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STRUCTURAL ANALYSIS OF SPACE EXPANSION OF CONCRETE BUILDING WITH RETROFITTING STEEL PORTAL

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Abstract

Changes in the function of buildings often necessitate modifications to the structural form, requiring construction reinforcement to ensure stability and safety. This study aims to evaluate the effectiveness of structural reinforcement using steel in buildings undergoing functional changes. The methodology involves comparing the structural analysis of the existing building with the building after reinforcement. The research findings indicate that using IWF 250x125x6x9 steel as a reinforcement solution significantly enhances the structure's load-bearing capacity. In conclusion, the reinforcement of concrete beams with IWF 250x125x6x9 steel has proven effective in increasing the building's load capacity, thereby ensuring the building's safety and sustainability.

Keywords: *Retrofitting, building structures, steel portal*

INTRODUCTION

The rapid development of construction technology demands innovative methods to strengthen and enhance the performance of building structures. One of the critical elements in building construction is reinforced concrete beams, which serve as supports for horizontal loads and ensure the overall stability of the structure. However, over time and with increased loads, concrete beams can experience a decrease in load capacity, deformation, and significant cracking. Therefore, strengthening efforts are necessary to ensure the safety and sustainability of buildings. Retrofitting building structures is carried out for various reasons, most of which are related to improving the safety, performance, and efficiency of buildings (Mr. Shirke Sani Rajesh et al., 2023)(Furtado, 2023)

Reinforcement of Reinforced Concrete Beams Using Steel Profiles, Specifically IWF (I Wide Flange) Steel, Has Become One of the Common Solutions in Structural Engineering Practice. IWF steel is chosen because of its high tensile strength and ability to withstand large loads with minimal deformation. Moreover, the geometric shape of IWF steel allows for more uniform stress distribution in the beam, thereby enhancing the efficiency of the reinforcement. (Prabowo & Lutfi, 2020). Several studies have shown that the use of steel as a reinforcement element can significantly increase the load capacity and stiffness of concrete beams, which is crucial in extending the service life and enhancing the safety of structures. However, there are still a number of challenges that need to be addressed to optimize the use of steel as reinforcement.

These include the development and application of proper installation methods to ensure good integration between steel and concrete. Additionally, the interaction between concrete and steel must be carefully considered to prevent potential issues such as corrosion or differences in material behavior under varying loads.(Wensheng et al., 2020)(Takayuki et al., 2018). This study aims to determine the reinforcement of steel in reinforced concrete beams strengthened with IWF steel through a numerical approach. Through this research, it is expected to gain a practical design understanding of reinforced concrete beams using IWF steel, as well as practical recommendations for its application in the field. Additionally, this study is expected to make a positive contribution to the field of structural engineering, particularly in efforts to improve building safety and performance through innovative and efficient reinforcement methods.

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THEORETICAL BACKGROUND

Reinforced concrete is indeed a composite material that effectively combines the compressive strength of concrete with the tensile strength of steel reinforcement, as highlighted in various research papers. The method of strengthening reinforced concrete elements through the addition of external steel components has been extensively studied, demonstrating that adding steel elements can significantly increase the load capacity of reinforced concrete beams. (Minchala Velecela et al., 2024). The guidelines for calculating concrete and steel structures follow the applicable standards in Indonesia, namely the Indonesian National Standard (SNI). The theoretical basis for the calculations in this writing refers to:

1. SNI 1727: 2020 Minimum Design Loads and Associated Criteria for Buildings and Other Structures (Nasional, 2020a)
2. SNI 2847: 2019 Requirements for Structural Concrete for Buildings and Explanations (Nasional, 2019b)
3. SNI 1729-2020 Specifications for Structural Steel Buildings (Nasional, 2020b)
4. SNI 1726:2019 Procedures for Earthquake Resistance Design for Building and Non-Building Structures (Nasional, 2019a)

The design regulations for steel structures in Indonesia are governed by SNI 1729-2020 regarding Specifications for Structural Steel Buildings. The basic requirements that must be met in the design are:

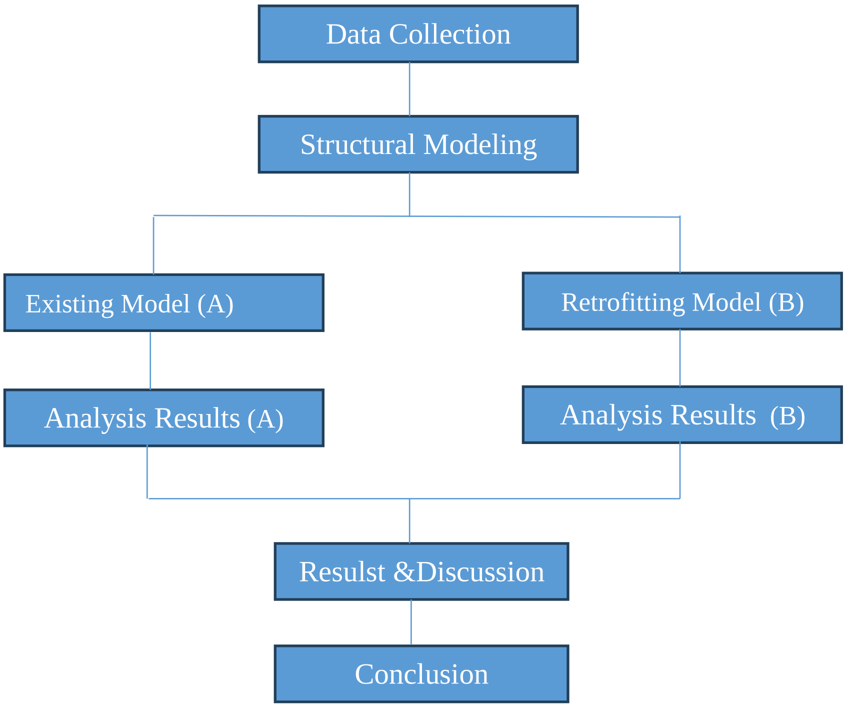
Designed strength ≥ Required strength
Ø (Nominal strength) ≥ U

ØMn ≥ Mu
ØVn ≥ Vu
ØPn ≥ Pu

Mu = Wx/Fy

METHOD

This research uses a building model where structural changes occur. For concrete quality data, a standard concrete quality of 20 MPa is used. Data collection involves secondary data (literature on building structures such as SNI 2487: 2019 on Requirements for Structural Concrete for Buildings and Explanations). The analysis is conducted using ETABS V18 software with the response spectrum method on two model variations: Structural analysis of the existing building (A) and Structural analysis of the existing building with changes in span length (B). The results from analyzing these two models will yield internal forces in the form of maximum moments, which will be used for designing reinforcement steel.



RESULT DAN DISCUSSION

This research begins with conducting a field survey related to the existing conditions, with the following data obtained:

Table 1. Existing Building Geometry Data

No	Dimension	Description
1	40x40 (K1)	Column
2	25x40 (B1)	Beam
3	25x30 (RB)	Secondary Beam

The building data under study has a concrete quality of 20 MPa, with earthquake data values Ss = 1.3701 and S1 = 0.6. The soil type is Medium (D). This research focuses on expanding the building space by removing columns in the central area of the first floor, thereby increasing the span from 3.5 meters to 7 meters. This change is necessary because the existing columns obstruct the new function as an auditorium. The building model data is provided figure 1 and figure 2:

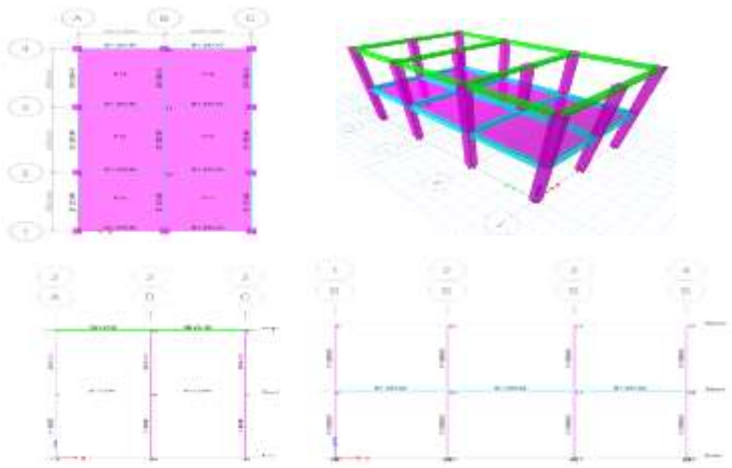


Figure 1. Existing Building Geometry

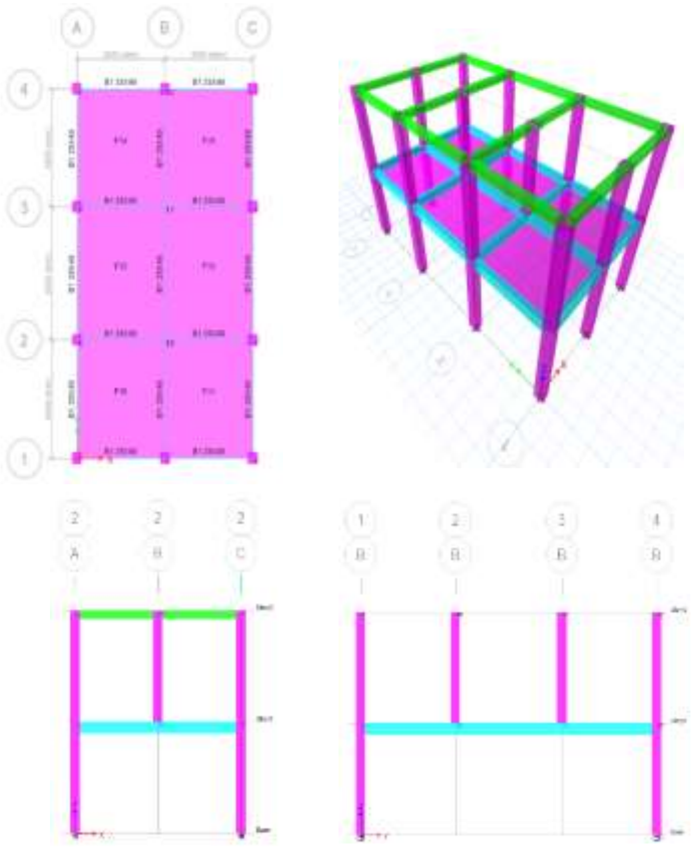


Figure 2. Retrofitting Building Geometry

Based on the data above, a structural analysis was conducted with loading conditions according to SNI 1727: 2020, including a live office load of 2.4 kN/m² and a brick wall load of 2.5 kN/m². The maximum moment obtained for the beam with the altered span is 71.54 kNm. The output of the analysis can be observed in figure 3.

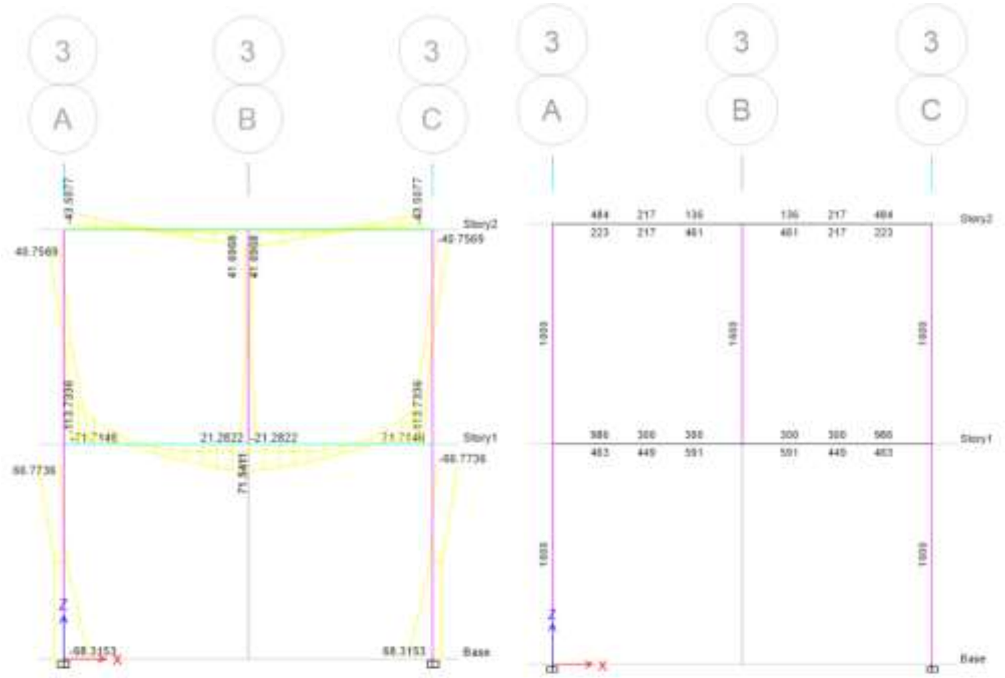


Figure 3. Ouput Structural Analysis

Subsequently, this data serves as a reference for designing the planned steel reinforcement. The design steps and theory are based on SNI 1729: 2020 regarding Specifications for Structural Steel Buildings (Nasional, 2020b). The maximum moment (Mu) used is 71.54 kNm, yield steel (Fy) is 240 Mpa, The practical calculation process is detailed below:

Mu = Wx . Fy
Wx = Mu/Fy
Wx = 71,54 x 10^6/ 240 = 298.000 mm^3

From the steel profile table, it can be determined that the IWF 250x125x6x9 steel profile has a value of Wx = 324,000 mm^3, making this steel profile an appropriate choice. The design results can be seen in Figure 4

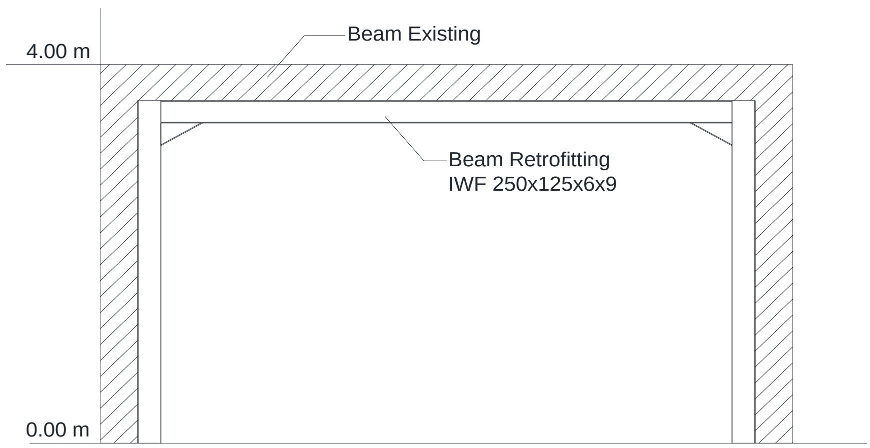


Figure 4. Retrofitting Design

CONCLUSION

Based on the results of the research, it can be concluded that removing columns in a building structure requires additional reinforcement to ensure the building's ability to bear the applied loads. One effective reinforcement solution is using IWF 250x125x6x9 steel, which has proven capable of withstanding the loads acting on the structure.

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