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COMPARATIVE ANALYSIS OF COST AND TIME FOR CONVENTIONAL BEAM AND HALF BEAM PRECAST WORK IN HIGH-RISE BUILDINGS

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Abstrak

The current technological advancements support the development of construction implementation methods. Various options for construction implementation methods are being enhanced to accelerate work time without incurring additional costs and without compromising the established quality. The selection of construction implementation methods plays an important role in the execution of a construction project to achieve optimal results, especially in terms of time and cost. One of the frequently used construction implementation methods in high-rise buildings today is the use of precast concrete. This study compares the conventional beam method with another method, the half beam precast method, in terms of time and cost using secondary data obtained from the project. Analysis in terms of time and cost is carried out based on applicable regulations according to field conditions. The results of the cost and time analysis comparison between the two methods show that the conventional beam method takes 145 days with a total cost of IDR 2,726,007,844.52, while the half beam precast method takes 121 days with a total cost of IDR 2,032,065,959.42. Therefore, the half beam precast method is more efficient in terms of time and cost as it is 24 days of 16,55% faster and costs IDR 693,941,885.10 or 25.46% less.
Keywords: *conventional beam, half beam precast, time and cost.*

INTRODUCTION

Current technological advancements today are fostering the development of construction methods. Various construction techniques have been improved to accelerate project timelines without additional costs and without compromising quality (Letra et al., 2021). Choosing the appropriate construction method is vital for archieving optimal project outcomes, particularly in terms of time and cost efficiency (Anugerahanto & Adistana, 2021). A common method currently employed in high-rise building construction is the use of precast concrete (Koesoema et al., 2023).

Precast concrete is fundamentally similar to conventional concrete, as both use materials like cement, fine aggregates, hard aggregates, and water. The key difference lies in the production process: precast concrete is manufactured off-site, while conventional concrete is made on the project site. Precast concrete offers several advantages, including time efficiency, easier schedule management, guaranteed concrete quality, enhanced worker health and safety, cleaner project environments due to reduced material usage, and cost savings from reusable formwork (Najoan et al., 2016).

As outlined, precast concrete and conventional concrete differ in several aspects. Contractors need to determine the most appropriate method for their projects to avoid extra costs and meet deadlines. This study compares the conventional beam method the half beam precast method. The findings from this comparison can serve as a reference for choosing the beam construction method in future high-rise building projects, especially regarding time and cost efficiency.

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THEORETICAL REVIEW

A. Beam

A beam is a critical element in building structures, designed to bear the load of the upper structure and transfer it to the columns (Darmansyah SKD & Chairani, 2022). Beams manage complex stresses, such as buckling and bending. Bending involves both compressive and tensile forces, resulting in uneven stress distribution across the beam's cross-section. When a beam is overloaded bending forces increase, creating high-stress areas where hinging can occur (Persada & Sumarman, 2017).

B. Conventional Concrete

Conventional concrete is produced directly at the project site. The concrete mixture is prepared in a mixer and then placed into the structure where reinforcement and formwork have already been installed (Najoan et al., 2016). This method offers advantages over precast concrete, such as eliminating transportation costs since the concrete is made on-site, and not requiring additional erection equipment (Hamdi & Harijadi, 2010). Despite its widespread use, the costs associated with conventional concrete can be substantial (Chasanudin et al., 2023).

C. Precast Concrete

Precast concrete is a method where the concrete is manufactured away from the project site, usually in a factory or workshop. It can also be produced in a designated casting area at the project site, known as the production yard. This area is specifically prepared for producing precast concrete components (Nauly et al., 2022). After the concrete has adequately cured, the precast elements are removed from the molds and assembled. This assembly process known as erection, typically involves heavy machinery such as tower cranes of mobile cranes.

Additionally, precast concrete is composed of the same materials as conventional concrete, such as Portland cement, water, fine aggregates, and hard aggregates. However, precast concrete has several advantages that conventional concrete does not, including assured quality, quicker construction times, and more cost-effectiveness for larger volumes (Hamdi & Harijadi, 2010).

D. Time Analysis

Time analysis is perfomed to ascertain the total duration needed for tasks in a project (Pertiwi et al., 2023). This analysis is based on calculating the work colume and worker productivity. Higher productivity means that tasks can be completed more quickly, while lower productivivty results in longer completion times. The time analysis can be calculated using the following (Widanti et al., 2020):

$$\text{Duration} = \frac{work\ volume}{work\ productivity}$$

E. Cost Analysis

Cost analysis is performed to manage the required expenses and assist in the allocation of resources and management strategies for each project implementation method (Riyadi et al., 2022). This analysis includes the volume of work, material costs, labor wages, and equipment expenses, derived from unit prices of the work, leading to the creation of a budget plan (RAB) (Kurniawan, 2016). The budget plan calculation can be done using the following formula (Sari, 2019):

$$\text{Cost budget plan} = \sum Volume\ of\ Work \times Unit\ Price\ of\ Work$$

RESEARCH METHODOLOGY

This study employs a quantitative approach using a case study method to compare the conventional beam construction method with the half beam precast method in terms of time and cost. The stages of the research are depicted in the research flowchart shown in Figure 1 below:

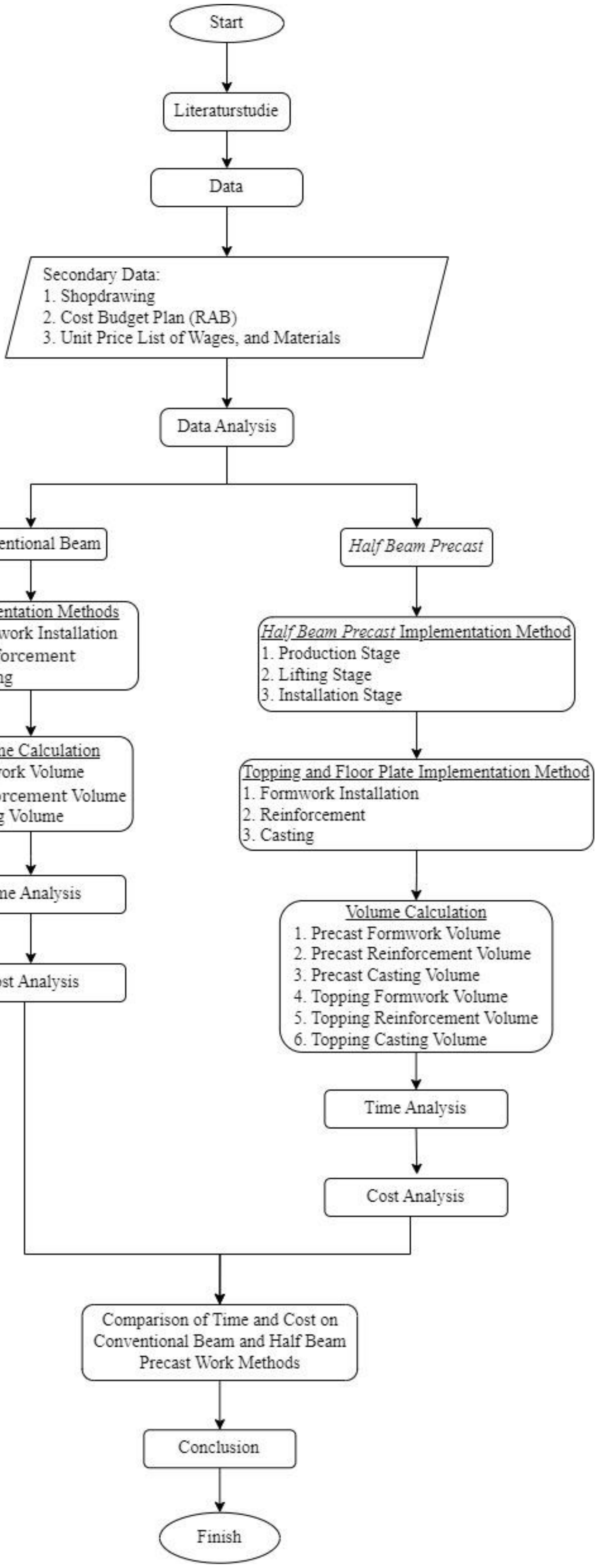


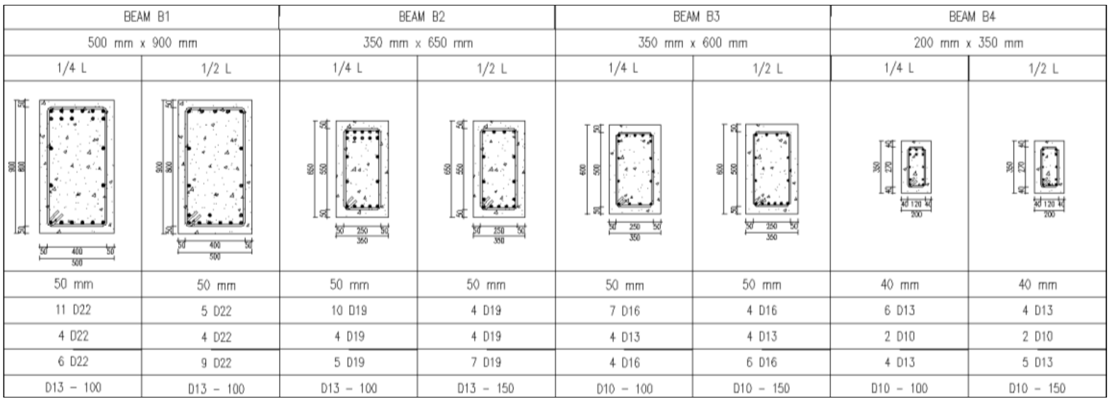
Figure 1. Research Flowchart

RESULT AND DISCUSSION

A. Beam Design

1. Conventional Beam

The design for the conventional beam in this study is bsed on the actual conditions of the construction project. The concrete quality used is f'c 31,2 MPa or K-350. Figure 2, based on the shop drawing, provides detailed design specifications for the conventional beam.



BEAM B1		BEAM B2		BEAM B3		BEAM B4	
500 mm x 900 mm		350 mm x 650 mm		350 mm x 600 mm		200 mm x 350 mm	
1/4 L	1/2 L	1/4 L	1/2 L	1/4 L	1/2 L	1/4 L	1/2 L
50 mm	50 mm	50 mm	50 mm	50 mm	50 mm	40 mm	40 mm
11 D22	5 D22	10 D19	4 D19	7 D16	4 D16	6 D13	4 D13
4 D22	4 D22	4 D19	4 D19	4 D13	4 D13	2 D10	2 D10
6 D22	9 D22	5 D19	7 D19	4 D16	6 D16	4 D13	5 D13
D13 – 100	D13 – 100	D13 – 100	D13 – 150	D10 – 100	D10 – 150	D10 – 100	D10 – 150

Figure 2. Conventional Beam Design

2. Half Beam Precast

Half beam precast method represents an advancement from the conventional beam construction technique. To form a complete beam, the half beam precast requires a topping layer, which can be installed concurrently with the floor slab work. An illustration of the half beam precast with its topping in place is shown in Figure 3.

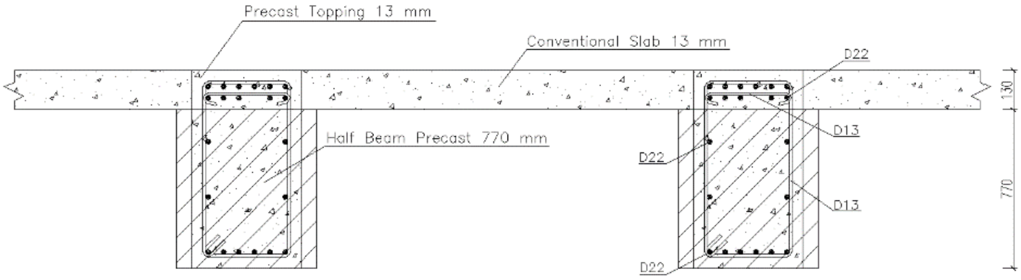


Figure 3. Illustration of Half Beam Precast with Topping Installed

The design of the half beam precast must be verified through calculations under three conditions: during lifting, before the composite state, and after the composite state. This verification ensures the design adheres to the required standards.

➢ Lifting Condition

During the lifting condition, it is assumed that the beam is supported by hinge supports at the lifting points. This scenario is depicted in Figure 4.

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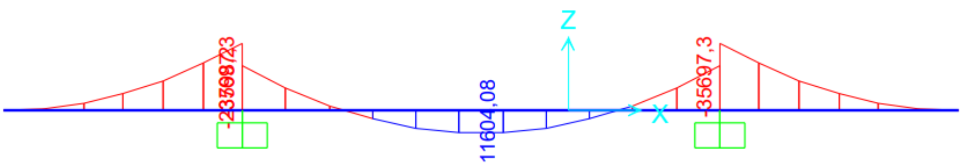

Figure 4. Moment in Lifting Condition

<u>Loading</u>

Dead Load (DL) = 924 kg/m

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Moment Control

The moment obtained is 35,6973 KNm. The control calculation can be calculated using the following formula (SNI 2847:2019):

ØMn = 0,85 × a × fc' × b (d - ½ a)
= 0.85 × 72,206 × 31,2 × 500 (720 - ½ × 72,206)
= 654796461,618 Nmm = 654,796 KNm

Condition : ØMn > Mu
654,796 > 35,6973 **OK**

Lifting Control

During lifting, it is planned to use reinforcement with a diameter of 13 mm and strength fy = 420 MPa can be used for lifting reinforcement. The control calculation can be calculated using the following formula (Kurniawan, 2016):

W = 2400 × 1,2 ×1,2 = 3456 kg/m^3
P = W × L × b × h
= 3456 × 10,15 × 0,5 × 0,77
= 13505,184 kg
0,25P = 0,25 × 13505,184
= 3376,296 kg

$T = \frac{0,25P}{\sin 60°} = \frac{3376,296}{\sin 60°} = 3898,611$ kg = 38986,11 N

$\sigma = \frac{T}{A}$

$= \frac{38986,11}{133}$

= 293,128 N/mm^2 < 420 N/mm^2 **OK**

Therefore, reinforcement with a diameter of 13 mm and strength fy = 420 MPa can be used for lifting reinforcement.

- Pre-Composite Condition

In this condition, it is assumed that the ends of the beam are supported by hinge-roller supports.

Loading

Dead load (DL) = 924 kg/m
Live load (LL) = 100 kg

Moment Control

The moment obtained is 146,8492 KNm and the planned reinforcement used is D22. The control calculation can be calculated using the following formula (SNI 2847:2019):

ØMn = 0,85 × a × fc' × b (d - ½ a)
= 0,85 × 37,629 × 31,2 × 500 (720 - ½ × 37,629)
= 349863527,240 Nmm = 349,864 KNm

Condition : ØMn > Mu
349,864 > 146,8492 **OK**

Therefore, D22 reinforcement is safe to use in the pre-composite condition.

- Post-Composite Condition

In this condition, it is assumed that the beam ends are supported by fixed supports, meaning the beam is clamped by the columns.

Loading

- On the floor slab:

Dead Load (DL) = 58,45 kg/m^2
Live load (LL) = 250 kg/m^2

- On the beam

Dead Load (DL) = 900 kg/m

Moment Control

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The moment obtained is 562,8738 KNm. And the planned reinforcement used is D22. The control calculation can be calculated using the following formula (SNI 2847:2019):

$\varnothing Mn = 0{,}85 \times a \times fc' \times b\ (d - ½\ a)$

$= 0{,}85 \times 57{,}512 \times 31{,}2 \times 500\ (850 - ½ \times 57{,}512)$

$= 626292529{,}520$ Nmm = 626,293 KNm

Condition : $\varnothing Mn > Mu$

626,293 > 562,8738 **OK**

Therefore, D22 reinforcement is safe to use in the post-composite condition.

The detailed design of the half beam precast is explained in Figure 5 below:

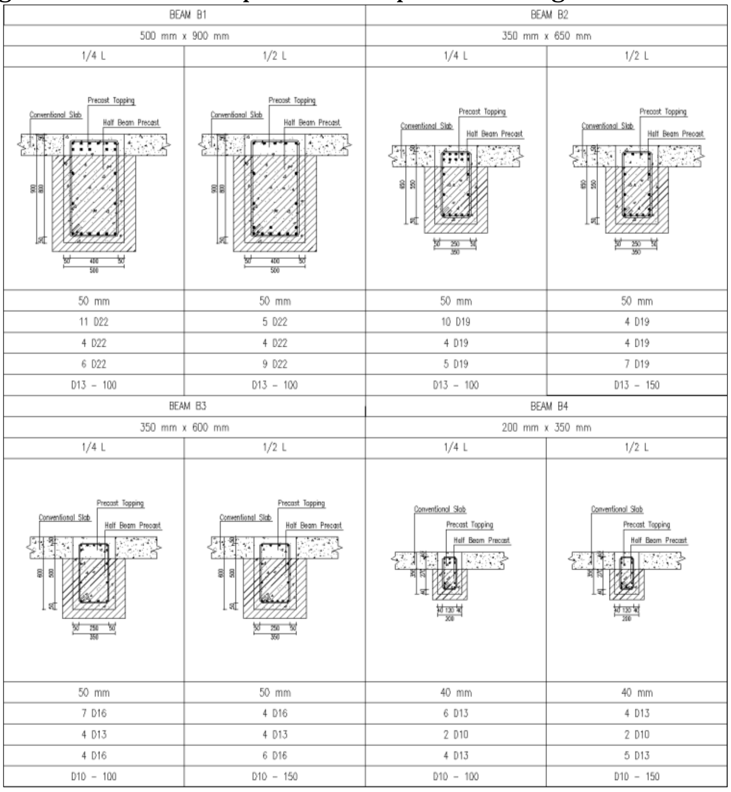

Figure 5. Half Beam Precast Design

B. Work Volume

1. Conventional Beam

The calculation of the work volume for conventional beams encompasses the volume of formwork, reinforcement work, and concreting work. The summarized volume calculations for conventional beams are shown in Table 1, based on project data:

Table 1. Summary of Conventional Beam Volumes

Floor	Formwork Volume	Reinforcement Volume	Concrete Volume
	(m^2)	**(kg)**	**(m^3)**
2	968,04	23842,89	144,50
3	968,04	23842,89	144,50
4	968,04	23842,89	144,50
5	967,32	23619,70	144,38

2. Half Beam Precast

The volume calculation for the half beam precast encompasses the formwork, reinforcement, and concreting for both the precast beam and its topping. A summary of these calculations is

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presented in Tables 2 and 3, derived from the design details of the half beam precast illustrated in Figure 5.

Table 2. Summary of Half Beam Precast Volume

Floor	Formwork Volume	Reinforcement Volume	Concrete Volume
	(m^2)	(kg)	(m^3)
2	799,32	14318,71	109,52
3		14318,71	109,52
4		14318,71	109,52
5		14285,11	109,97

Table 3. Summary of Topping Precast Volume

Floor	Formwork Volume	Reinforcement Volume	Concrete Volume
	(m^2)	(kg)	(m^3)
2	142,85	7490,61	25,44
3	142,85	7490,61	25,44
4	142,85	7490,61	25,44
5	143,63	7477,75	25,58

C. Time Analysis

1. Conventional Beam

Calculating the time required for conventional beam work involves referencing project unit prices to determine worker productivity. It also relies on the volume data of conventional beams listed in Table 1 to estimate the duration for each specific task involved in conventional beam construction. The outcomes of this time analysis are summarized in Table 4 below:

Table 4. Summary of Conventional Beam Durations

Type of Work	Duration (Days)
Floor 2 (Elv. +4.450)	
Formwork for Beams	6
Reinforcement for Beams	5
Concrete for Beams	2
Formwork for Floor Slabs	5
Reinforcement for Floor Slabs	4
Concrete for Floor Slabs	2
Floor 3 (Elv. +8.950)	
Formwork for Beams	6
Reinforcement for Beams	5
Concrete for Beams	2
Formwork for Floor Slabs	5
Reinforcement for Floor Slabs	4
Concrete for Floor Slabs	2
Floor 4 (Elv. +13.450)	
Formwork for Beams	6

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Type of Work	Duration (Days)
Reinforcement for Beams	5
Concrete for Beams	2
Formwork for Floor Slabs	5
Reinforcement for Floor Slabs	4
Concrete for Floor Slabs	2
Floor 5 (Elv. +17.950)	
Formwork for Beams	6
Reinforcement for Beams	5
Concrete for Beams	2
Formwork for Floor Slabs	2
Reinforcement for Floor Slabs	4
Concrete for Floor Slabs	1

To determine the total duration of conventional beam work, the calculated durations were input into Microsoft Project, resulting in a total duration of 145 days.

2. Half Beam Precast

In analysing the time required for half beam precast work, references are made to AHSP PUPR Ministerial Regulation No. 1 of 2022 and HSPK Surabaya City of 2022 are used to establish worker productivity benchmarks. Additionally, it relies on the volume data of half beam precast detailed in Table 2 and 3. The findings of this time analysis are summairzed in Table 5 below:

Table 5. Summary of Half Beam Precast Durations

Type of Work	Duration (Days)
Floor 2 (Elv. +4.450)	
Formwork for Precast Molds	1
Reinforcement for Precast	3
Concrete for Precast	2
Transporting 1 precast beam	1
Installing 1 precast beam	1
Formwork for Floor Slabs	6
Reinforcement for Floor Slabs	5
Concrete for Floor Slabs	3
Formwork for Precast Topping	6
Reinforcement for Precast Topping	5
Concrete for Precast Topping	4
Floor 3 (Elv. +8.950)	
Reinforcement for Precast	3
Concrete for Precast	2
Transporting 1 precast beam	1
Installing 1 precast beam	1

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Type of Work	Duration (Days)
Formwork for Floor Slabs	6
Reinforcement for Floor Slabs	5
Concrete for Floor Slabs	3
Formwork for Precast Topping	6
Reinforcement for Precast Topping	5
Concrete for Precast Topping	4
Floor 4 (Elv. +13.450)	
Reinforcement for Precast	3
Concrete for Precast	2
Transporting 1 precast beam	1
Installing 1 precast beam	1
Formwork for Floor Slabs	6
Reinforcement for Floor Slabs	5
Concrete for Floor Slabs	3
Formwork for Precast Topping	6
Reinforcement for Precast Topping	5
Concrete for Precast Topping	4
Floor 5 (Elv. +17.950)	
Reinforcement for Precast	2
Concrete for Precast	2
Transporting 1 precast beam	1
Installing 1 precast beam	1
Formwork for Floor Slabs	6
Reinforcement for Floor Slabs	4
Concrete for Floor Slabs	2
Formwork for Precast Topping	4
Reinforcement for Precast Topping	3
Concrete for Precast Topping	2

D. Cost Analysis

1. Conventional Beam

Similar to the time analysis, the cost analysis for conventional beam work requires project unit prices. In cost analysis, these prices serve as the basis for preparing the budget. The total cost for conventional beam work is summarized in Table 6 below:

Table 6. Summary of Conventional Beam Work Costs

No	Cost Type	Work Volume	Unit	Unit Price (IDR)	Total Price (IDR)
1	Formwork	3871,44	m^2	210,220.50	813,856,052.52
2	Reinforcement	95148,36	kg	13,608.00	1,294,778,902.48

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3	Concreting	577,89	m^3	1,068,322.50	617,372,889.53
				Total Cost of Conventional Beam Work	**2,726,007,844.52**

2. Half Beam Precast

For the cost analysis of half beam precast work, references such as AHSP PUPR Ministerial Regulation No. 1 of 2022 and HSPK Surabaya City of 2022 are used to prepare the budget. The total cost for half beam precast work is summarized in Table 7 below:

Table 7. Summary of Half Beam Precast Work Costs

No	Cost Type	Work Volume	Unit	Unit Price (IDR)	Total Price (IDR)
1	Formwork	799,32	m^2	39,853.67	31,855,855.43
2	Reinforcement	57241,23	kg	12,938.61	740,621,950.94
3	Concreting	438,54	m^3	1,003,598.75	440,117,819.48
4	Half Beam Precast Lifting	369	unit	128,898.60	47,563,583.40
5	Installing Half Beam Precast	369	unit	448,577.42	165,525,067.98
6	Formwork for Topping	572,18	m^2	200,210.00	114,556,558.22
7	Reinforcement for Topping	29949,57	kg	12,960.00	388,146,460.25
8	Concrete for Topping	101,90	m^3	1,017,450.00	103,678,663.73
				Total Cost of Half Beam Precast	**2,032,065,959.42**

E. Comparison of Time and Cost Analysis

After completing the time and cost analyses for both conventional beams and half beam precast, a comparison of the two analyses is made and presented in Table 8 below:

Table 8. Comparison of Time and Cost Analysis

Method	Total Duration	Total Cost (IDR)
Conventional Beam	145	2,726,007,844.52
Half Beam Precast	121	2,032,065,959.42
Difference	24	693,941,885.10
Percentage Difference	16,55%	25,46%

CONCLUSION

From the comparison of the analyses of the conventional beam method and the half beam precast method, it is evident that the conventional beam method requires 145 days to complete and costs IDR 2,726,007,844.52. Meanwhile, the half beam precast method takes 121 days to finish and costs IDR 2,032,065,959.42. Therefore, it can be concluded that the half beam precast method is more efficient in terms of time and cost. It reduces the completion time by 24 days of 16.55% and lowers the cost by IDR 693,941,885.10 or 25,46%.

REFERENCES

Anugerahanto, K., & Adistana, G. A. Y. P. (2021). Perbandingan Pelaksanaan Pekerjaan Dinding Precast dan Dinding Konvensional Pada Konstruksi High Rise Building Ditinjau Dari Segi Waktu dan Biaya. *Rekaya Teknik Sipil*, *9*(4). https://ejournal.unesa.ac.id/index.php/rekayasa-teknik-sipil/article/view/43604

Badan Standardisasi Nasional. (2019). Persyaratan Beton Struktural Untuk Bangunan Gedung (SNI: 2847-2019).

Chasanudin, M. L., Sundari, T., Yulianto, T., Nugroho, M. W., & Ramadhani, R. (2023). Cost and Time Comparison Analysis of Conventional Slab with Half Slab Method for PT. AMP Surabaya Office Building Construction. *Civilla : Jurnal Teknik Sipil Universitas Islam Lamongan*, *8*(2), 145–156. https://doi.org/10.30736/cvl.v8i2.1101

Darmansyah SKD, M., & Chairani, E. (2022). Analisa Struktur Balok Beton Pada Pembangunan Rumah Tempat Usaha 6 Lantai Di Jalan Perniagaan N0.55 Medan. *Jurnal Teknik Sipil*, *1*(1). https://jurnal.uisu.ac.id/index.php/JTSIP/article/view/5773

Hamdi, & Harijadi, S. (2010). Analisis Pemilihan Metode Cast In Situ dan Precast Terhadap Biaya Pada Pekerjaan Tempat Duduk Tribun Stadion Utama Jakabaring Palembang. *Teknika*, *29*(1). https://jurnal.polsri.ac.id/index.php/teknika/article/view/10

Koesoema, H. C., Kushartomo, W., & Prabowo, A. (2023). Analisis Penggunaan Beton Pracetak Di Proyek Pembangunan Mall XYZ Kota Wisata. *JMTS: Jurnal Mitra Teknik Sipil*, *6*(2), 407–414. https://doi.org/10.24912/jmts.v6i2.23026

Kurniawan, M. (2016). Perbandingan Analisis Struktur dan Efisiensi Biaya Struktur Slab on Pile Menggunakan Metode Precast Half-Slab dan Metode Monolite, Serta Kombinasi Mutu Beton Slab on Pile (Studi Kasus Jembatan Perawang). *Jurnal Saintis*, *16*(1), 46–62. https://journal.uir.ac.id/index.php/saintis/article/view/2862/1571

Letra, I. M., Wiryadi, I. G. G., Darmayasa, I. G. O., & Astari, N. W. Y. (2021). Analisis dan Perencanaan Balok Beton Bertulang Dengan Sistem Precast In Site. *Jurnal Ilmiah Kurva Teknik*, *10*(1), 24–32. https://doi.org/10.36733/jikt.v10i1.2142

Najoan, C. H., Tjakra, J., & Pratasis, P. A. K. (2016). Analisis Metode Pelaksanaan Plat Precast Dengan Plat Konvensional Ditinjau dari Waktu dan Biaya (Studi Kasus: Markas Komando Daerah Militer Manado). *Jurnal Sipil Statik*, *4*(5), 319–327. https://ejournal.unsrat.ac.id/v2/index.php/jss/article/view/12552

Nauly, A., Rambe, Mhd. R., & Patriotika, F. (2022). Analisa Perbandingan Biaya Dan Waktu Pelaksanaan Pelat Lantai Konvensional Dengan Pelat Lantai Pracetak Pada Gedung Berlantai Tiga. *Statika*, *5*(2), 55–62. https://jurnal.ugn.ac.id/index.php/statika/article/view/1071/814

Persada, R. M., & Sumarman. (2017). Analisis Perencanaan Struktur Hotel Dialog Grage Cirebon Menggunakan Struktur Beton SNI 2013. *Jurnal Konstruksi*, *6*(5). https://jurnal.ugj.ac.id/index.php/Konstruksi/article/view/3865/1905

Pertiwi, W. S. D. M., Wijayaningtyas, M., & Iskandar, T. (2023). Analisis Percepatan Proyek Dengan Metode Crashing Program Pada Proyek Pembangunan Gedung Rumah Sakit Islam Unisma Malang. *Student Journal Gelagar*, *5*(1), 47–56. https://ejournal.itn.ac.id/index.php/gelagar/article/view/5696

Riyadi, I., Handayani, E., & Dony, W. (2022). Analisa Perbandingan Sistem Pelat Konvensional dengan Sistem Precast Half Slab dalam Segi Waktu dan Biaya. *Jurnal Civronlit Unbari*, *7*(2), 63. https://doi.org/10.33087/civronlit.v7i2.100

Sari, S. N. (2019). Evaluasi Anggaran Biaya Menggunakan Batu Merah dan Batu Bata Ringan Gedung Kantor Kelurahan Bareng Kecamatan Klaten Tengah Kabupaten Klaten. *Jurnal Qua Teknika*, *9*(1). https://doi.org/10.35457/quateknika.v9i1.635

Widanti, P. A., Wijayaningtyas, M., & Indra, S. (2020). Penerapan Alternatif Metode Hollow Core Slab Pada Pembangunan Gedung Malang Creative Center. *Student Journal GELAGAR*, *10*(10), 1–5. https://eprints.itn.ac.id/12025/9/JURNAL.pdf