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Analysis of the Building Structure for Mixed-Use Al-Amin Living Lab and Industrial Park in Sampe Cita Village, Kutalimbaru District

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Abstract. *A mixed-use building refers to the combination of several different functions in one building, such as residential, office, shopping, and recreational functions built on one site. Designing the structure of a mixed-use building requires careful planning and consideration of various factors such as functional needs, aesthetics, and energy conservation. Additionally, the design of mixed-use buildings includes various functions in one area. The floor slabs and roofs use plain reinforcing steel with a strength of Fy = 240 MPa (Ø8mm). Concrete cover is taken as 20 mm. The design results in several types of slab thicknesses according to the working loads that must be accommodated above them. Below are the moments acting on the floor slabs and roofs. Reinforcement calculations are carried out using the capacity strength design method according to SNI 2847-2019. The concept of capacity design refers to controlling the formation of plastic hinges at predetermined locations. The SAP2000 program can directly calculate the feasibility of structural dimensions and the required reinforcement area from the input program results. In the SAP2000 program, the concrete regulations used are those of the American Concrete Institute ACI-318-05/IBC 2003, which in some aspects differ from Indonesian concrete regulations SNI 2847-20219. Adjustments need to be made to comply with Indonesian regulations. Internal forces from the SAP2000 program are selected from load combinations that produce the maximum field moments and support moments at the column faces. Flexural and shear reinforcement of beams can be directly read from the SAP2000 program output in the form of the required reinforcement area information.*

Keywords: *Building, Industrial Park, Living Lab, Mixed-Use Building*

INTRODUCTION

A multifunctional or mixed-use building refers to the combination of several different functions in one building, such as residential, office, shopping, and recreational functions built on one site (Sutarman & Bendatu, 2013). Designing the structure of a mixed-use building requires careful planning and consideration of various factors such as functional needs, aesthetics, and energy conservation (Sholeh, 2021). Additionally, the design of mixed-use buildings encompasses various functions within one area.

The design of the multifunctional building at Al-Amin Living Lab and Industrial Park in Kutalimbaru District, Sampe Cita Village aims to create a mixed-use building to achieve mutual benefits by providing a space for businesses and other activities to take

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advantage of economic development in Sampe Cita Village, Kutalimbaru District, thereby increasing regional income. Additionally, the building design must also consider the structural analysis to be used for the building.

Structural analysis is the process of calculating and determining the effects of loads acting on a physical structure and its components, such as buildings, bridges, piers (Dewobroto, 2005), machines, and others. Structural analysis is crucial to ensure the distribution and impact of loads on the structure under review. Besides the loads affecting the structure's behavior, the materials used and the structural system also influence the structure's behavior.

Structural analysis in mixed-use buildings is the process of evaluating and planning the building structure designed for multifunctional use (Farisa & Widati, 2017). The appropriate structural system for mixed-use buildings can be reinforced concrete, steel, or a combination of both. The structural system of mixed-use buildings must be designed to withstand loads such as building loads, wind forces, and earthquakes.

LITERATURE REVIEW

Definition of Mixed Use Building

A mixed-use building is a structure with multiple functions or more than one function. Mixed-use buildings can consist of one or several interconnected building masses with different functions. In spatial planning, the government has established Government Regulation Number 15 of 2010 concerning the Implementation of Spatial Planning (Setiawan & Woyanti, 2010). According to regulations issued by the State Secretariat of the Republic of Indonesia, in addition to zoning, land management design must also include provisions to control the development of mixed-use buildings (Setiawan & Woyanti, 2010). Therefore, criteria for determining mixed-use areas are important to be established as guidelines. These provisions form the basis of RDTR (Detailed Spatial Plan), enabling the designation of mixed-use areas within a planning region.

Characteristics of Mixed-Use Buildings

Characteristics of Mixed-Use Buildings (Aharonian et al., 2004)

1. Multiple Functions: Encompasses two or more different building functions within a related area, including apartments, hotels, schools, hospitals, malls, and others.
2. Integration: There is physical and functional integration of the functions contained within it.
3. Proximity and Connectivity: Buildings are connected with each other at a relatively close distance, interconnected through pathways within the development.
4. Pedestrian Connectivity: Pedestrian pathways play an important role in connecting the buildings.

Principles of Mixed-Use Areas

In the Adelaide City Council guidebook, it is explained that there are several supportive factors for the success of a mixed-use design concept (Council & Council, 2002). The guidebook divides mixed-use building precedents in the city of Adelaide (Council & Council, 2002). The fundamental principles of mixed-use area development in the guidebook are:

a. Compact Development involves not only focusing on building mass but also encompassing public spaces (Council & Council, 2002). Public spaces can support circulation access, reduce reliance on motor vehicles, land consumption, energy use, and air pollution (Council & Council, 2002).
b. Accessibility for pedestrians, including factors of safety and comfort (Council & Council, 2002). Establishing circulation systems within the design area to provide safe and comfortable pedestrian access (Council & Council, 2002).
c. Interconnected street networks (Street Connections). In the design area, external parts are connected with roads that serve transportation (Council, 2002). S Thus, improving both external (outside the area) and internal (within the area) road networks should be accessible (Council & Council, 2002). This access also includes nearby public facilities and other functions (Council & Council, 2002).
d. Crime Prevention and Security involve planning and design solutions that enhance public safety (Council & Council, 2002). It's crucial to consider that increasing density in an area can lead to higher crime rates (Council & Council, 2002). Therefore, designs should incorporate aspects like territoriality, surveillance, access control, supportive activities, and maintenance.
e. Creating and Securing Public Spaces (Council & Council, 2002). Building and maintaining public spaces such as sidewalks, plazas, parks, public buildings, and gathering places can facilitate community interaction in the area (Council & Council, 2002).
f. Parking and Efficient Land Use (Council & Council, 2002). Designing and managing parking areas efficiently (Council & Council, 2002). Implementing mixed-use development can limit parking, especially in densely populated areas (Council & Council, 2002).
g. Human Scaled Building Design (Council & Council, 2002). Designing aesthetically pleasing buildings that are comfortable for pedestrians and compatible with other land uses (Council & Council, 2002). Key considerations include building size, architectural coherence between horizontal and vertical structures, roof forms, window and door rhythms, and the relationship between buildings and public spaces such as streets, plazas, other open spaces, and public parking (Council & Council, 2002).

Configuration of Mixed-Use Building Layout

Mixed-use Tower, with building mass A mixed-use area or building is considered successful in its achievement if it can connect between buildings well. There are 4 (four) configurations of building layouts in mixed-use areas (Sumargo, 2003), namely :

1. Single-structured and height classified as high-rise buildings with functions placed on those layers. Generally, mixed-use towers are considered high-rise buildings.
2. Multitowered Megastructure, a mixed-use building where all its towers are integrated with an atrium located at the bottom of the building. The atrium functions as a mall/shopping center. In multitowered megastructures, components in the podium are crucial as they serve as meeting areas or transitions for building users.
3. Freestanding Structure with Pedestrian Connection, which is a planning idea for organizing in a mixed-use area that consists of several standalone masses connected through pedestrian pathways. As a result, the functions of each building are not mixed. Combination, a concept that combines three forms of building masses within a mixed-use area.

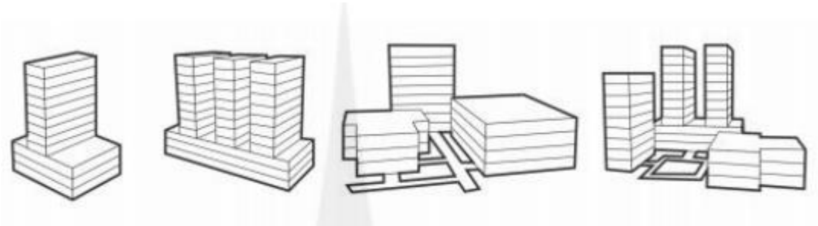

Figure 1. Configuration of Mixed-Use Building Layout

Analysis of Building Structure

1. Definition of Structural Analysis

Structural Analysis is the science of determining the effects of loads on physical structures and their components. Its branches include the analysis of buildings, bridges, tools, machinery, soil (Pantow et al., 2015). Structural analysis combines fields of mechanical engineering, materials science, and engineering mathematics to calculate structure deformations, internal forces, stresses, pressures, support reactions, accelerations, and stability. The results of such analysis are used to verify the strength of structures that are being or have been constructed. Thus, structural analysis is a crucial part of structural engineering design (Paena et al., 2020).

2. Structural Elements

A structural system is a combination of structural elements and their materials. It is crucial for engineers to classify structures based on their form and function by recognizing the various elements that constitute them. Some structural elements include:

a) Simple Beam Flexural Elements

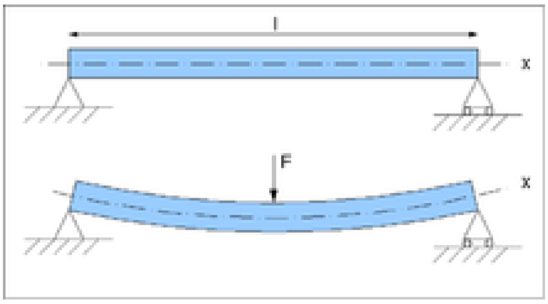

Figure 2. Simple Beam Flexural Element

A slender beam subjected to simple support will experience bending. The term bending refers to the study of stress and deformation that occurs in elements under the action of forces. Typically, perpendicular to the axis of the element, causing one edge of the fiber to elongate and the other edge to contract. The simple equation for determining bending stress in a beam with simple support

$$\sigma=\frac{My}{Ix}$$

σ = the bending stress,

M = the moment about the neutral axis

y = the perpendicular distance from the neutral axis to the outer fiber

Ix = the moment of inertia of the cross-sectional area about the neutral axis xxx

b) Compression Element: Column

In addition to load-bearing walls, columns are extensively used vertical elements. Typically, columns do not experience direct bending because there are no perpendicular loads on their axis. Columns are categorized based on their length. Short columns fail due to material failure (determined by material strength). Long columns fail due to buckling, which means instability failure rather than strength failure.

3. Types of Structures

The combination of structural elements and the materials that comprise them is referred to as a structural system. Each system is constructed from one or more of the four basic types of structures.

a) Truss

A truss consists of elements such as tension members (usually in the form of tensioned beams) and short columns, typically arranged in triangular shapes. Planar trusses are composed of elements lying in the same plane (2D) and are often used in bridges and roof supports. Conversely, space trusses have elements that can expand into three dimensions and are suitable for cranes and towers. Their span capacity ranges from

10 m to 125 m. In the case of bridges in Indonesia, the span capacity of Warren truss types can reach up to 60 m, compared to simple prestressed beam bridges that can only span up to 30 m.

b) Cable

Two other forms of structures used for long spans are cables and arch-shaped buildings. Cables are typically flexible and support their loads in tension. Unlike tensioned members that resist external loads along their axis, cables do not carry external loads along their axis, resulting in the cable adopting a specific curved shape.

Cables are commonly used for purposes such as supporting bridge girders and building roofs. When used for these purposes, cables have an advantage over beams and trusses, especially for spans exceeding 50 meters. Because they function primarily in tension, cables do not experience sudden instability or collapse as beams or trusses sometimes do. In terms of cost, trusses require additional construction costs and can increase height due to longer spans. On the other hand, the use of cables is limited mainly by weight and suspension methods.

c) Arch

An arch achieves its strength through compressive stress because it has a curved shape opposite to that of a cable. Arches must be compressed to maintain their shape, and as a result, secondary loads such as shear forces and moments must be considered in their design. Arches are often used in bridge structures, domes, and for the entrances of stone buildings.

d) Frame

Frames are often used in buildings composed of beams and columns connected either by pin joints or rigid connections. Loading on a frame causes bending of its members, and due to the rigidity of connections, such structures are generally indeterminate from an analytical standpoint. The strength of a frame is derived from the interaction of moments between beams and columns at rigid connections, and the economic benefits of using a frame depend on the increased efficiency in using smaller beam sizes relative to the increased column sizes due to bending at the connections.

RESEARCH METHOD(S)

This research is a qualitative descriptive study using the literature review method through library studies based on previous research journals (Kurniawan, 2014) related to the title, as well as through accessing data obtained from websites as sources of information publication. Qualitative descriptive research can be interpreted as the researcher being the key instrument, where data collection techniques are carried out through data compilation and inductive data analysis (Sugiyono, 2012), thus resulting in

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processing and presenting descriptive data such as narrating interview results and/or observations.

FINDINGS AND DUSCUSSION

The Universitas Pembangunan Panca Budi plans to develop a planned area located in the Glugur Rimbun area, precisely in the Village of Sampe Cita, Kutalimbaru District, which is projected to become a Mixed Use building center providing facilities for all study programs at UNPAB. The structural analysis for the Mixed Use building, named Al-Amin Mixed Use Building, includes commercial areas such as restaurants, cafes, and meeting rooms.

Kutalimbaru District is located within Deli Serdang Regency, North Sumatra Province. The natural conditions of Kutalimbaru District generally experience two seasons: dry and rainy seasons influenced by sea winds and mountain winds. Administratively, Kutalimbaru District borders several areas: to the north with Sunggal and Pancur Batu Districts, to the south with Sibolangit District, to the east with Pancur Batu District, and to the west with Langkat Regency (BPS Deli Serdang, 2021).

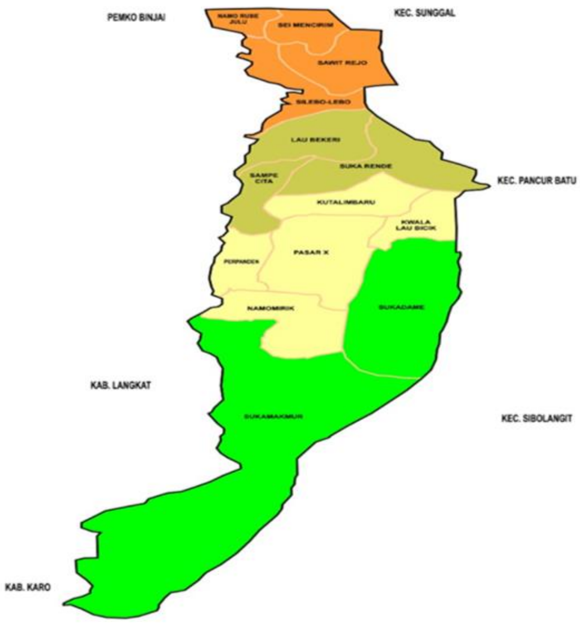

Figure 3. Map of Kutalimbaru District, Deli Serdang Regency.

This structural analysis aims to ensure that the building complies with all applicable regulations and standards, such as earthquake resistance, fire resistance, and local building regulations. Good structural design can also make building maintenance easier and more efficient, thereby reducing long-term maintenance costs.

CONCLUSION AND RECOMMENDATION

Conclusion

Based on the discussion, the conclusions drawn from this research are as follows:

1. Floor Slabs and Beams use Plain Reinforced Steel with a Strength Grade of Fy = 240 MPa (Ø8mm). Concrete cover is taken as 20 mm. Various slab thicknesses are designed to accommodate the working loads above them. Below are the moments acting on the floor slabs and beams.
2. Reinforcement calculations are conducted using the capacity strength design method according to SNI 2847-2019. The concept of capacity design aims to control the formation of plastic hinges at predetermined locations. SAP2000 software directly assesses structural dimensions and required reinforcement areas from input processing results. In SAP2000, the concrete provisions used are based on the American Concrete Institute ACI-318-05/IBC 2003, which differs in some aspects from Indonesian concrete regulations (SNI 2847-2019).

Recommendation

Based on the conclusions, the recommendations for this research are as follows:

1. It is necessary to adjust to the applicable regulations in Indonesia. The internal forces from SAP2000 are selected from load combinations that result in maximum bending moments and support moments at column faces. Flexural reinforcement and shear reinforcement of beams can be directly read from SAP2000 output in terms of required reinforcement area information.

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