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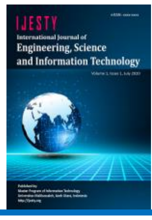

Re-Analysis of the Prototype Structure of Earthquake-Resistant Flats Built in the Seismic Mitigation Area Central of Borneo

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Abstract

Indonesia is an earthquake-prone area; to reduce the risk of disasters, it is necessary to construct earthquake-resistant buildings. The concept of earthquake-resistant buildings attempts to make all structural elements into a unified whole that is not easily collapsed by an earthquake. In general, the planning of the structure of an apartment is made of a prototype whose structure is calculated to be earthquake-resistant. However, not all flats are built in earthquake-prone areas. One is in Central Borneo Province, which is not prone to earthquakes. The research aims to determine the comparison of the dimensions and reinforcement requirements on the prototype with *Kriteria Desain Struktur (KDS) 'BC' Structural Design Criteria* compared to structural planning in the Central Borneo Seismic Mitigation Area. Design standards refer to SNI 1727:2013, SNI 2847:2013, SNI 2847-2019, and SNI 1726-2019. The building being studied is the Type 36 Prototype Flat (5 floors) using concrete *fc'* 22.8 MPa and reinforcing steel *my* 420 MPa. Research on Columns and Beams' superstructure includes the design of the structural dimensions and reinforcement requirements. Structural dimensions and reinforcement area will be designed efficiently and declared safe by controlling the reinforcement ratio*(p)*. Structural dimensional limitations. Structural calculation analysis using the ETABS computer application.

Keywords: *Prototype, Seismicity Mitigation, Flats, Structures.*

1. Introduction

Indonesia is an archipelagic country located at three major tectonic plate confluence: the Indian-Australian tectonic plate, the Pacific plate, and the Eurasian plate [1]. Meeting these three plates causes Indonesia to be seismically active [2]. In the event of an earthquake, many buildings experience structural failure due to poor planning and implementation [3]. Because of this, there is awareness of the dangers of earthquakes and the need to design earthquake-resistant buildings [4].

Housing is a primary need for every human being. Before, the government tried to meet the need for housing for the people of Indonesia [5]. Through the Ministry of Public Works and Public Housing, the government has a specific target in the Flats field in its strategic plan, namely facilitating and stimulating the construction of Flats. One is the construction of Flat Type-36 (5 floors) [6].

The analysis and design of the building structure is a prototype design with *Kriteria Desain Struktur* "BC" structural design criteria (KDS) so that the buildings included in the design do not refer to a particular area but rather to all areas that can be categorized as areas with type B, C structural design criteria (KDS), namely with seismic design of risk building categories I or II [7]. The structural system is a *Rangka Pemikul Momen Khusus (SRPMK)* Special Moment Resisting Frame, with the method used for calculating building structures in the Indonesian category zone 6 earthquake area, namely the area of the maximum level of earthquake influence [8]. However, the problem is that the Type-36 MBR Flats are also being built in several regions of Indonesia, including in non-earthquake areas (zone I areas), one of which is the construction of Flats in Kapuas Regency, Central of Borneo [9]. For efficiency and effectiveness while still considering the structure's safety, this thesis aims to provide a comparative description of the design needs of an earthquake-resistant prototype structure if it is built in the Seismic Mitigation Area of Central Borneo [10]. This research will compare the structure dimensions and the area of reinforcement (AS) between the prototype design and seismic mitigation Central Of Borneo with the ideal planning design standards [11].

2. Literature Review

2.1. Building Structure

Beam: A beam is a rod in a horizontal direction in the building structure based on the function of the structure [12]. Column: The column is a vertical compression member of the structural frame that carries the load from the beam [13]. The column is a compressed structural element that plays a vital role in a building. Platform: Besides having gravity loads, floor slabs can function as diaphragms that distribute lateral forces and increase building stiffness in the horizontal direction [14]. Concrete Reinforcing Steel: Reinforcing iron or concrete iron (reinforcing bar) is a steel rod shaped like a steel mesh used as a pressure device in reinforced concrete and supported concrete structures to strengthen and help concrete under pressure. Reinforcing iron significantly increases the tensile strength of the structure. (*Civil Engineering Handbook Second Edition*) [15].

2.2. Concrete Theory

Concrete is a mixture of Portland cement or other hydraulic cement, aggregate, coarse aggregate, and water with or without added ingredients to form a solid mass [16]. Standard concrete has a unit weight (2200 – 2500) kg/m3 using natural aggregates, which are broken down [17]. Fine aggregate is natural sand due to the natural disintegration of stone or sand produced by the stone crushing industry and has the largest grain size of 5.0 mm [18]. Coarse aggregate is gravel due to the natural disintegration of stone or in the form of crushed stone obtained from the stone crushing industry and has a grain size between 5 mm and 40 mm [19]. The compressive strength of the required concrete is determined by the structural designer (based on a cylindrical specimen with a diameter of 150 mm and a height of 300 mm). The targeted concrete compressive strength is the average compressive strength expected to be more significant [20].

3. Methods

3.1. Research Methods

Data collection was carried out using a series of existing data in numerical form.

1. Determining the building structure of the type of flat class that will be taken for the case study, in this case, the author chooses the type of Construction of Flats Type 36, 5 floors from the Ministry of Public Works and Public Housing, Director General of Housing Provision, Republic of Indonesia.
2. Review of the literature that will be used as a reference for evaluating structural calculations if it is built in the Central Borneo seismic mitigation area.
3. Analyzing the comparison of the prototype's dimensions and reinforcement area compared to the calculation of the structure with the design response spectrum in which the building is built.
4. Calculate the author's structure using the ETABS program application.
5. Make conclusions and suggestions from the research.
6. The research flowchart is shown in Figure 1.

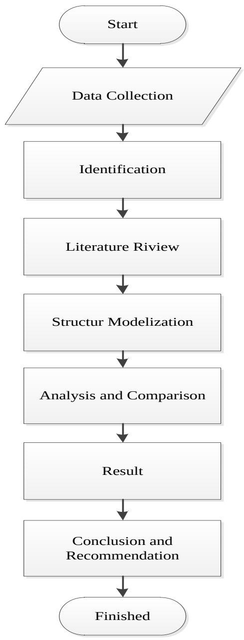

Fig 1. Research Flowchart

3.2. Research Design

The research design was carried out to achieve the objectives as stated in Chapter 1, namely to find out the difference in the area of reinforcement of the prototype Flats building structure with the *Kriteria Desain Struktur (KDS)* "BC" Structural Design Criteria if it was built in Central of Borneo Seismic Mitigation.

The analytical method used compares the differences in reinforcement column beams. The result obtained from all calculations is the value of efficiency.

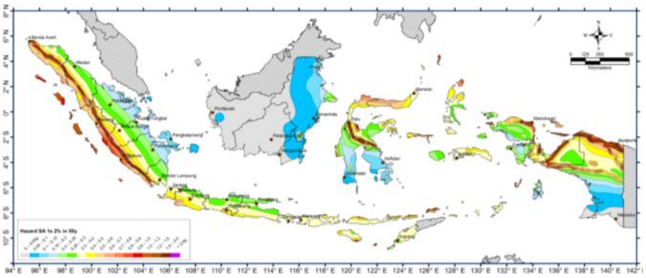

Fig 2. Response Spectrum Acceleration Map

3.3. Research Stage

To achieve the research objectives, the research framework is outlined in the stages of the research process, which can be explained as follows:

1. Formulate the background of the research.
2. Collect primary data needed in research.
3. Problem identification is carried out to collect problems that support research.
4. Formulate research objectives that relate to the analytical methods that must be used to achieve research objectives.
5. Literature study to understand the rules and basic theory of calculating earthquake loads.
6. Data processing and analysis are vital to the research, and appropriate methods must be used to achieve the research objectives.
7. Making conclusions and policy suggestions for determining development methods and determining structural calculations, which can later be used as material for consideration in determining policies in determining development methods.

3.4. Data Collection

Methods of data collection from the Ministry of Public Works and Public Housing, Director General of Housing Provision, Republic of Indonesia, secondary data, and literature studies. The necessary data were obtained by obtaining Structural Planning Drawing data, while secondary data was obtained by seeking information from other literature. Literature study, namely collecting data by studying and understanding various reading materials related to the thesis and notes and scientific writings related to the research being carried out.

3.5. Obtained Data

The data obtained of the Prototype Flats Type 36 – 5 floors are as follows:

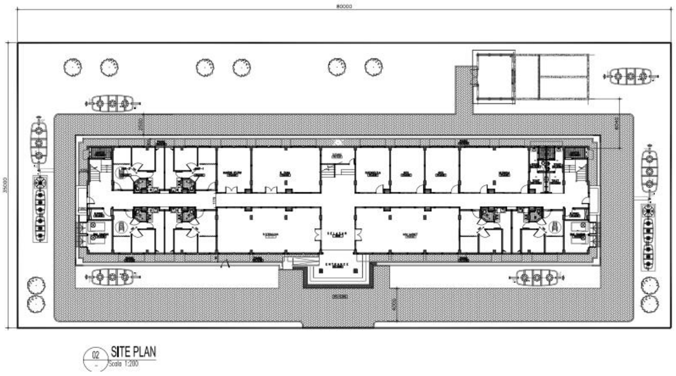

Fig 3. Site Plan Prototype Flat Type 36-5 Floors

Fig 4. Front View of the Type 36-5 Floor Flat Prototype

4. Results And Discussion

4.1. Earthquake load calculation SNI 1726:2019: data obtained

S_s = 0,0824
S_1 = 0,0477
Class size (Class site) = E
F_a = 2,4
F_{in} = 4,2
S_{MS} = 0,19776 g
S_{M1} = 0,20034
S_{DS} = 0,13184
S_{D1} = 0,13356
Risk Category II
SPMK structure system
I_{AND} = 1
H(m) = 20,95
$C_s = S_{DS} / (R/I_c)$ = 0,0165
$C_s = S_{D1}/[T(R/I_{It\ is})]$ = 0,02332
C_s min = 0,044 S_{DS}Ie = 0,0053
S_1(g) = 0,0477
C_s used = 0,0165
The effective weight of the building W = 24,655.3 kN
Earthquake shear force = V=C_s W = 571.54 kN

From the calculation of the weight and height of the building obtained:

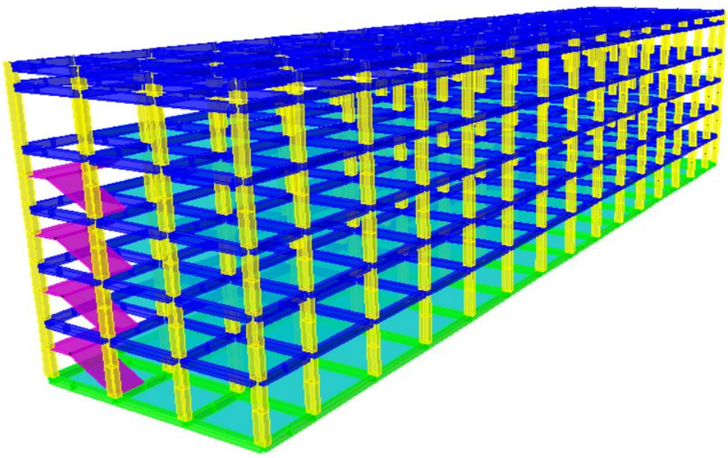

Fig 7. 3 D Structure Design

Table 1. Building weight per story from the ETABS program

Story	We (kN)	Zi (m)	Wi z_i^k (kNm)	Fi (kN)
5	3.312,00	17,15	77.668,57	162,41
4	4.205,83	12,95	72.207,29	150,99
3	4.205,83	9,75	52.691,98	110,18
2	5.147,59	6,55	41.467,94	86,71
1	7.784,03	3,3	29.295,84	61,26
	24.655,28	Σ	273.331,62	

4.3. Reinforcement area as a result of design calculation

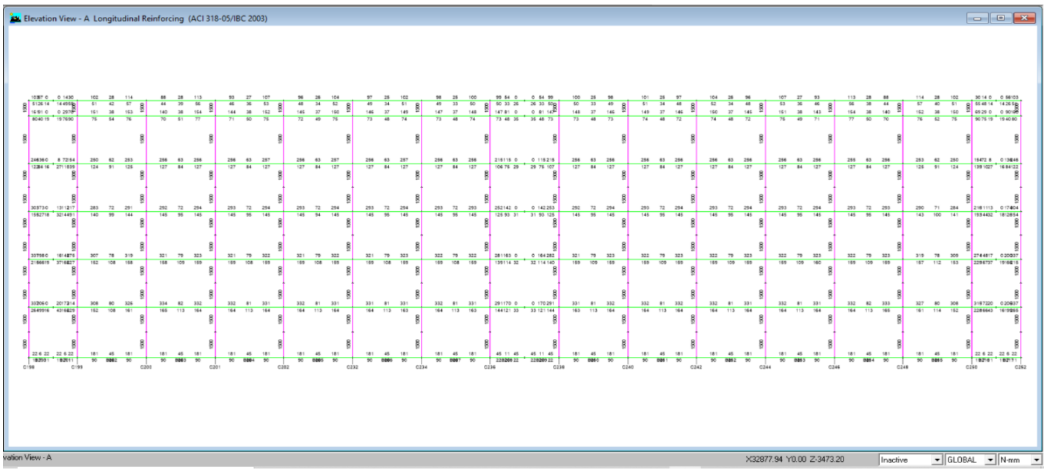

Fig 8. Amount of longitudinal beam reinforcement

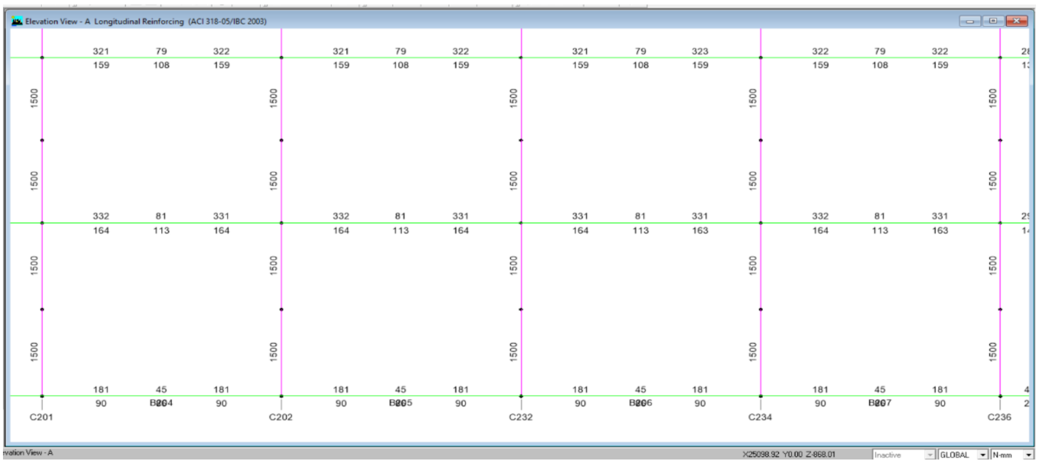

Fig 9. Amount of longitudinal beam reinforcement

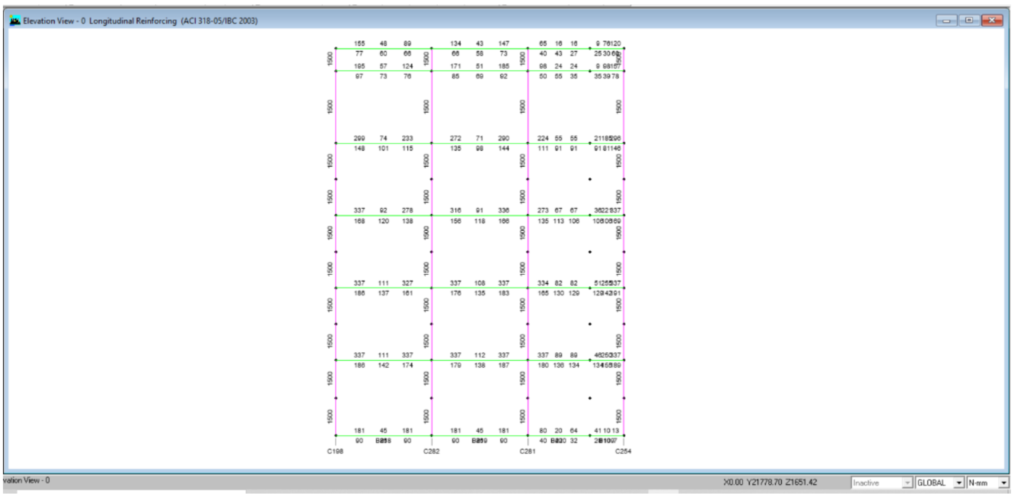

Fig 10. Amount of transverse beam reinforcement

Table 2. Design dimensions and beam profile design prototype

Structural Components	Structure Code	Dimension (mm)	Cross-sectional area (mm^2)	Reinforcement Ratio (%)
Column Story 1,2,3,4 and 5	K1	300x500	2.010	1,34

Calculation of the total cross-sectional area of the reinforcement in mm2

Diameter	Cross-sectional area	Number of Rebars	Total Number
16	201	6	1.206
10	79	2	158
		Total	1.364

Structural Components	Structure Code	Dimension (mm)	Cross-sectional area (mm^2)	Reinforcement Ratio (%)
Beam story 2,3 and 4	G1	250x450	1.364	1,21

Table 3. Calculation of the cross-sectional area of the Central Kalimantan Earthquake mitigation reinforcement

Calculation of the total cross-sectional area of the reinforcement in mm2

Diameter	Cross-sectional area	Number of Rebars	Total Number
16	154	5	770
10	79	2	158
		Total	928

Table 4. Design dimensions and profile reinforcement Column planning prototype

Calculation of the total cross-sectional area of the reinforcement in mm2

Diameter	Cross-sectional area	Number of Rebars	Total Number
16	201	10	2.010
		Total	2.010

Structural Components	Structure Code	Dimension (mm)	Cross-sectional area (mm^2)	Reinforcement Ratio (%)
Column Story 1,2,3,4 and 5	K1	300x500	2.010	1,34

Table 5. Design dimensions and reinforcement of the Central Of Borneo Seismicity Mitigation Column

Calculation of the total cross-sectional area of the reinforcement in mm2

Diameter	Cross-sectional area	Number of Rebars	Total Number
16	201	8	1.608
		Total	1.608

Structural Components	Structure Code	Dimension (mm)	Cross-sectional area (mm^2)	Reinforcement Ratio (%)
Column Story 1,2,3,4 and 5	K1	300x500	1.608	1,072

5. Conclusion

From the results of the analysis carried out with the ETABs program, which is calculated based on seismic mitigation in Central Borneo compared to the Prototype Design, it can be concluded as follows:

Table 6. Comparison of Dimensions and Area of Beam and Column Reinforcement

Structural Components	Structure Code	Prototype Cross-sectional Area (mm^2)	Central Kalimantan Mitigation Cross-sectional Area (mm^2)	Prototype Longitudinal Reinforcement Area (mm^2)	Area of Central Kalimantan Mitigation Longitudinal Reinforcement (mm^2)
Beam	G1	112.500	90.000	1.364	928
Column	K1	150.000	150.000	2.010	1.608

1. The comparison of the beam structure calculations is 928: 1,346 = 68.04%; the reinforcement area can be efficient by 31.96%
2. The comparison of the column structure calculations is 1,608: 2,010 = 80.00%; the reinforcement area can be efficient by 20.00%.

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