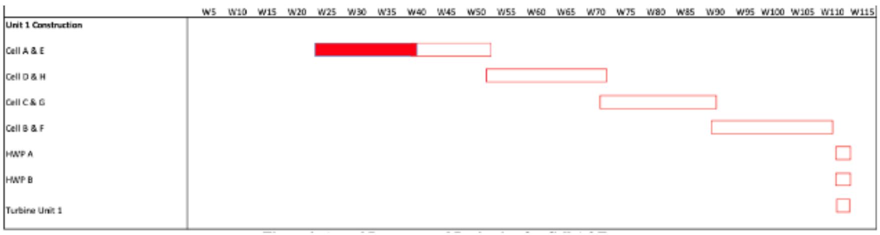

Figure 3. Project Gantt Chart before Project Crashing Conducted

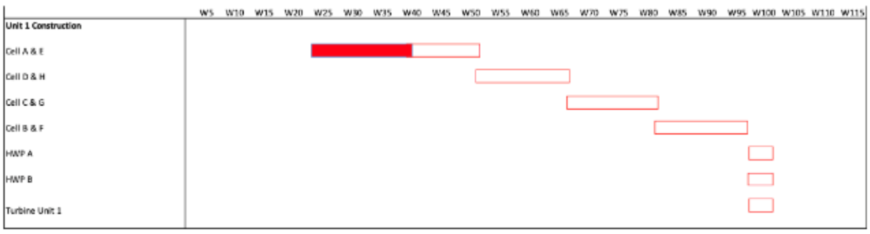

Figure 4. Project Gantt Chart after Project Crashing Conducted

Based on the comparison between Figure 3 and Figure 4, it can be concluded that after the project crashing has been conducted, the project completion time reduced for 12 weeks from initially the project is projected to be finished at week 111, after the project has been crashed, the project is projected to be finished at week 99.

CONCLUSIONS

Based on the research conducted, several conclusions can be drawn, including: Bad weather conditions were the main factor that caused the project delay. The interview with the project's key personnel confirmed that prolonged periods of heavy rain significantly disrupted outdoor activities, in compliance with company safety regulations. To address the resulting losses, the project implemented a time acceleration strategy using project crashing. The overtime decision was based on a comparative cost analysis, which indicated that overtime involved fewer indirect expenses, such as mobilization, insurance, and equipment costs. From a financial perspective, the cost of accelerating the project through overtime amounted to Rp 399,544,839, which is only 17.02% of the potential penalty. This highlights the substantial cost savings achieved through the chosen mitigation strategy. Project crashing proved to be effective in improving project performance, resulting in a 12-week reduction in the overall schedule. Besides the tangible benefits, this strategy also protects the contractor's reputation with the client, which is critical for securing future project opportunities and sustaining long-term business relationships.

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