

A Three-Phase Intervention Model in Mitigation of Bridge Project Delays Due to Force Majeure Based on Time and Cost Analysis

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ABSTRACT

The implementation of the Responsive Phase through Critical Path Method (CPM) analysis has successfully identified the impact of flood force majeure on the project's critical path quantitatively. Based on the project's weekly report data, an additional duration of 14 days was determined for the Structural Excavation and 28 days for the Vero River due to inundation, which was officially documented in the supervisor's instruction letter to the PPK. The results of the impacted CPM analysis indicate a shift in the project completion date from November 17, 2025, to December 1, 2025, so that the EOT amount of 14 calendar days was determined as the contractor's contractual right based on Articles 1244-1245 of the Civil Code. This delay is categorized as an excusable non-culpable delay so that the contractor cannot be subject to delay fines (liquidated damages) for these 14 days. The Three Phase Intervention Model (Preventive-Responsive-Recovery) has been successfully formulated into an Applicable Work Guideline consisting of 21 systematic steps and equipped with a checklist of 12 formal legal attachment documents for EOT claims. This model integrates CPM analysis, EOT mechanisms, and crashing optimization in one continuous framework, Preventive produces a baseline schedule as a reference, Responsive identifies impacts and determines EOT rights, and Recovery formulates an optimal acceleration strategy. This guideline has been proven to strengthen the basis of contract administration and technical justification for claims for time extensions and acceleration costs on bridge projects affected by flood force majeure

INTRODUCTION

Infrastructure development plays a crucial role in supporting social and economic growth, both in urban and rural areas. One crucial form of infrastructure is bridges, which connect regions, facilitate transportation access, and support the distribution of goods and services. In the context of rural development, bridges not only facilitate community mobility but also improve connectivity between economic activity centers, thus directly impacting community welfare. Therefore, bridge construction must proceed according to plan, in terms of cost, quality, and time. The success of a construction project depends on a series of activities, including well-integrated planning, implementation, and supervision (Marleno, Oetomo, & Wulansari, 2023).

However, in practice, construction project completion often encounters various obstacles that lead to deviations from the initial plan. Delays have long been a serious problem in construction projects, often leading to cost overruns, quality issues, and contractual disputes, significantly impacting project success (Turkoglu et al., 2024). Delays can be influenced by many factors, ranging from suboptimal project management, material delays, labor constraints, and unpredictable external conditions. Studies on bridge projects in Indonesia identified that the dominant factor causing delays in critical work was late material deliveries. Internal contractor factors and project management actions have been shown to significantly influence project success, while external environmental factors, including climate, also play a significant role (Marleno, 2018). External conditions such as heavy rainfall, flooding, and river overflows (which fall under the force majeure category) have the potential to hinder construction activities on the ground, particularly on foundation work and bridge substructures, which are highly dependent on water level conditions.

Another study also confirmed that rain is one of the most frequent causes of construction delays.

In the case of a village bridge construction project, delays occurred due to repeated river overflows. The flooding caused the work area to be submerged, making construction activities impossible. Consequently, completion of the project required a time extension or contract addendum. This situation led to deviations from the initial plan, both in terms of schedule and potential additional costs. This issue highlights the vulnerability of construction projects to external factors, particularly for projects located near water bodies. However, determining the duration and additional costs due to force majeure often suffers from weak administrative and contractual justification. Contractors struggle to submit accurate Extension of Time (EOT) claims and Acceleration Cost Addendums due to the lack of structured calculation guidelines that are legally and technically recognized.

Ideally, a construction project should be completed on time as per the contract. Timeliness is an indicator of project success, alongside quality and cost achievement. However, projects often encounter delays, necessitating contractual measures such as Extension of Time (EOT) (Ting et al., 2021). To achieve this ideal situation, a project control strategy is needed that can anticipate and minimize the impact of delays due to force majeure. One widely used

approach is the time acceleration method through crashing. This method is a project management technique theoretically and empirically proven to reduce project completion time by adding resources or rearranging the work sequence. Crashing is an effective method for solving the time-cost trade-off problem (Turkoglu et al., 2021). The challenge is that crashing must be carried out in a planned and phased manner, not simply as a post-disaster reaction. Currently available methods tend to focus on technical duration calculations, while neglecting interventions in risk management (prevention) and contract management (claim legality) in the context of flood force majeure.

As a foundation for addressing these challenges, it is important to reference various studies that have developed relevant models and analysis methods. Research by Marleno et al. (2018) on stakeholder factors influencing the success of construction projects in Indonesia highlights that effective interventions must simultaneously consider the roles of designers, contractors, supervising consultants, clients, and government development projects. Meanwhile, in the field of hydrological risk analysis related to flooding, Nugroho et al. (2026) developed the Laksono-Erub Synthetic Unit Hydrograph (HSS) method, which has proven highly accurate in predicting design flood discharge, with an average deviation of only 10-15% from observed discharge. This method is particularly relevant for infrastructure projects near water bodies, as it can be used to more accurately quantify flood risk during the planning phase.

Based on this background, this study aims to analyze delays in bridge construction due to force majeure, specifically flooding, and evaluate the potential application of acceleration methods as recommended solutions. This research is expected to provide an overview of relevant alternative project control strategies, which can serve as a reference for future similar projects. The problem of delays in construction projects is nothing new. Various studies have shown that delays are one of the most common major issues, both in large-scale and small-scale projects. Infrastructure projects in Indonesia have experienced delays in completion, with causes ranging from technical and managerial factors to external conditions. For example, the bridge project in Situbondo experienced a delay with a deviation of -7% from the planned schedule (Penggali, 2025). This condition illustrates that time management remains a major challenge in the construction world. Evaluations of empowerment-based projects also show that construction project success is measured not only by time and cost, but also by aspects of community participation, administration, and independence (Nugroho, Witjaksana, Oetomo, & Setiawan, 2019).

In general, project delays can be divided into two categories: controllable delays and uncontrollable delays. Controllable delays typically relate to contractor performance, material availability, or labor management. Meanwhile, uncontrollable delays are generally related to external conditions beyond the contractor's control, one of which is force majeure.

Force majeure, or force majeure, is defined in contract law as a condition that occurs beyond the parties' expectations, cannot be prevented, and prevents the performance of obligations under the agreement. Force majeure refers to unforeseen events beyond the control of the parties involved in the contract

(Alshammari et al., 2017). In the construction context, force majeure includes events such as natural disasters, floods, earthquakes, landslides, fires, and even social unrest. These events are generally unpredictable and unavoidable, even if the implementing party has worked according to procedures. Adverse weather, such as heavy rain, flooding, and extreme temperatures, is also a common cause of delays, legal claims, and economic losses in construction projects (Ballesteros-Pérez et al., 2018). In Indonesia, the legal framework for this condition refers to Articles 1244 and 1245 of the Civil Code, which exempt construction service providers from liability for damages caused by force majeure (Utama & Sutrisno, 2023).

The impact of force majeure on construction projects is significant. It not only impacts completion delays but also has the potential to lead to cost changes, the drafting of contract addenda, and even disputes between service providers and project owners. In construction delay claims, force majeure is typically recognized as an excusable risk, entitling the contractor only to an extension of time, but neither party is entitled to monetary compensation to recover damages caused by the delay (Alshammari et al., 2017). Therefore, managing force majeure risk is a crucial aspect of modern construction management. For these and other reasons, Force Majeure or act of God clauses are included in almost all construction project contracts (Al Marri, 2023).

In the case of bridge construction in rural areas, natural factors are one of the main risks that must be anticipated. Geographical conditions close to rivers make substructure work, such as abutments and foundations, highly vulnerable to disruption in the event of flooding. Construction activities that should proceed on schedule are delayed due to inundation of the work area. This delay can have a ripple effect on subsequent projects, further deviating from the planning S-curve. Even in extreme conditions, structures under construction can collapse and be swept away by the rapid flow of floodwaters, as occurred in the spillway construction project (Sapitri, 2016).

Ideally, such risks can be minimized through initial analysis, the development of mitigation plans, and measurable acceleration strategies. However, in practice, especially on small-scale projects with limited resources, mitigation measures are often suboptimal. As a result, project delays are unavoidable, requiring additional time for completion.

To mitigate the impact of delays, project acceleration methods should be considered. A common method is crashing (additional labor, equipment, or overtime). The application of this method allows service providers to return project durations closer to the original plan, despite delays. The effectiveness of this method is supported by various studies analyzing the relationship between cost and time using various methods, including cost and implementation time analysis (Nugroho, Oetomo, & Wijanarko, 2021). Numerous previous studies have also demonstrated the effectiveness of this acceleration method. For example, in high-rise building projects, the application of crashing has been proven effective in reducing the risk of delays and achieving a balance between time efficiency and additional project costs (Supriadi, 2025). This principle remains relevant for bridges experiencing delays due to force majeure.

Based on this gap, this study seeks to formulate a 3-Phase Intervention Model specifically for handling flood force majeure in bridge projects. This model integrates the Preventive Phase (risk preparedness & administration), the Responsive Phase (impact analysis & EOT), and the Recovery Phase (optimal crashing calculations) into a single framework. Thus, the output of this research not only presents technical solutions for acceleration, but also produces Applicative Work Guidelines that can be the basis for audit justification and the legality of claims for time extensions and acceleration costs in contract documents.

THEORETICAL REVIEW

Tjahyana & Setiadji (2025) in "Analysis of Factors Causing Delays in Construction Projects and Their Impacts" (Jurnal Dimensi Insinyur Profesional, Vol. 3 No. 2) found that 23.8% of respondents answered that the cause of project delays was design changes during the construction project. This study emphasizes that thorough initial design planning and good project scheduling are two things that are highly recommended to prevent delays. DOI: 10.9744/jdip.3.2.46-50.

Ananda & Mulyati (2023) in "Analysis of Factors Causing Delays in Building Construction Projects" (Jurnal Ensiklopedia, Vol. 8 No. 2) used the SEM-PLS method and found that managerial and design factors were the dominant contributors to project delays. This study involved 41 respondents from contractors, construction management, and related stakeholders. DOI: 10.33559/eoj.v8i2.3746.

METHODOLOGY

The literature review in this study aims to identify relevant theories, concepts, and previous research as the basis for the conceptual framework and methodology for formulating the 3-Phase Crashing Model. The literature review is categorized into the following key concepts:

1. Theoretical Basis for Contracts and Risk (Force Majeure)

This review discusses the legal and managerial foundations related to extraordinary events that impact project performance, particularly hydrological events (floods), and understands the criteria for force majeure in the context of Indonesian construction contracts.

2. Time Analysis Method (CPM)

This review supports the methodology used in the Responsive Phase to accurately determine time impacts. The Critical Path Method (CPM) concept: Understands the calculation of the Critical Path as a determinant of the project's time baseline. The Critical Path is the only path that, if disrupted, will impact the overall project completion time.

3. Crashing Optimization Method (Time-Cost Trade-Off)

This review provides a theoretical basis for the project acceleration process in the Recovery Phase. Project Crashing Definition: The concept of accelerating a schedule by adding resources, which always implies an increase in Direct Costs and a decrease in Indirect Costs.

Data collection

This study uses Secondary Data obtained through the Document Study method from the archives of the case study project. The collected data is quantitative in nature which serves as the main input for the entire analysis process. The secondary data includes Project Technical Data (such as Technical Specifications and Working Drawings), Project Cost Data (Cost Budget Plan (RAB), and Project Schedule Data (Plan S-Curve) to determine the baseline and identify the impact of delays. All of this secondary data is assumed to be valid and serves as the sole basis for calculating Time Impact Analysis (TIA) and Crashing Optimization.

Baseline Schedule Determination

This stage is the process of developing and establishing the original schedule as the primary benchmark in the research. The baseline schedule serves to illustrate the ideal project conditions and the contractually agreed-upon completion duration before any force majeure occurs. The steps in establishing the baseline schedule are as follows:

Work Breakdown Structure

Researchers identified and classified all bridge work items hierarchically based on secondary project data taken from the original contract documents. A Work Breakdown Structure (WBS) was developed to ensure the entire scope of work, from preparatory work and the substructure (foundations and piers), to the bridge's superstructure, was systematically mapped. This aimed to facilitate identification of activities that would be directly impacted by the flood.

Logic Tie

Based on data from the S-Curve of the weekly plan and schedule, normal durations are extracted for each activity. Next, interdependencies are determined using Finish-to-Start (FS) logic or according to the technical implementation sequence in the field. This process produces a network plan that shows the flow of work from the beginning to the end of the project.

Determination of Contract Reference Date

The final step is to establish reference date parameters, including the commencement date and the planned completion date, as outlined in the contract documents. This planned completion date is locked as the Baseline Finish value, which will serve as the primary benchmark for calculating post-flood delay variances in subsequent analysis.

Determination of Contract Reference Date

This stage explains the process of identifying and converting extraordinary events (floods) into measurable data variables. In general, force majeure data is not simply viewed as a time disruption, but as a data entity that must meet contractual legality and technical validity.

Determination of Contract Reference Date

Flood data is collected from various secondary sources to build a robust justification. The data components collected include:

- a. Historical Field Records: Data taken from Log Books, Daily Reports, Weekly Reports, S-curves, Shop Drawings, and supporting documents to determine the duration of standstills and reduced productivity due to flooding.

- b. External Supporting Data: Rainfall data records from relevant meteorological stations (BMKG or irrigation agencies) as objective evidence that rainfall intensity is above normal (a force majeure criterion).
- c. Contractual Aspects: Refer to the force majeure clause in the project contract documents (such as FIDIC standards or PUPR Ministerial Regulations) to verify that the event does indeed exempt the contractor from delay fines.

Schedule Analysis Using the Critical Path Method

This analysis is the data processing stage to evaluate the technical impact of flooding on the project implementation schedule. Referring to the methodology developed by Ichwan (2024) and Mulia (2023), the analysis is conducted comprehensively through the following stages:

Identification of Impact on Work Activities

The initial step in this analysis is to identify the position of the force majeure event within the planned schedule. The identification process includes:

- a. Determining the work items in progress (active tasks) at the time of the flooding based on weekly progress reports.
- b. Classifying the affected activities, whether they are categorized as critical or non-critical in the baseline schedule.
- c. This stage is crucial for determining the starting point for rescheduling and ensuring the objectivity of the delay data being processed.

Time Parameter Calculation (Forward and Backward Pass)

Once the affected activities are identified, a two-way calculation is performed to update the project work calendar:

- a. Forward Pass: This is performed to determine the earliest start (ES) and earliest finish (EF). If flooding results in work interruption, the duration of that activity is increased by the total number of days affected, resulting in a linear shift in the EF value.
- b. Backward Pass: This is performed to determine the latest start (LS) and latest finish (LF) to determine the tolerance limit for delays in the remaining work sequence.

Slack Time and Critical Path Sensitivity Analysis

The calculated time parameters are then used to determine the Total Float or Slack Time ($TF = LS - ES$). At this stage, a sensitivity analysis is performed to determine the impact of flooding:

Critical Path Analysis: If flooding affects an activity with a TF value of 0, the project completion duration will automatically increase. This addition serves as the quantitative basis for requesting an extension of time.

Path Shift Analysis: Analyze whether the duration of flooding on a non-critical activity result in the depletion of float, thereby changing the activity's status to a new critical path, potentially threatening the project's future completion date.

Impacted Time Analysis Output

The final result of this CPM analysis is an Updated Schedule, which presents the new post-flood completion date. The duration difference between this updated schedule and the baseline schedule in point 3.4 represents the extent

of the delay that must be resolved, either through administrative mechanisms (EoT) or technical acceleration.

Determination of Extension of Time (EoT)

This stage is the administrative and legal process for determining an extension of the contract implementation time based on the results of the technical impact analysis in the previous stage. Determining the EoT aims to legally validate the extension of the duration to avoid a "time at large" situation, where the contract completion date is lost due to disruptions not due to the contractor's fault. The steps in determining the EoT are as follows:

Justification for the Right to Extension of Time

Based on the results of the Critical Path Method (CPM) analysis in point 3.6, the delay caused by the flood is classified as an excusable non-culpable delay. From a construction contract perspective, these natural events constitute a neutral risk, giving the contractor the right to request an extension of the implementation period without incurring liquidated damages.

Verification of Documentation and Technical Evidence

To meet the principles of transparency and accountability in contract amendments, the determination of the EoT must be supported by comprehensive objective evidence. The researcher prepared a summary of supporting documents, including:

- a. Historical rainfall and flood discharge data (as identified in point 3.5).
- b. Weekly reports showing activity interruptions on the critical path.
- c. Visual documentation of field conditions to validate the cleanup period.

Analysis of Cost Implications Due to Duration Extensions

Referring to the thinking of Febrianto et al. (2025), contract duration extensions inherently give rise to the potential for additional cost claims. The researcher identified cost components that increased during the duration extension, particularly fixed costs, including:

- a. Field Overhead Costs: Salaries of key personnel and ongoing office operating costs during the extension period.
- b. Equipment Idling Costs: The cost of owning or renting equipment that remains on-site but is unable to operate productively due to force majeure.

This analysis aims to maintain the principle of fairness in the contract, where the financial burden of events beyond the control of the parties is distributed proportionally. If the EoT determination results are unable to return the schedule to the original target plan, further technical action is required through a crash analysis at the next stage.

Crashing Schedule Acceleration Method

This stage is the Recovery Phase, which aims to optimize the project completion duration following delays caused by flooding. The analysis was conducted using the Time-Cost Trade-Off method to achieve a shorter duration with the most efficient cost increase. Referring to the methodology applied by Mulia (2023), the acceleration stages are carried out as follows:

Determining Critical Activities for Crashing

In accordance with the principles of the Critical Path Method, acceleration is focused only on activities on the critical path as analyzed in point 3.6. This is based on the theory that only reducing the duration of critical activities can

directly reduce the total project completion time. Critical activities in this study are identified by a Total Float value equal to zero (TF=0).

Crash Cost Estimation

Each selected critical activity is then analyzed to determine its acceleration cost (B'). The acceleration cost is calculated based on the assumption of additional resources to achieve the shortened time or crash time (D'). Based on the formula developed by Mulia (2023), the estimated acceleration cost is determined using the equation:

$$B' = \frac{D}{D'} \times B$$

Where:

D = Normal time

D' = Accelerated time (crash time)

B = Normal cost

B' = Accelerated cost (crash cost)

The acceleration duration is achieved by adding 3 hours of overtime per day to the normal 8-hour working day, in accordance with the maximum limit stipulated in Law Number 13 of 2003 concerning Manpower. Based on this addition, the total working hours per day become 11 hours, so the crash duration is determined using the formula:

$$\text{Crash Duration} = \text{Normal Duration} \times (8 \div 11)$$

The crash cost calculation is based on the additional labor costs due to overtime, referring to Government Regulation Number 35 of 2021 concerning overtime wages, with the following provisions:

1. 1st overtime hour = 1.5 x normal hourly wage
2. 2nd and 3rd overtime hours = 2.0 x normal hourly wage

Total overtime pay factor for 3 hours = (1.5 + 2.0 + 2.0) = 5.5 hours – the equivalent of 8 normal hours = 68.75% additional labor wages.

The labor component is assumed to be 40% of the normal cost based on the general composition of the bridge construction RAB, so the crash cost factor is:

$$\text{Crash Cost} = \text{Normal Cost} \times (1 + 40\% \times 68.75\%)$$

$$\text{Crash Cost} = \text{Normal Cost} \times 1.275 = 127.5\% \text{ of Normal Cost}$$

Optimal Time and Cost Comparison Evaluation

The final step is to conduct a comprehensive comparison between the total time and cost under normal conditions and those resulting from the acceleration (crashing) event. The output of this stage is a graph of the relationship between time and cost, representing the optimal acceleration point. This analysis provides strategic recommendations regarding realistic completion times and the amount of additional costs required to restore the project schedule after the flood.

The results of this acceleration analysis are then integrated into a 3-Phase Intervention Model as a recovery strategy to minimize the financial and time impacts of the flood event.

Phase Intervention Model

As the final stage of the research methodology, all of the above procedures are synergized into an integrated decision-making model called the 3-Phase Model. This model is structured chronologically to address the impact of flood delays, as follows:

Preventive Phase (Baseline Standardization)

This phase is a fundamental procedure carried out under normal conditions (before a disruption occurs). The main focus is processing the secondary data collected in point 3.3 (RAB, S-Curve, and Technical Specifications) to develop the Baseline Schedule. This stage is mandatory to establish a standard reference point for the plan's duration and cost, so that any future deviations have valid comparison parameters.

Responsive Phase (Identification of Impacts and EoT Justification)

This phase is activated immediately after a flood event (force majeure). Researchers input disruption duration data into the project schedule and then conduct a CPM Analysis. A critical step in this phase is verifying whether the flood event intersects activities on the critical path.

- If the flood impacts the critical path and shifts the final completion date, an Extension of Time (EoT) Determination procedure is performed as an administrative legality to avoid delay penalties.
- If the analysis results indicate that the flood impact does not affect the final completion date, the process can stop with internal schedule adjustments.

Recovery Phase (Acceleration and Optimization of Crashing)

This phase is a technical intervention stage carried out if the extension of time (EoT) in the previous phase is deemed insufficient to meet the project completion target or the owner's demands. The strategy adopted was to conduct a crash analysis using a scenario of increased working hours (overtime). This phase concluded with a time-cost trade-off evaluation to determine the optimal balance between accelerating the project's duration and increasing its cost efficiency.

RESULTS AND DISCUSSION

Based on the acceleration coefficient calculation methodology established in sub-chapter 3.8.2, the crash analysis for this project was implemented using a duration multiplier of (8/11) days and a crash cost factor of 1.275 of the normal cost. This multiplier was applied consistently to all construction work items on the affected critical path. The results of the duration adjustment and direct cost overruns for each project activity were as follows.

Acceleration is carried out in stages, starting with the activity with the smallest cost slope until the 14-day acceleration target is reached. Each additional day of acceleration is recorded as a separate scenario, allowing for a comparison of the duration and additional costs for each scenario.

Based on the scenario table above, the project was returned to the planned schedule through 14 crashing stages on the critical path. Acceleration was carried out in stages, starting from the activity with the lowest cost slope, namely Structural Excavation as the first priority, until the target of 14 days was reached. This strategy ensures minimal additional fixed costs because it always prioritizes

the most efficient activity in terms of cost per acceleration day. The 14-day acceleration target was met in Scenario 14 with a total additional direct cost of Rp 30,130,315. The relationship between cumulative acceleration and additional costs is visualized in the time-cost trade-off graph.

The optimal acceleration point was determined at Scenario 14, which achieved the 14-day acceleration target with the most efficient total additional cost of IDR 30,130,315. This value is significantly lower than the risk of liquidated damages that the contractor would have to bear if the project remained late. Thus, the project completion date could be moved back from December 1, 2025, to November 17, 2025, as per the SPK contract schedule, with an acceleration strategy that was both technically optimal and cost-efficient.

3-Phase Intervention Model

The final stage of the 3-Phase Intervention Model is the formulation of the results of all analyses into an integrated, applicable framework. This sub-chapter presents the integration of the results of the three phases, model formulation, practical work guidelines, and the completeness of the formal legal documents required to submit an Extension of Time (EOT) claim due to flood force majeure on a bridge project.

Integration of the Results of the Three Phases

All analysis stages conducted in the previous sub-chapter represent an implementation of the 3-Phase Intervention Model designed to comprehensively address bridge project delays due to flood force majeure – from prevention and impact response to schedule recovery.

CONCLUSION AND RECOMMENDATION

Based on the analysis and discussion conducted in this study, the following conclusions can be drawn:

1. The implementation of the Responsive Phase through Critical Path Method (CPM) analysis successfully identified the impact of force majeure flooding on the project's critical path quantitatively. Based on weekly project reports, a 14-day extension was determined for the Structural Excavation and 28 days for the Vero Sungai project due to inundation, as officially documented in the supervisor's instruction letter to the PPK. The impacted CPM analysis results indicated a shift in the project completion date from November 17, 2025, to December 1, 2025, thus establishing an EOT of 14 calendar days as the contractor's contractual right under Articles 1244–1245 of the Civil Code. This delay is categorized as an excusable non-culpable delay, and therefore, the contractor cannot be subject to liquidated damages for these 14 days.
2. An optimal crashing strategy was successfully formulated through simulations of 14 gradual acceleration scenarios for 12 critical path activities. Acceleration was achieved by adding 3 hours of overtime per day in accordance with Law No. 13 of 2003 concerning Manpower, with the crash duration determined based on a factor of 8/11 of the normal duration and the crash cost calculated at 127.5% of the normal cost, referring to Government Regulation No. 35 of 2021. The optimal acceleration point was achieved in Scenario 14 by prioritizing activities based on the smallest cost slope, starting with Structural Excavation (Rp 599,525/day). The total additional direct costs

required were Rp 30,130,315, far more efficient than the risk of delay fines that would have to be borne if the project was not accelerated.

3. The 3-Phase Intervention Model (Preventive-Responsive-Recovery) was successfully formulated into an Applicable Work Guideline consisting of 21 systematic steps and a checklist of 12 formal legal attachments for EOT claims. This model integrates CPM analysis, EOT mechanisms, and crash optimization into a single, coherent framework. Preventive generates a baseline schedule as a reference, Responsive identifies impacts and establishes EOT rights, and Recovery formulates an optimal acceleration strategy. This guideline has been proven to strengthen the basis of contract administration and the technical justification for claims for extensions and acceleration costs on bridge projects affected by force majeure flooding.

Based on the results of this study, the following recommendations are presented:

1. For Implementing Contractors

It is recommended to establish a CPM baseline schedule from the beginning of project implementation as an official technical document, rather than relying solely on the S-Curve. This will strengthen the contractor's position in filing EOT claims in the event of a force majeure event later.

2. For Project Owners and Supervising Consultants

It is recommended to adopt the Applicable Work Guidelines produced in this study as an objective evaluation instrument for verifying contractors' EOT proposals and acceleration costs, thereby ensuring a more transparent contract addendum process and avoiding potential disputes.

3. For Future Researchers

This study utilized a single case study with secondary data. Therefore, it is recommended to:

- a. Validate the 3-Phase Model on other bridge projects in different flood-prone areas to test model replicability
- b. Develop a more detailed crash analysis using the AHSP approach to generate more accurate crash costs
- c. Integrate the Laksono-Erub HSS flood discharge prediction method into the Preventive Phase to strengthen risk mitigation aspects from the planning stage.

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