

Assessment of Precast Structural Design for Economy and Time Savings in the Borong Hospital Design and Build Initiative

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ABSTRACT

The erection of hospital edifices necessitates building techniques that fulfill the criteria for excellence, economical expenditure, and swift project finalization. One strategy that is commonly utilized is the adoption of precast concrete frameworks, which are seen as effective in enhancing productivity and shortening the period of on-site construction. This research intends to assess how the integration of a precast structural framework influences cost and time efficiency within the Borong Hospital Design and Build Initiative. The study utilized a quantitative descriptive approach by performing a comparative investigation between precast structural design and traditional structural design, focusing on working blueprints, cost projections (RAB), and project timelines. The evaluation centered on primary structural elements, such as columns, beams, and floor slabs, to ascertain the degree of cost savings and time efficiency achieved. The findings demonstrate that the use of precast structures can lead to a decrease in the timeline for structural tasks, as the manufacturing process occurs concurrently with on-site construction activities, enhancing project time efficiency by a total of 46 days, which is equivalent to 20.91%. Moreover, the incorporation of precast structures offers cost advantages due to diminished needs for formwork, labor, and wastage of construction materials, leading to savings of IDR 1,150,515,798.29, representing 5.18% of the overall structural expenditure. Hence, precast structural design can be regarded as a viable option for enhancing the performance of construction endeavors, especially in hospital projects that demand high quality standards and strict deadlines

INTRODUCTION

Article 28, Part H, paragraph (1) of the 1945 Constitution states that everyone has the right to receive health services. Furthermore, Article 34, paragraph (3) states that the state is responsible for providing adequate health care facilities and public service facilities. Law Number 17 of 2023 concerning Health, Article 19, states that the government is responsible for the availability of all forms of quality, safe, efficient, and affordable health care.

The increase in life expectancy has not been without impacts on health care service patterns. The increasing elderly population and shifts in Indonesian lifestyles have generally impacted service demand patterns and the epidemiology of certain diseases that require significant funding, including heart disease, cancer, and stroke. This is illustrated by the significant decline in deaths from infectious diseases over the past 10 years, but the proportion of deaths from degenerative diseases (heart and blood vessel, neoplasm, endocrine) has actually increased.

Based on proposals from the Expert Team and the President-elect's Synchronization Team, the proposed programs include efforts to improve health care standards through the development of infrastructure and the development of comprehensive, high-quality hospitals in districts/cities.

There are 66 Class D and D Pratama hospitals that require hospital competency enhancement to support the KJSU (Community Based Health Service) Program. These 66 hospitals are located in 24 provinces, including remote areas.

Against this background, the Ministry of Health is planning to develop hospitals through a program to upgrade hospitals in these areas from Class D/D Pratama to Class C. This program, called the Quick Wins (PHTC) Program, aims to strengthen KJSU services, enabling them to provide Class C-level healthcare services in remote areas.

The strengthening of KJSU in question is an effort to develop health facilities, infrastructure and equipment, namely operating rooms, additional outpatient rooms, inpatient rooms (additional number of beds according to Class C Hospital standards), intensive care rooms, cathlab rooms and ICVCU, radiology rooms (CT-Scan, Mammography), and other supporting rooms if upgrades are needed. The area limit for this upgrade is +7,000 m² to accommodate the additional functions of the aforementioned spaces.

In general, the development of public and social facilities uses the principles of service scale, walking accessibility, and integration with the surrounding area. These principles aim to improve the effectiveness of public and social facilities for the residents they serve. The general design principles for shared facilities include accessibility; connectivity; green infrastructure; management; security; and disaster response.

One of the focus locations for the hospital upgrade is Borong Regional General Hospital in East Manggarai Regency. The hospital to be upgraded in East Manggarai is a Class D Regional General Hospital that will be upgraded to Class C, with requirements in accordance with Minister of Health Regulation Number 14 of 2021 concerning Standards for Business Activities and Products in the

Implementation of Risk-Based Business Licensing in the Health Sector and Minister of Health Regulation Number 40 of 2022 concerning Technical Requirements for Hospital Buildings, Infrastructure, and Medical Equipment.

The physical construction of the East Manggarai Regional Hospital (RSUD) is planned to be carried out using a single-year design-build contract, specifically for the 2025 fiscal year. To support the construction implementation and the procurement of construction services, on-site supervision and control are required to ensure the physical construction meets quality, time, and cost requirements, and adheres to administrative procedures in accordance with applicable regulations. Given this need, the hospital construction project requires the involvement of a Construction Management consultant to oversee the on-site construction process to ensure it runs smoothly and as planned.

Design-build work is common in several large-scale projects with relatively short turnaround times. This method is highly effective in its implementation. The effectiveness of this method can speed up implementation time, improve collaboration and communication, and increase opportunities for innovation that occur in the field.

One of the projects currently underway is the Borong Nusa Tenggara Timur Hospital Project, run by the Ministry of Health. To expedite the work and implementation, the Design and Build system is being used by Brantas Abipraya, with Pandu Persada as the planner. This research will use this data to assess the progress of the ongoing work.

Design and build projects tend to use lump-sum contracts, making it difficult to assess the percentage of work completed within the limits of daily, weekly, and monthly progress. Similarly, inspections by authorities can be difficult to assess. This is because the planning process is still ongoing, making it difficult to assess the volume and cost of the work being carried out. Therefore, it is difficult for the owner, construction management, and implementing contractor to assess the progress of the work.

In an effort to improve the efficiency of construction projects, various methods and technologies are being developed, one of which is the precast concrete construction system. Precast methods have been widely used due to their numerous advantages, such as improved structural quality, accelerated construction times, and reduced fieldwork. One implementation of this system is the use of precast half slabs, which are semi-finished floor slabs produced in a factory and then finished through casting on-site.

The use of precast half slabs has potential advantages over conventional methods, such as reduced formwork usage, improved work quality, and increased time efficiency. However, using this method also requires a comprehensive analysis, particularly regarding production costs, transportation, installation, and coordination between field workers.

In the Borong Hospital design and construction project, the choice of floor slab construction method was a critical factor influencing the overall success of the project. Given the complex nature of hospital projects, including specific space requirements and high quality standards, an evaluation of the construction

methods used was necessary to achieve optimal results in terms of both cost and time.

Therefore, this study was conducted to evaluate the precast half slab design in terms of cost efficiency and implementation time for the Borong Hospital design and construction project. This evaluation is expected to provide a clear picture of the advantages and disadvantages of this method compared to conventional methods and serve as a reference for decision-making on similar construction projects in the future.

THEORETICAL REVIEW

Design and Build Project

In a Design and Build contract system, effective communication can be established between design and construction service providers, allowing for optimal integration of the contractor's and planner's construction knowledge and experience into the design (Ashworth & Perera, 2015). Many provisions are applied in Design and Build projects, one of which relates to provisions for the procurement of imported materials (Fikri et al., 2023). The process of identifying, ordering, shipping, and managing imported materials according to project specifications and schedule requirements is the responsibility of the Design and Build Service Provider (Giovannus, 2020).

In the legal and regulatory context, Law No. 2 of 2017 concerning Construction Services and Regulation of the Minister of Public Works and Public Housing No. 1 of 2020 concerning Standards and Guidelines for Procurement of Integrated Design and Build Construction Works serve as the legal basis governing Design and Build construction projects (Kerzner, 2022).

The Design and Build system, which integrates the roles of designers and construction partners, synergizes intensively with the owner. This demonstrates the significant role of the planner/designer, implementer, and managerial capabilities (project manager, owner) in this mosque project. The project scope significantly impacted the completion time, as overtime was accelerated and additional construction personnel were employed. Suggestions from the implementation of this project include the need to further clarify the rules for collaboration between the planner/designer roles to minimize conflict with both the contractor and the owner (Prasetya & Winansih, 2024).

METHODOLOGY

Precast Concrete

Building structures are integrated elements that function as a whole, one of which is the precast structure in buildings. This section will discuss the advantages and disadvantages, connection methods, and basic theories related to analysis, specifically regarding structural planning concepts that refer to applicable regulations.

There are several differences between precast concrete and conventional concrete analysis. Precast design takes into account the lifting conditions of the concrete before it reaches 24 hours of age. Cracking can occur when concrete is lifted very young. Precast design takes into account the lifting method, storage,

delivery, and installation of the precast concrete on the project site. Therefore, stronger connections are required.

In general, precast concrete component structural systems can be classified as follows (Nurjaman, 2000, cited in M. Abduh, 2007):

1. Partially precast component structural systems, where the system stiffness is not significantly affected by component breaks, for example, precast slabs and walls where the breaks are not at the beams and columns or at the joint points.
2. Fully precast systems, where columns, beams, and slabs are precast and connected, forming a monolithic structure.

Using the AHP method, work safety criteria were the highest weighted/priority criteria, at 16.4%, followed by structural strength criteria at 13.6%, work quality criteria at 12.7%, implementation cost criteria at 11.8%, implementation time criteria at 9.7%, planning criteria at 8.6%, contractor capability criteria at 7.4%, building form criteria at 7.3%, building aesthetics criteria at 6.9%, and weather changes criteria at 5.7%.

The highest priority value from the calculation results for determining the best alternative indicates that precast concrete is the most frequently chosen concrete method for building construction in Surabaya (64.9%). Meanwhile, conventional concrete methods have a percentage value of 35.1%. (Zainul, Ruslin, and Hamzah, 2011).

Concrete quality control is crucial and must be implemented for all projects, whether funded by the government or the private sector. The stages of quality control and engineering of concrete work include: Preliminary work, namely the study of plans and specifications, a thorough understanding of the project location, equipment and contractor organization, definition of tasks and responsibilities, identification of necessary testing, records and reports. (Rumihin, 2023)

Advantages and Disadvantages of Precast Concrete

The principle of this precast system is that it is molded or cast before installation. When considering precast systems, the first considerations for using this system are typical shapes and large quantities. Examples of jobs often created using precast systems include water channels, beams, stairs, and other repetitive and numerous projects.

The advantages of using precast systems include more efficient time, which is particularly effective for typical jobs. While the precast work is being prepared, we can work on other parts. While this system has advantages, it also has disadvantages, including requiring more complex analysis than on-site casting. Connection systems must be considered, reinforcement joints must meet the required length, and transportation and installation locations must be considered during planning. (Novdin, 2012)

Advantages of Precast Beams

1. Technical quality control can be achieved because the production process is carried out in the factory and laboratory testing is carried out.
2. Shorter implementation time.
3. Can reduce construction costs.
4. Not affected by weather.

Disadvantages of Precast Beams

1. Requires large initial investment and advanced technology.
2. Requires skill and precision.
3. Requires production equipment (transportation and erection).
4. Large-scale construction.

Precast Beam and Column Connections

The beam-column junction is an area of extremely high stress interaction. Due to seismic loads, this junction is a potential area for collapse due to the diagonal shear forces generated by the earthquake. Therefore, the beam-column junction must be designed to meet SNI requirements. The connection between precast beams and columns in this article uses a connection like that shown in Figure 1 (Novdin, 2012).

This research focuses on a quantitative description of the progress of work on a design and construction project. Users are asked to choose the format that is easiest to understand in determining the progress of a project.

The main objective of this research is to determine the best format for creating daily, weekly, and monthly reports for the design and construction project.

A quantitative approach is used to assess the volume and cost values used in formulating the work progress value. This research was conducted through several main stages, as follows:

1. Identifying the scope of the design and construction project.
2. Collecting and detailing work items in the design and construction project.
3. Compiling unit prices for work that does not deviate from the project scope or the PPK document.
4. Calculating daily volumes that can be identified as work progress.
5. Conclusions and recommendations for the ideal format for determining the design and construction work progress.

This work sequence will allow us to conclude the progress value that can be accounted for in the Borong Hospital project value.

Research Location

The hospital to be upgraded in East Manggarai is a Class D Regional General Hospital, which will be upgraded to Class C. The requirements are in accordance with Minister of Health Regulation Number 14 of 2021 concerning Standards for Business Activities and Products in the Implementation of Risk-Based Business Licensing in the Health Sector, and Minister of Health Regulation Number 40 of 2022 concerning Technical Requirements for Hospital Buildings, Infrastructure, and Medical Equipment.

The physical construction of the East Manggarai Regional General Hospital (RSUD) is planned to be carried out under a single-year design-build contract, specifically for the 2025 fiscal year. To support the construction process and the procurement of construction services, on-site supervision and control are required to ensure the physical construction is carried out in accordance with applicable regulations, quality, time, and cost, and administratively in accordance with applicable regulations. Therefore, the hospital construction project requires the involvement of a Construction Management consultant to

oversee the on-site construction process to ensure it runs smoothly and as planned.

The address of the Borong Regional General Hospital (RSUD) is in the capital of East Manggarai Regency, Lehong-Borong. Borong Regional General Hospital stands on an area of ± 6.5 hectares, which is located in Lehong, Gurung Liwut Village.

Borong District, East Manggarai Regency, East Nusa Tenggara Province, Land Area 6.5 Hectares. Northern Land Boundary: Office of the Learning Activity Center (SKB) of the East Manggarai Regency Education Office. Southern Boundary: Land of the East Manggarai Regency Government, with future plans to build vertical offices for the police, prosecutor's office, military, and court. Eastern Boundary: Planned construction of a Health Laboratory owned by the East Manggarai Regency Health Office. Western Boundary: Bordered by land owned by the general public.

The analysis in this study focuses on assessing project progress by assessing the volume of work and determining its weight, which is then translated into physical progress reports, consisting of daily, weekly, and monthly reports at Borong Regional Hospital.

The data analysis stages conducted in this study are as follows:

1. Conducting a literature review on related work, namely Design and Construction, and studying regulations related to design and construction.
2. Collecting relevant theories and basic concepts by implementing control instruments in the design and construction project.
3. Reviewing the precast design calculations.
4. As the planning process progresses, the value of the work can then be reassessed by preparing a detailed Budget Plan in stages, starting with the Structure.
5. Preparing the implementation schedule using the S-curve method and the Critical Path Method (CPM).
6. Comparing the work speed between precast and conventional methods.
7. Developing conclusions and recommendations that can be used as guidelines for the Borong Regional Hospital design and construction project.

RESULTS AND DISCUSSION

Cost Calculation Comparison

Cost calculations for conventional and precast concrete work are conducted to determine which method is more efficient in terms of cost, time, labor, and project implementation. Both methods have different cost components depending on the implementation system.

Conventional concrete is a concrete work method where the entire casting process is carried out directly on-site, from formwork installation and reinforcement to concrete pouring.

Precast concrete, on the other hand, is a construction method where concrete elements are pre-produced in a factory or casting yard, then transported and installed at the project site.

Precast Concrete Implementation Time

Work begins with the preparation of approved shop drawings, including detailed element dimensions, lifting points, connection details, and installation elevations. Additionally, inspections are conducted to determine the readiness of the work area, the route for heavy equipment mobilization, and the capacity of the crane to be used for the erection process.

Before installation begins, all precast beam and half slab elements are inspected to ensure their dimensions, concrete quality, reinforcement position, and physical condition are in good condition and free from cracks or defects. This inspection is crucial to ensure the safety and quality of the structure upon installation.

The precast beams are first installed as the primary support for the half slab. They are lifted using a mobile crane or tower crane, secured to the lifting points specified by the manufacturer. The lifting process is carried out carefully and slowly to prevent impact or damage to the elements. Once the beams are in position, elevation and alignment are adjusted according to shop drawings using measuring instruments such as a water level or theodolite. The beams are then installed on column supports or supporting structures and provided with temporary support (bracing) to maintain stability during subsequent work.

Once all beams are properly installed, the precast half slab is installed. Prior to erection of the half slab, scaffolding and pipe supports are installed as temporary supports according to the planned spacing and elevation. The half slab is then lifted using a crane and placed on top of the precast beams in stages according to the installation sequence. The half slab panels are tightly and securely installed to prevent shifting during the topping casting process.

After the half slab installation is complete, reinforcement connections are made between panels and additional reinforcement or wire mesh is installed on the topping slab, as per the working drawings. At this stage, embedded utilities such as electrical conduits, pipe sleeves, and other installation openings are also installed before casting begins.

The surface of the half slab is cleaned of dust, dirt, and standing water to ensure a proper bond between the old and new concrete. The topping concrete is then poured evenly until it reaches the thickness specified in the structural design. The pouring process is carried out in stages, using a vibrator to ensure the concrete is solid and honeycomb-free.

Conventional Concrete Implementation Time

Conventional concrete is a concrete structure construction method where the entire work process is carried out directly on-site. Conventional concrete construction generally takes longer because each stage of the work is carried out in stages and is interdependent.

The process begins with measuring, installing formwork, reinforcing, installing scaffolding, pouring concrete, curing, and dismantling the formwork once the concrete has reached the required strength. Each stage requires time and supervision to ensure the quality of the structure is maintained.

Time Calculation Comparison

Comparing the construction time between conventional concrete and precast concrete is a crucial aspect in determining the most efficient construction

method for a project. Both methods have different implementation stages, resulting in varying project durations.

In conventional concrete, the entire work process is carried out directly on-site. These stages include formwork installation, scaffolding installation, reinforcement work, concrete pouring, concrete curing, and dismantling the formwork once the concrete has reached a certain strength. Because the work is carried out in stages and requires a time lag between processes, the construction time for conventional concrete tends to be longer. Furthermore, the work is heavily influenced by weather conditions, the number of workers, and the availability of materials and equipment on site.

Curing for conventional concrete also requires additional time before the structure can receive loads or move on to the next project. The larger the work volume and the taller the building, the longer the construction time will be.

In contrast, with precast concrete, most structural elements are pre-manufactured in a factory or casting yard before being shipped to the project site. Element production can be carried out concurrently with structural preparation work on site, resulting in more efficient work. Once the elements are manufactured, field work only involves transporting, erecting, or installing, elements using a crane, connecting elements, and casting joints or toppings, if necessary.

Because it eliminates the need for full formwork installation and dismantling on-site, the precast method significantly speeds up project implementation. Furthermore, precast work is less affected by weather conditions because the production process takes place in a more controlled fabrication area.

In general, precast concrete has a higher productivity than conventional concrete, especially in high-rise buildings, apartments, hospitals, and buildings with repetitive structural elements. The use of precast concrete can accelerate floor construction and reduce the total project duration.

CONCLUSION AND RECOMMENDATION

1. The use of a precast structural system in the Borong Hospital Design and Construction project increased construction efficiency compared to conventional methods, particularly for floor structure work.
2. From a cost perspective, the use of precast demonstrated efficiency in labor costs, formwork, and project implementation time. Conventional costs were Rp. 11,099,063,233.00, while precast costs were Rp. 9,948,547,434.71. This represents a 5.18% savings of Rp. 1,150,515,798.29.
3. In terms of time, the precast method accelerated the project duration because the element fabrication process could be carried out simultaneously with field work (parallel working), resulting in shorter casting and dismantling time for formwork on site. The implementation time for conventional concrete was 110 days, while the implementation time for precast concrete was 64 days, a 20.91% reduction of 46 days.
4. Based on the evaluation results, the precast structural system is more effective when applied to multi-story building projects with repetitive work volumes and tight completion targets, such as hospitals.

5. Overall, the precast method provides better efficiency than conventional methods when supported by proper production, transportation, and installation planning.

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