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Design and Analysis Structural of a Sustainable Prayer Hall Building Using Precast Concrete

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A B S T R A C T

The construction of musholla buildings requires efficient, durable, and cost-effective structural planning. An increasingly adopted method is using precast concrete, known for its faster implementation, controlled quality, and reduced waste. This study aims to design the structural framework of a musholla using precast concrete, focusing on elements such as beams, columns, and slabs, in line with Indonesian standards like SNI 2847:2019 and SNI 1726:2019. The process includes analyzing structural loads—dead, live, and seismic—and calculating dimensions and reinforcements. Additionally, connection designs between precast components ensure overall stability. The findings highlight that precast concrete provides faster construction, predictable costs, and maintains safety and strength, offering valuable insights for small- to medium-scale projects

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INTRODUCTION

Building a musholla as a place of worship holds immense significance in addressing the spiritual and social needs of communities, especially in residential neighborhoods, workplaces, and educational institutions. Mushollas are not only dedicated spaces for prayer but also serve as venues for various religious and community activities, such as Quran study sessions, recitations, and communal gatherings. For this reason, having a musholla with a sturdy, secure, and visually appealing structure is crucial for fulfilling these purposes effectively. (Arsitek Depok, 2023). Additionally, mushollas contribute significantly to fostering social connections among community members. Properly designed and well-equipped mushollas act as focal points for religious education, social engagement, and community cohesion, ultimately enriching the quality of life in the area. (Arsitek Depok, 2023)

Furthermore, ensuring a robust structural design is essential in musholla construction. A durable and resilient structure guarantees safety and comfort while withstanding potential hazards like earthquakes and strong winds. This strength ensures the musholla can continue serving its purpose sustainably over time. (Fuji Home Japan, 2023)

One of the main challenges in constructing a musholla is overcoming constraints in time and budget. Often, such projects rely on community contributions, which may be limited in scope. As a result, employing efficient construction methods that optimize costs and time without sacrificing quality becomes crucial. A widely recognized solution in the construction industry is the use of precast concrete technology. This method offers significant advantages, as precast components are manufactured in factory-controlled environments, ensuring consistent precision and durability. Furthermore, the ability to mass-produce these components and deliver them to the site minimizes on-site construction time. For musholla projects, precast concrete enables modular designs that cater to specific needs in terms of size and aesthetics. (Metromont, 2023)

In addition to efficiency, safety and structural reliability are critical factors in construction planning. As Indonesia is highly prone to earthquakes, compliance with building regulations such as SNI 2847:2019 on structural concrete and SNI 1726:2019 on earthquake-resistant design is essential. Using precast concrete requires a detailed analysis of various loads, including dead loads, live loads, and seismic loads, to ensure safety and resilience. Key structural elements like beams, columns, and slabs must be designed to withstand these loads and maintain long-term durability. (Springer Link, 2023)

Moreover, precast concrete supports sustainability initiatives in construction. Its manufacturing process produces less waste compared to traditional methods, aligning with environmentally friendly practices. The controlled production environment ensures precise material specifications and reduces the likelihood of errors that could compromise structural integrity. This aligns with contemporary construction trends focused on resource efficiency and reducing environmental impact. (Nitterhouse Concrete.,2023)

This research seeks to design and analyze the structural framework of a musholla using precast concrete comprehensively. (Metromont., 2023) The study includes calculations for the dimensions and reinforcement of structural components, as well as the connections between precast elements to maintain overall stability. (Springer link, 2023) Additionally, considerations for cost efficiency, ease of construction, and aesthetic value are integral to the planning process. Through this innovative approach, musholla construction aims to address financial and time limitations while promoting advancements in sustainable building practices in Indonesia. (Nitterhouse concrete., 2023)

LITERATURE REVIEW

Implementation of Precast Concrete in Hotel Building Design as a Housekeeping Laboratory at Politeknik Negeri Manado

The use of precast concrete technology has a substantial impact on the efficiency and sustainability of construction projects, offering numerous advantages such as time efficiency, cost-effectiveness, and improved structural quality. This study seeks to explore and highlight the application of this innovative technology in the context of a hotel facility, which is specifically designed to function as a housekeeping laboratory. By utilizing precast concrete, the research aims to demonstrate how this technology can enhance both the construction process and the functionality of the resulting structure. The study culminates in the development of a detailed design for a four-story hotel building, showcasing the practical implementation of precast concrete technology in achieving a modern, efficient, and purpose-built facility. (Kevin D. Landeng.,2023)

Hotel Design Planning with a Shipping Container Concept Using Precast and Conventional Methods

The design of the hotel embraces a shipping container concept, utilizing a combination of precast and conventional construction methods to achieve an efficient and modern structure. The estimated budget for the project's construction is calculated at IDR 2,832,283,455.59. This study emphasizes the advantages of integrating precast and conventional methods, showcasing how their combined use can significantly accelerate the construction process while also simplifying various stages of development. By blending the strengths of both approaches, the design not only ensures structural efficiency but also optimizes time and resource management, making it a practical and innovative solution for hotel construction. (Andreas Makalew.,2023)

METHODOLOGY

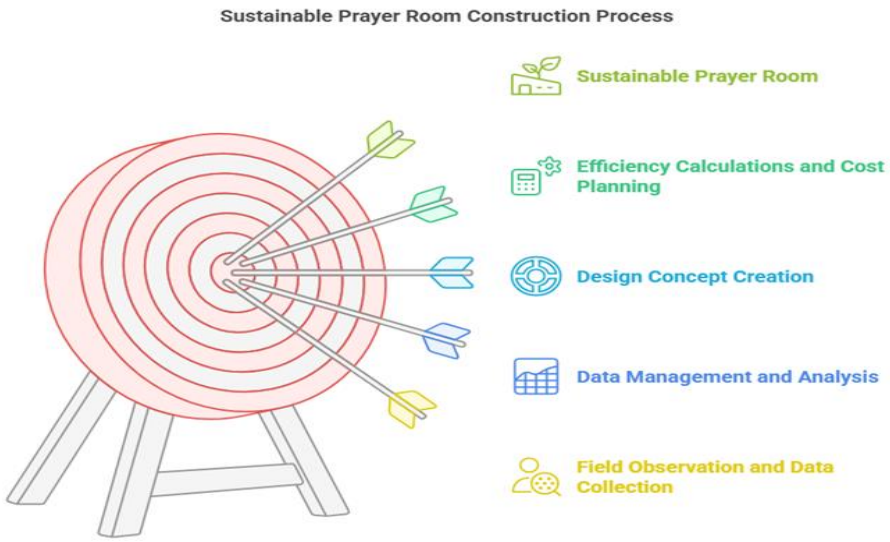

Figure 1. Flowchart

Figure 1 illustrates the flowchart of this study, which outlines the systematic process involved in planning and constructing a sustainable prayer room. The process begins with field observation, which is a crucial initial stage where a comprehensive assessment of the site is carried out to gather firsthand information about the location, space requirements, and any environmental considerations. This stage helps in understanding the physical constraints and opportunities that the site presents, which can influence the design and construction approach.

Following field observation, data collection takes place. This step involves gathering relevant information from various sources, such as surveys, measurements, interviews with stakeholders, and reviewing applicable building regulations or guidelines. The collected data provides a foundation for informed decision-making throughout the design and construction process.

The next phase is a literature study, where existing research, best practices, and case studies related to sustainable building design, construction techniques, and materials are reviewed. This step helps identify effective strategies and solutions that can be applied to the prayer room project, ensuring that the design not only meets functional needs but also adheres to sustainability principles.

Once the foundational data has been gathered, the next stage involves data management and analysis. This is where all the collected information is organized, processed, and analyzed to form a clear understanding of the project's requirements. Detailed analysis helps in refining the design, identifying potential challenges, and providing solutions to overcome them. This is also when efficiency considerations, such as energy use and environmental impact, are taken into account.

After the analysis phase, the report preparation begins, summarizing the findings, proposed solutions, and design direction. This documentation serves as

a reference throughout the remainder of the project and ensures all stakeholders are aligned with the planned approach.

The process continues with a detailed quantity and price analysis, where materials, labor, and other construction costs are estimated. This helps in preparing a realistic budget and ensures that the project is financially feasible while maintaining the necessary quality and safety standards.

Simultaneously, the design concept is developed, which includes creating detailed floor plans, elevations, sections, and 3D drawings. These visual representations allow stakeholders to visualize the final product and provide a comprehensive overview of the layout and structure. Along with these drawings, specific details such as material specifications and construction methods are outlined.

Efficiency calculations, including structural, energy, and operational efficiencies, are also conducted at this stage. These calculations ensure that the design optimizes the use of resources, minimizing waste and maximizing performance over time.

Finally, a Cost Budget Plan (RAB) is prepared, which includes a detailed breakdown of all anticipated costs, from construction materials to labor and project management. This ensures that the project stays within budget while meeting all the safety, aesthetic, and sustainability requirements.

Each stage of this process is designed to ensure that the prayer room construction is executed with the highest standards of safety, aesthetics, and sustainability, while also maintaining optimal cost efficiency. The thoroughness of each phase guarantees that the final structure will not only meet the needs of the community but also contribute positively to the environment and adhere to best practices in building design and construction.

RESULTS

In figure 2 is a plan of a prayer room with a scale of 1:100. This plan shows the layout of the various rooms and facilities in the prayer room. The design of the prayer room plan of the Manado State Polytechnic which has been designed for 1 floor consists of a prayer room measuring 9m x 9m, Mihrab 2m x 2m, sound system room 3.5m x 2m, Warehouse 3.5m x 2m, terrace 9m x 5m and also has 3 main doors on the left, right and center of the room.

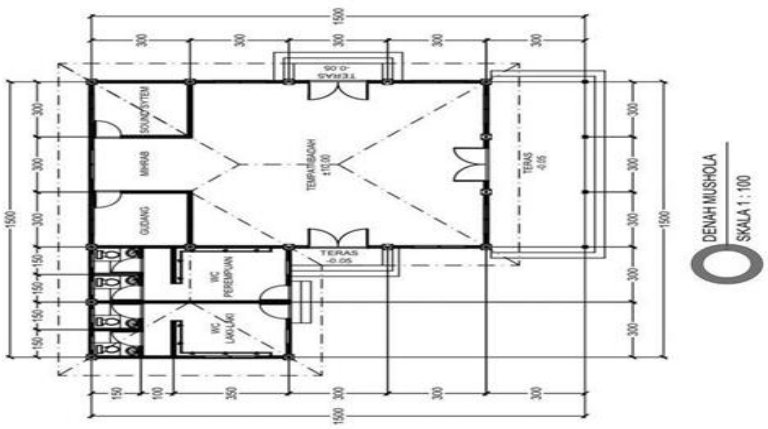

Figure 2. Prayer Room Plan

Figure 3 is the front view of a prayer room consisting of 1 main door and 2 windows, the front view of a prayer room is often a distinctive feature that attracts attention. It usually looks simple but impressive with a touch of design that invites peace and comfort. In general, the front view of this prayer room displays a friendly design and reflects the inclusive and open nature of the place of worship. Figure 4 shows the back view of the prayer room which has several windows for ventilation and natural lighting, similar to the front view. There is no door on the back view, indicating that the main access is at the front and side of the prayer room.

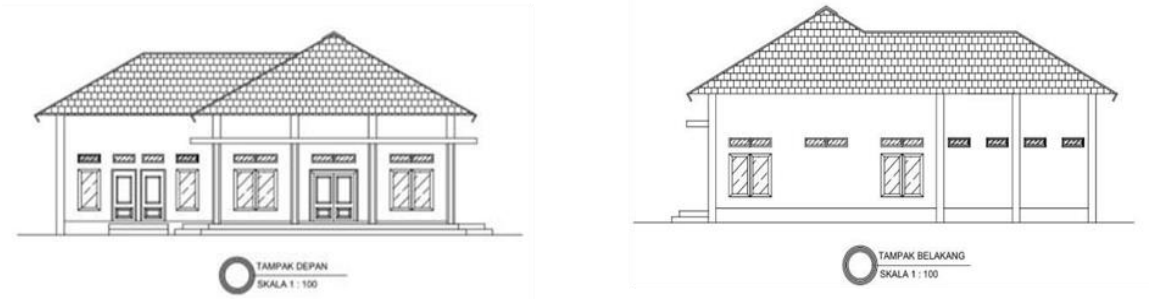

Figure 3. Front Look & Back View

In the construction of the Manado State Polytechnic prayer room, the precast components that will be used are only the main column, practical column and main beam. Figure 5 is a detail of the main column showing the cross-section of the main column with dimensions of 30cm x 30cm with the main reinforcement consisting of 8 D12 rods, Stirrups using Ø10 with a distance of 150mm.

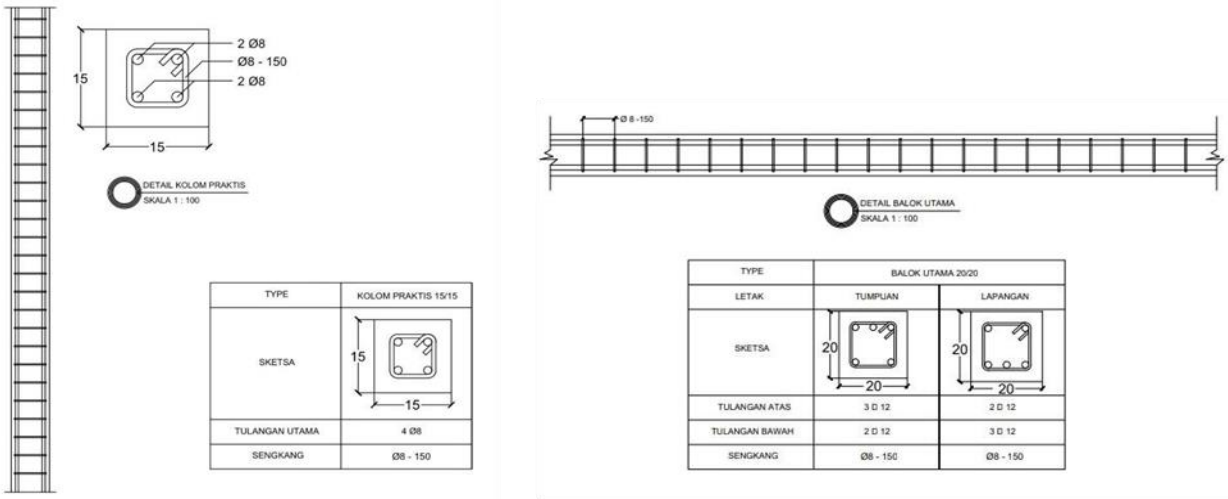

Figure 4. Practical Column Details & Main Beam Details

Analysis of the structure of the Manado State Polytechnic prayer room construction using ETABS software, this method is very efficient and accurate for designing and inspecting buildings. After being analyzed using ETABS and referring to the SNI 2847-2019 standard concerning Structural Concrete Requirements for Building Structures and SNI 1726-2019 concerning Procedures for Earthquake Resistance of Building and Non-Building Structures.

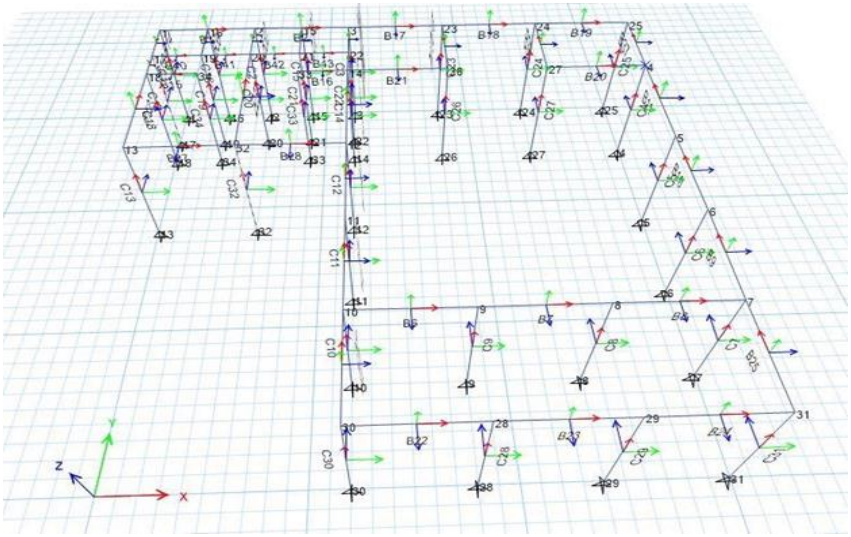

Figure 5. 3D Prayer Room in Etabs

The results obtained show that the prayer room building of the Manado State Polytechnic using the given specifications shows that it can withstand the loads given and in accordance with the existing SNI shows that this building is earthquake resistant.

The calculation of the preparation of a detailed Budget Plan basically requires working drawings, unit price analysis of work, and a list of volumes in each type of work available. This study will only show the Budget Plan that will be used on precast concrete components of columns and beams.

Tabel 1. Rab Precast Components

III	**PRECAST CONCRETE WORK**				
1	Main Beam (20 x 20) F'C 21.7 Mpa	13	bra	357,990.00	4,653,870.00
2	Main Column (30 x 30) F'C 21.7 Mpa	12	bra	990,870.00	11,890,440.00
3	Beam Installation Costs	13	bra	139,611.00	1,814,943.00
4	Column Installation Costs	12	bra	139,611.00	1,675,332.00
				SUB TOTAL	20,034,585.00

DISCUSSION

The design, planning, and structural analysis of the sustainable mosque building at Manado State Polytechnic aim to address not only functional requirements but also contribute to sustainable development, ensure user safety, and improve the religious and social experiences on campus. This project aligns with the strategic research agenda of the Civil Engineering Department, specifically within the Building Construction Study Program. The research focuses on construction designs that adhere to sustainable principles.

CONCLUSIONS AND RECOMMENDATIONS

The conclusion of the purpose of this study is to design a prayer room at the Manado State Polytechnic that can accommodate an adequate number of worshipers, with a structure that meets safety standards, durability, and functional needs. The design of the prayer room must also consider the aesthetic aspects and architectural flexibility in accordance with the campus environment, as well as using environmentally friendly materials and efficient construction technology to accelerate the construction process at an effective cost.

FURTHER STUDY

This journal has explained the design planning and structural calculation of the sustainable prayer house building that uses precast concrete. Further research can be conducted to deepen and expand the scope of this journal.

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