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Comparative Analysis of Construction Costs for Concrete and Steel: A Case Study of the Modern Islamic Boarding School an – Nizam Purwokerto

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A B S T R A C T

The selection of structural materials plays a crucial role in determining cost efficiency and construction time in building construction projects. This study aims to analyze and compare the construction costs of reinforced concrete and steel structures in the construction of the Modern Islamic Boarding School An-Nizam in Purwokerto. A quantitative comparative method was used by calculating the volume of work, construction cost estimates (RAB), and project duration for both types of structures. The analysis focused on main structural elements such as columns and beams, based on detailed drawings, unit price standards, and project technical data. Based on the calculations and analysis of this project, it can be concluded that the total construction cost for the reinforced concrete structure is Rp 8,983,363,148.58. Meanwhile, the total construction cost for the steel structure is Rp 8,445,489,989.60. The duration of the steel construction work is 19-20 weeks, and the duration of the concrete structure construction work is 25-30 weeks. Therefore, it can be concluded that from this case study, the total cost required for concrete structure construction is cheaper than steel structure construction by a difference of Rp 537,873,158.98. However, the duration of steel structure construction is faster than concrete construction, with a difference of 6-10 weeks.

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INTRODUCTION

The selection of a structural system at the initial stage of a construction project is a fundamental aspect that directly impacts design, cost, duration, and project implementation methods. Primary materials such as reinforced concrete and steel have unique characteristics that influence the entire project cycle. Errors in material selection not only increase costs but can also cause delays and implementation inefficiencies (Hendrickson & Au, 2008). Common examples encountered in the field include extended construction timelines due to prolonged concrete curing times, limited interior design flexibility caused by conventional concrete beam systems, and high maintenance costs for steel structures due to corrosion if surface protection is inadequate (Arifi & Setyowulan, 2020; Wahyuni et al., 2023). Therefore, the selection of structural materials must consider technical, economic, duration, and functional requirements of the project comprehensively from the planning stage.

Reinforced concrete structures are widely chosen due to their abundant availability, ease of construction, and relatively lower initial costs. Meanwhile, steel structures offer advantages in terms of high tensile strength, standardized fabrication processes, and faster construction time (Tampubolon, 2022; Arifi & Setyowulan, 2020). However, the cost efficiency between the two systems remains a subject of debate and is highly contextual to the type of project and construction location. Previous studies have yielded varying results. Wahyuni et al. (2023) state that although steel structures have advantages in terms of construction time, the total construction cost tends to be higher than that of concrete structures. Similar findings were reported by Sunatha et al. (2023) in a case study of dormitory construction, where steel structures incurred higher costs than concrete, despite having a shorter construction time. Therefore, the selection of appropriate structural materials is crucial because it not only affects technical aspects and costs but also impacts construction efficiency, project sustainability, and future maintenance ease (Lawson & Ogden, 2008; Maskur et al., 2023).

This study aims to provide a quantitative analysis of the cost comparison between reinforced concrete and steel structures in institutional building construction, specifically in the Modern Islamic Boarding School An-Nizam Purwokerto project. This is important considering that cost efficiency is a crucial aspect in projects funded by community contributions and donors. Using a comparative approach, this study is expected to provide technical-economic recommendations that can serve as a reference for project owners, planners, and construction contractors.

LITERATURE REVIEW

Previous studies have discussed the comparison between reinforced concrete structures and steel structures, both in terms of cost and construction duration. Wahyuni et al. (2023) found that steel structures are indeed superior in terms of time efficiency, but the total construction cost tends to be higher than reinforced concrete structures in logistics warehouse projects. This indicates that the use of steel structures is less ideal for projects with budget constraints.

Maskur et al. (2023) conducted a study on a promotional and marketing center building project, and the results showed that concrete structures are more economical overall. They also highlighted that steel structures become a viable option only when there is a need for project acceleration and sufficient budget support.

Syamsuddin et al. (2025) added a long-term dimension by comparing maintenance costs between the two types of structures. They concluded that concrete structures are more advantageous in terms of life cycle cost, although they did not review the details of the implementation duration.

On the other hand, Hernandes & Abrar (2023) in an empirical study on an industrial workshop building project, showed that steel structures can be more efficient overall if the project is located in an area with logistical constraints or difficulty accessing ready-mix concrete.

From the overall literature, it can be concluded that there is no single material that is absolutely superior in all contexts. The selection of a structural system must be tailored to the project characteristics, location, available resources, and the project's primary priorities, such as cost efficiency, time efficiency, or sustainability. This study aims to enrich this discussion by focusing on an institutional community-based project, namely the construction of the Modern Islamic Boarding School An-Nizam, where cost efficiency is a critical factor.

METHODOLOGY

This study employs a quantitative-comparative approach with a case study methodology. The primary focus of the research is to compare cost efficiency between reinforced concrete and steel structures in the construction of the Modern Islamic Boarding School An-Nizam in Banyumas Regency, Central Java.

1. Data Sources
   - Primary Data

Data collected from the actual project includes materials, construction methods, and types of structures used.

   - Secondary Data

Data collected from design drawings, Unit Price Analysis (UPA), Cost Estimate (CE), and scientific articles.

2. Data Collection Techniques
   - Collection of working drawings for volume calculations
   - Data collection and unit prices
   - RAB and construction schedules for concrete and steel structures
3. Data Analysis Methods
   - Identification of structural elements

Determining the main structural components (columns and beams) to be compared between concrete and steel systems.

- Calculation of work volume

The volume of work is calculated based on the design drawings using volume units of m^3 for concrete and kg or m^2 for steel.

- Construction cost estimation

Costs are calculated by multiplying the volume of work by the appropriate unit prices for materials, labor, and equipment.

- Comparison of total costs

The cost estimates for both structures are directly compared, presented in tables and graphs, and the differences are analyzed in terms of efficiency percentages.

- Efficiency analysis

Determining the most efficient structure in terms of cost and implementation time, as well as evaluating the factors causing the differences.

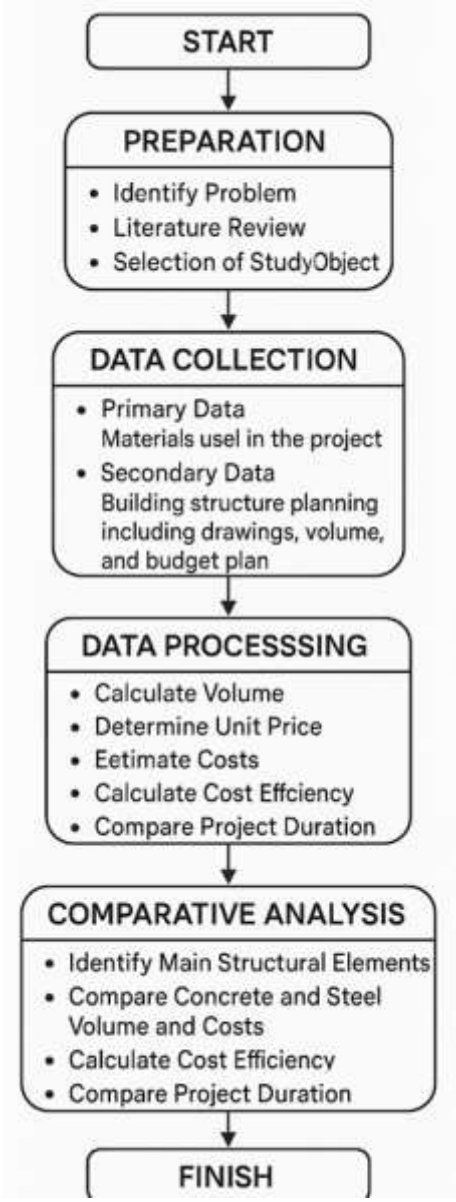


Figure 1. Work Framework

The planning location is on Jalan Raya Kebanggan, Kebanggan Village, Sumbang Subdistrict, Banyumas Regency, Central Java.

Figure 2. Research Location

RESEARCH RESULTS

Design conversion

Table 1. Design conversion

No	Concrete Structure	Moment (KNm)	Steel Structure	Moment (kNm)
1	K1 (700x700)	219,192	WF 350x350x12x19	405
2	K2 (400x400)	95,507	WF 250x250x9x14	184.5
3	BI1 (250x500)	172,726	WF 350x175x7x11	183.3
4	BI2 (300x700)	351,154	WF 400x200x8x13	366.75
5	BA1 (200x400)	67,056	WF 200x100x5.5x8	71,325
6	BA2 (200x400)	56,919	WF 200x100x5.5x8	71,325

Source: Author's Data, 2025

From the results of the design conversion calculations for concrete columns and beams to steel, it was found that with slimmer dimensions, steel structures tend to have greater strength compared to concrete structures.

Results of the comparison between the construction of concrete and steel structures

Table. 2 Results of the comparison between the construction of concrete and steel structures

Structure	**Equipment**	**Labor**	**Material**
Concrete	Rp 96,000,000	Rp 439,560,000	Rp 8,447,803,146
Steel	IDR 73,559,954	Rp 112,332,000	Rp 8,259,598,030
	Total Concrete		Rp 8,983,363,146
	Total Steel		Rp 8,445,489,984

Note: Difference between concrete and steel: Rp 537,873,158.98

Source: Author's Data, 2025

The results of the cost estimation calculation for the main structural elements of the construction of the Modern Islamic Boarding School An-Nizam building indicate a significant difference between the construction costs of reinforced concrete structures and steel structures. The comparison was made for column and beam structural elements with the following details:

1) Equipment Components

From the table, it is found that the equipment costs for reinforced concrete construction are higher than those for steel construction, with reinforced concrete construction requiring Rp 96,000,000.00 and steel construction costing Rp 73,559,954.00.

2) Labor Component
   - Concrete structures require labor with a total cost of Rp 439,560,000.00.
   - Steel structures require fewer workers, resulting in significantly lower costs, namely Rp 112,332,000.00.

In this study, the concrete used is conventional concrete, which inherently requires a significant amount of labor. This difference indicates that the cost of concrete structures is relatively high and contributes significantly to the total cost.

1) Material Components
   - The concrete structure requires material costs of Rp 8,447,803,146.00.
   - Steel structures require material costs of Rp 8,259,598,030.00.

Material costs show the same trend as other components, namely that concrete structures have higher costs.

2) Total Cost
   - The total cost for the concrete structure is Rp 8,983,363,148.00.
   - The total cost of the steel structure is Rp 8,445,489,989.00.

Therefore, there is a cost difference of Rp 537,873,158.98, indicating that the steel structure is more cost-effective than the concrete structure in this project.

Table. 3 duration calculation results

Structure	Construction Duration (weeks)	Duration Difference (weeks)
Concrete	25 weeks	
Steel	19 weeks	6 weeks faster

Source: Author's data, 2025

Based on the analysis results, concrete structures require 25 weeks for construction, while steel structures only need 19 weeks. Therefore, steel structure construction is 6 weeks faster than concrete.

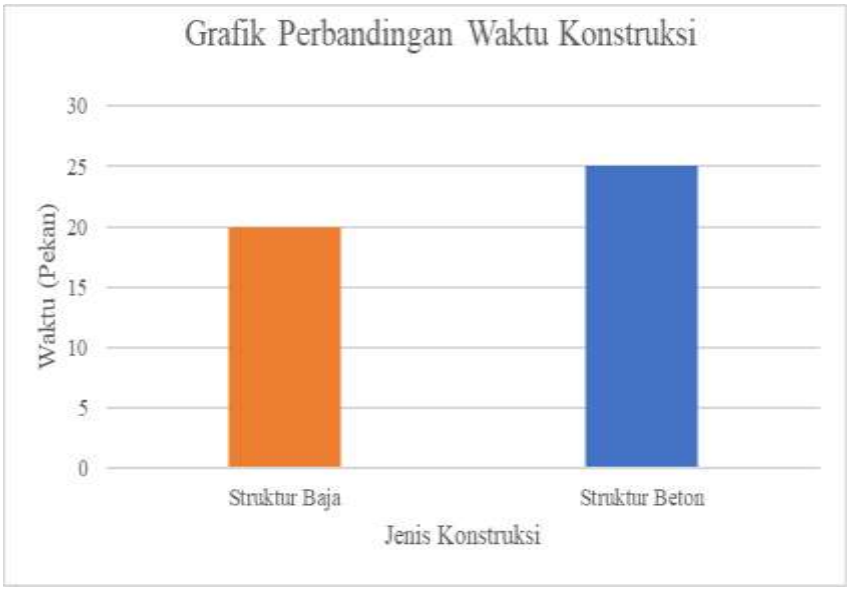
This time advantage is due to the steel fabrication process being carried out off-site and more efficient installation without the need for curing time, as required for concrete.

Cost and duration comparison graph

Source: Author's Data, 2025

Figure 3. Cost and duration comparison graph

From the graph, it can be seen that steel structures tend to have lower costs compared to concrete structures, particularly in terms of labor and equipment. Meanwhile, material costs for steel structures also demonstrate competitive efficiency. This indicates that the use of steel structures can be a more economical alternative in construction, especially for projects with high cost efficiency requirements.



Source: Author's Data, 2025

Figure 4. Construction Time Comparison Chart

From the second diagram, it is observed that the construction time for steel columns and beams is faster compared to concrete columns and beams.

DISCUSSION

The research results indicate that reinforced concrete structures are more economical than steel structures. The total cost of the concrete structure is Rp 8.983 billion, while the steel structure reaches Rp 8.445 billion, making steel structure construction approximately Rp 538 million more cost-effective.
The largest cost difference is in the labor component, where steel material costs are significantly higher. Meanwhile, in terms of construction duration, steel structures are more advantageous as they can be completed in 19 weeks, 6 weeks faster than concrete structures, which require 25 weeks.

This finding aligns with research conducted by Hernandes & Abrar (2023) in an industrial project context, where steel structures are considered more effective due to their ability to accelerate construction in hard-to-access locations. This indicates that geographical and logistical factors also play a significant role in material selection for structural design.

However, Syamsuddin et al. (2025) note that from a long-term maintenance perspective (*life cycle cost*), concrete structures offer advantages due to their greater resistance to corrosion and reduced need for additional protection.
Therefore, in this case study, steel structures are more suitable for projects emphasizing construction speed, such as modern boarding schools.

CONCLUSIONS AND RECOMMENDATIONS

Based on the calculations and analysis of this project, it can be concluded that the total construction cost of the concrete structure is Rp 8,983,363,148.58 (Eight billion nine hundred eighty-three million three hundred sixty-three thousand one hundred forty-eight rupiah), while the total construction cost for the steel structure is Rp 8,445,489,989.60 (Eight billion four hundred forty-five million four hundred eighty-nine thousand nine hundred eighty-nine rupiah). The duration of the steel construction work is 19-20 weeks, and the duration of the concrete structure construction work is 25-30 weeks.

Therefore, it can be concluded that from this case study, the total cost required for steel structure construction is cheaper than concrete structure construction by a difference of Rp 537,873,158.98 (five hundred thirty-seven million eight hundred seventy-three thousand one hundred fifty-eight rupiah). The construction duration for steel structures is also faster than concrete, with a difference of 6-10 weeks.

ADVANCED RESEARCH

This study has limitations in the scope of analysis, which only covers main structural elements such as columns and beams, and is based on a single case study of an institutional project at the An-Nizam Modern Islamic Boarding School ( ). Therefore, to obtain more generalizable results, further research is recommended to include more project variations with different building types, such as high-rise buildings, commercial facilities, or industrial buildings.

Additionally, future research could expand the scope of analysis by considering aspects of material sustainability, environmental impact, long-term maintenance (*life cycle cost*), and construction risks related to weather and

geographical location. Integration with BIM (*Building Information Modeling*) technology could also be a direction for further development to facilitate real-time simulation of time and costs, as well as to enhance the accuracy of decision-making in selecting structural systems.

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