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Analysis Cost Implementation Using Erection Method in Bridge Construction Malo District – Bojonegoro

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Abstract

The construction of the Malo Bridge in Bojonegoro Regency encountered significant challenges during the superstructure erection phase, primarily due to limited site accessibility and the use of a less suitable erection method. This study aims to evaluate the comparative efficiency of two primary erection techniques: the use of a 250-ton crawler crane operated from land and a combined method involving a 100-ton crawler crane supported by modular pontoons operating from the water. A case study approach with a quantitative methodology was applied, focusing on three main parameters: erection duration, construction cost, and risk management. The analysis indicates that the land-based 250-ton crawler crane method required a shorter erection period of 181 days, compared to 203 days for the modular pontoon method, resulting in a time-efficiency gain of 10.84%. Furthermore, the 250-ton crawler crane method demonstrated greater cost-effectiveness and a lower level of operational risk. These findings highlight that selecting an erection method that aligns with the site's geographical and logistical conditions is crucial for optimizing construction performance. Appropriate method selection can lead to significant improvements in both time and cost efficiency, especially in complex or constrained environments.

Keywords : erection method , steel bridge, time efficiency , construction cost, risk management.

INTRODUCTION

Development technology in construction has made significant progress in infrastructure development, particularly bridges. Innovation in implementation methods is not only intended to improve aesthetics but also to address time efficiency, cost, and work safety (Boatca et al., 2025; Karakhan & Gambatese, 2017; Laudante, 2017). One of the critical stages in a bridge project is the erection process, namely the installation of the superstructure, which requires thorough planning in accordance with geographical and technical conditions.

The Malo Bridge – Bojonegoro in Bojonegoro Regency is designed as a steel arch bridge (arch bridge) with a main span of 145 meters and a maximum ارتفاع of 27 meters above the road surface. This bridge does not have a central pier and is supported by two abutments on the Malo and Bojonegoro sides. These conditions make the erection method a vital aspect because the entire structural load must be transferred through the two main support points (Karnovsky & Lebed, 2021).

In its implementation, the initial erection method used was a combination of a mast crane and a pontoon, referring to the approach used in the Bangkinang Bridge project in Riau. However, due to differences in the dimensions and weight characteristics of the steel segments, the equipment could not support lifting operations optimally (Bouh &

Riopel, 2015; Tian et al., 2016). This failure caused a project delay of up to two months. The subsequent method used a 100-ton crawler crane with limited land access, but it still faced constraints during the rainy season, which resulted in damage to work access and disturbances to equipment stability (Mishra, 2022; Pandey, 2025; Pradhanang et al., 2024).

These problems demonstrate the importance of selecting an appropriate erection method in accordance with field conditions. Therefore, this study compares two main potential methods applied, namely: (1) a 250-ton crawler crane method from the land side and (2) a combination method using a 100-ton crawler crane on a modular pontoon. Both methods are analyzed from the aspects of implementation time acceleration, cost efficiency, and risk management.

Based on Wahyu et al.'s (2019) study, the crawler crane method was proven to be faster compared to the beam launcher in kite bridge projects. Meanwhile, Widi Nugraha and Chairulloh (2018) emphasized the importance of pontoon stability when using a crane to avoid operational failure. These findings show that the selection of an erection method must comprehensively consider both technical and geographical aspects.

This study aims to analyze the efficiency of erection time and cost, as well as the implementation risks between the two methods. The results of this study are expected to provide a practical contribution as a technical reference for other bridge projects, especially in areas with limited land access and challenging geographical conditions, such as large river flows.

Based on that position, the purpose of this study is to analyze and compare the efficiency of the two erection methods applied to the Malo Bridge project, especially in terms of erection duration, construction cost, and implementation risk. More specifically, the research seeks to determine whether the land-based 250-ton crawler crane provides better project performance than the modular-pontoon alternative, and to explain why one method is more suitable under the site's logistical and geographical conditions. In this sense, the study does not merely compare equipment capacities; it examines how construction strategy should be aligned with environmental context, access characteristics, and the practical demands of steel arch bridge erection.

The expected contribution of this research is both theoretical and practical. Theoretically, it enriches construction management and bridge execution literature by showing that erection method selection should be treated as a multi-criteria decision problem involving time, cost, and risk simultaneously. Practically, it provides a technical reference for contractors, planners, consultants, and project owners who must select lifting methods for similar bridge projects, especially those located in river corridors or areas with restricted work access. The objectives of the study are therefore to identify the comparative performance of each method, measure the efficiency difference between them, and formulate a more rational basis for method selection. The benefit of the research is that it can help future projects minimize delays, reduce unnecessary expenditures, and improve construction safety through better-matched erection planning (Adriana, 2016).

RESEARCH METHODS

This study used a quantitative approach and a case study design with the objective of analyzing the efficiency comparison between two erection methods in the project development Bridge Malo District, Regency Bojonegoro. The study was conducted based on primary data from project implementation and secondary data from literature as well as planning documents. A comparative approach was used to evaluate differences in performance between erection methods based on implementation time, work costs, and risk management arising during the implementation process.

The object of the study was the superstructure erection work on the Malo–Bojonegoro Bridge, a 145-meter steel arch bridge that did not have a central pier. The research focused on the two erection methods used in this project, namely the first method using a 250-ton capacity crawler crane operated from the land side, and the second method involving the combined use of a 100-ton crawler crane positioned on a modular pontoon for implementation from the river side.

The comparison between the two methods was conducted by analyzing erection execution duration data and cost estimates based on the Unit Price Analysis of Work of Bojonegoro Regency (AHSPK). In addition, risk assessment was carried out through the identification of technical and environmental factors affecting erection execution, such as equipment stability, load weight, weather conditions, and work-access readiness.

The efficiency of erection execution time was calculated using Formula 1, as follows:

$$E_w = \left(\frac{T_P - T_C}{T_P}\right) \times 100\%$$

With $E_w$is the erection time efficiency in percent, $T_P$is the total erection duration using the modular pontoon method, and $T_C$is the total erection duration using the crawler crane method. Based on project data, the modular pontoon method has an erection duration of 203 days, while the 250-ton crawler crane method has a duration of 181 days. Thus, the following time efficiency is obtained:

$$E_w = \left(\frac{203 - 181}{203}\right) \times 100\% = 10{,}84\%$$

This showed that the crawler crane method had superiority in terms of implementation time. The estimated erection cost was calculated by considering components such as equipment mobilization weight, daily rental costs, and additional costs resulting from weather constraints and terrain conditions. Technical and operational risks from both methods were evaluated to provide a comprehensive description of the effectiveness of erection method implementation in this project.

RESULT AND DISCUSSION

This study analyzed the two erection methods used in the development of the Malo Bridge – Bojonegoro, namely the 250-ton crawler crane method from the land side and the modular pontoon method using a 100-ton crane on the river. Both methods were compared in terms of implementation duration, cost efficiency, and potential operational risks that could arise during the erection process.

Based on the results of field data collection, the erection method using a crawler crane had an implementation time of 181 days, while the modular pontoon method required up to 203 days. This difference was calculated using Formula 1 in the Research Methods section, resulting in a time efficiency of 10.84%. This value showed that the crawler crane method was capable of significantly reducing the erection duration compared to the modular pontoon method. These findings also strengthened the results of the study by Wahyu Kurniawan et al. (2019), which showed that crane-based lifting methods from land are more time-efficient and flexible in limited workspaces.

Table 1. Duration Erection Implementation Based on Method

Method	Duration Implementation (day)
Crawler Crane 250 tons	181
Modular Pontoon + Crawler Crane 100t	203

Source table data reference: Project data Field (2024)

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In addition to time, cost efficiency was also a focus of the analysis. Based on calculations using local unit prices (AHSPK), the crawler crane method tended to have lower implementation costs compared to the modular pontoon method. This was due to the additional logistical requirements of the pontoon method, such as the use of pontoons, mooring systems, and material transportation via waterways. Although both methods required high-capacity heavy equipment and had relatively similar daily operational costs, the pontoon method required more extensive technical adjustments and supporting infrastructure in the field, resulting in higher total costs.

Table 2. Summary Comparison Erection Cost

Component Cost	Crawler Crane (250t)	Modular Pontoon + Crane (100t)
Heavy Equipment Mobilization	Currently	Tall
Daily Operations	Tall	Tall
Access Support	Low	Tall

Component Cost	Crawler Crane (250t)	Modular Pontoon + Crane (100t)
Potential Addition Cost	Low	Tall
Total Estimate	More Efficient	More expensive

Source table data reference: AHSPK Regency Bojonegoro (2024), processed data researcher

Other aspects analyzed were technical and operational risks. Based on the results of observations and the literature review, the erection method using modular pontoons had higher risks, especially related to the stability of the work platform on water, weather interference, and crane operator safety. In contrast, the crawler crane method, which was operated from land, offered better work stability, if there was an adequate and well-compacted work area.

Table 3. Matrix Erection Method Risks

Aspect Risk	Crawler Crane (250t)	Modular Pontoon + Crane (100t)
Tool Stability	Stable (land) congested)	Vulnerable (current river, waves)
Access and Logistics	Easy	Complex
Weather	Affected currently	Very affected
Operator Safety	Awake (access) stable)	Vulnerable (crane on pontoon)
Risk Addition	Low	Tall

Source table data reference: Analysis researcher based on studies field

The risks that arose in the pontoon method are consistent with the study by Elvis Adril et al. (2014), who noted the potential failure of heavy equipment because of pontoon instability and operational faults on water. Therefore, the use of pontoons must be supported by a robust mooring and securing system, as well as certified operator training.

This study was also compared with previous studies discussing steel bridge erection methods. Some of them, such as Widi Nugraha and Chairulloh (2018), highlighted the importance of controlling deflection during girder lifting using a crane on a pontoon. Meanwhile, Affandhie et al. (2018) and Jadhav et al. (2017) emphasized the importance of synchronization between structural design and the erection method used. In the context of the Malo Bridge, which crosses the Bengawan Solo River with limited land access and complex geographical conditions, the results of this analysis showed that the land-based crane erection method was more superior in terms of time efficiency, cost, and risk level, provided that site conditions allowed.

Thus, this discussion clarified that the selection of an appropriate erection method was not only based on technical effectiveness, but also considered location accessibility, potential risks, and economic efficiency (Faraji et al., 2021; Rezaee et al., 2020; Rezaie & Rosen, 2012; Zhasmukhambetova et al., 2025). The results of this research are expected to serve as a reference in planning erection methods for similar projects, especially in locations with access challenges such as large rivers or isolated areas.

CONCLUSION

Based on the analysis of the two erection methods for the Malo Bridge – Bojonegoro, the 250-ton crawler crane method demonstrated clear superiority in terms of time efficiency, cost, and risk level compared to the combined modular pontoon method with a 100-ton crane. The crawler crane method completed erection in 181 days, 10.84% faster than the 203 days required for the pontoon method. It also required simpler logistics, was less dependent on water conditions, and posed lower environmental and operational risks. In contrast, the pontoon method was more vulnerable to river currents, waves, and extreme weather, and required certified operators and stricter work management. Therefore, the 250-ton crawler crane method is recommended for projects with sufficient land access and stable ground conditions, while the modular pontoon method can serve as an alternative in locations with limited land access, provided that operational risks and logistics are carefully managed. Future research could explore hybrid or adaptive erection strategies that optimize efficiency and safety in sites with highly variable environmental and access constraints, potentially integrating real-time monitoring and predictive risk management tools.

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