Planning Study Of Earthquake Resistant Concrete Building Using Elastic Second Order Analysis*

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ABSTRACT

In the District of Jember, the last few years often happen earthquakes with a magnitude of medium. Therefore, the planning of high-rise buildings in the District of Jember have to take into account the earthquake forces, so that it can provide performance at least life safety. In doing a planning of earthquake resistant building should be an analysis of the structure in order to get the style that occurs on the elements of the structure. Analysis of the structure of itself has a lot of updates occur following the era of the development of the times, one analysis is the Analysis of the Second- Order Elastic contained in the regulations of ACI 318-14. In the Analysis of the second Order Elastic version of ACI 318-14, the column must take into account the influence of the load is axial, the existence of the area of cracks on the entire length of the component structure of the column, so that for reinforced concrete columns are subjected to a fixed load, creep transfer most of the load from the concrete to the longitudinal reinforcement, load transfer this result to reinforcement press having a yielding prematurely, resulting in loss of EI as effective. Based on the data and the results of the calculation of the planning of the reinforcement of column using Analysis of second Order Elastic obtained extensive reinforcement (As) as follows , K2 = 1134,11 mm2, K3 = 2268,23 mm2, K4 = 13210,40 mm2, K5 = 5284,16 mm2, K6 = 13210,40 mm2.

Keywords: Earthquake, Earthquake-Resistant Building, a Column, Analysis of Second Order Elastic.

1. Introduction

In the Jember Regency area itself, in recent years, earthquakes of medium magnitude have often occurred. Therefore, the planning of high-rise buildings in the Jember Regency area must take into account the earthquake force, so that it can provide a minimum performance of life safety, where buildings are allowed to experience damage but not collapse [1] [2]. In designing an earthquake-resistant building structure, it must have sufficient rigidity to withstand all loads imposed on the building structure, so that the movement of the building due to lateral loads can be limited. To plan an earthquake resistant building, it is necessary to conduct a structural analysis in order to obtain the forces that occur in these structural elements [3]. The structural analysis itself has had many updates following the era of the times, one of the most recent analyzes is the Second Order Elastic Analysis contained in the ACI 318-14 regulations. In the Second Order Analysis of Elasticity of ACI 318-14 Version, the column must take into account the effect of axial loads, the presence of crack areas in the entire length of the column structural components, so that for reinforced concrete columns subjected to fixed loads, the crawl transfers part of the load from the concrete to the longitudinal reinforcement, load transfer this causes the compressive reinforcement to prematurely melt resulting in a loss of its effective EI [4] [5].

Referring to the background of the problem above, the problem can be formulated in the writing of this final project, namely How are the results of earthquake-resistant reinforced concrete column planning using second-order elastic analysis in the Integrated Laboratory building, Faculty of Engineering, University of Jember and How are the results of the comparison of column reinforcement calculations using second-order analysis elastic with the existing column in the field in the Integrated Laboratory building, Faculty of Engineering, University of Jember [6].

2. Research Methods

The research method used in this final project is the planning analysis of the Integrated Laboratory Building, Faculty of Engineering, University of Jember using second order analysis. The analysis used is based on the ACI regulations 318-14, SNI 03-1726-2012, SNI 03-2847-2013 and PPIUG 1983 [7] [8] [9] [10]. While the application used in this analysis is the SAP 2000 application, which functions to determine the internal forces that occur in structural elements, and the results of the SAP 2000 analysis will be used to plan column reinforcement.

2.1 Research Stages The stages of analysis that will be carried out in this final project are as follows:

a. Data collection.
b. Preliminary design (determining column dimensions).
c. Loading
   The loading that is taken into account in the planning of the integrated laboratory building of the engineering faculty of the University of Jember is as follows: Dead load is based on the PPIUG 1983 regulations, Live load is based on PPIUG regulations 1983, the quake load is based on SNI 03-1726-2012 regulations.
d. Modeling using the SAP 2000 application to get Pu, Mu, Vu due to gravity and earthquake loads.
e. Calculations to determine the diameter and amount of column reinforcement using second-order elastic analysis.
f. The nominal axial force controls the ultimate axial force that occurs.
g. Discussion and Conclusion.

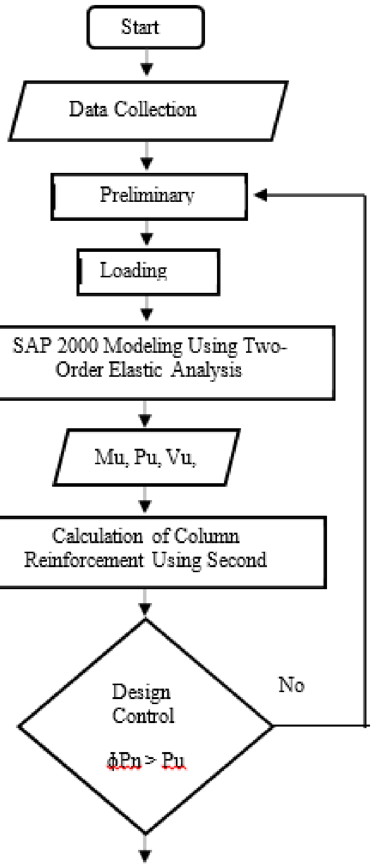

Figure 1. Flowchart

3. Results and Discussion

As for the 1st floor plan of the Integrated Laboratory Building, Faculty of Engineering the University of Jember is as follows:

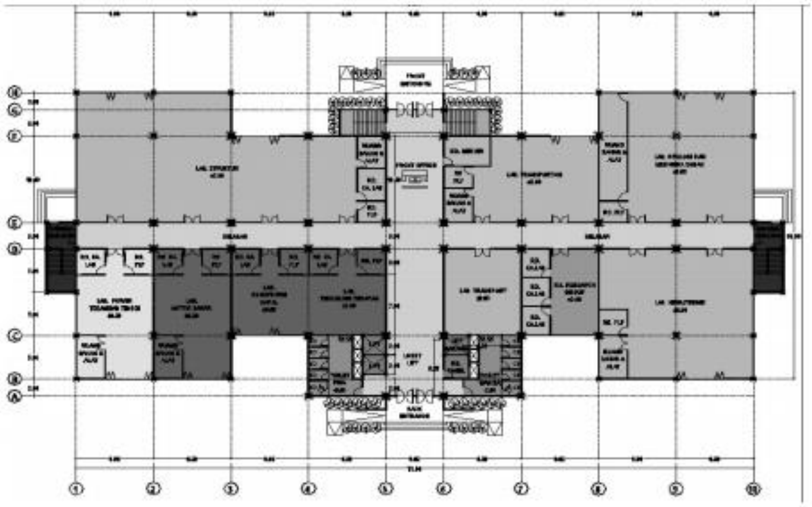

Figure 2. Floor plan 1

Building Location

The location of the building is located in the Jember University campus area has an address at Jl. Kalimantan no.37 Campus Tegal Boto District Sumbersari Jember Regency.

Building Functions

The building which is used as a case study in this final project is to function as an integrated laboratory which has a building width of 70 m, length the building is 35 m high and the building is 25 m high with 6 floors.

Building Geometry Data

The geometry data used in this final project are as follows:

a. Concrete quality (f 'c) = 25 mpa
b. Reinforcement quality (fy) = 360 mpa
c. Laboratory live load = 400 kg / m²

The period of building vibration (Tc) in this final project is obtained with assistance SAP 2000 program, while the vibration period in this final project is tabulated as follows in Table Period of Shakes from SAP 2000 Analysis.

TABLE: Capital Periods And Frequencies
Output Case Step Type StepNum Period Frequency
Text Text Unitless Sec Cyc / sec
CAPITAL Mode 1 1.4548 0.687379
CAPITAL Mode 2 1.39734 0.7156451
CAPITAL Mode 3 1.29207 0.7739503
CAPITAL Mode 4 0.84971 1.1768768
CAPITAL Mode 5 0.83511 1.1974506
CAPITAL Mode 6 0.66926 1.4941972
CAPITAL Mode 7 0.58601 1.7064435
CAPITAL Mode 8 0.5465 1.8298348
CAPITAL Mode 9 0.54506 1.8346512
CAPITAL Mode 10 0.53976 1.8526858

CAPITAL Mode 11 0.53062 1.8846006
CAPITAL Mode 12 0.52085 1.9199539

For the approach Ta value can be calculated by the following formula:
Ta = Ct x hnx
Ta = 0.0466 x 27,670.9
Ta = 0.925 seconds

Whereas for Tmaks it is calculated by the following formula:
Tmaks = Cu x Ta
Tmax = 1.4 x 0.925
Tmax = 1.295 seconds

So based on the description above, the following results are obtained:
Tc = 1.454 seconds> Tmax = 1.295 seconds

So based on the textbook of earthquake resistant concrete structure 2 edisis written by Ir. Pujo Priyono, MT. if, Tc> Tmax then, T = Tmax.

Steps of Structural Modeling in SAP 2000
The steps for modeling the structure with the help of the SAP program 2000 is as follows:

1. Block data
   Open SAP 2000 new model file and select grid only after that fill in the width of the x direction, y direction, and z direction.
2. Material input
   Select the menu define material add new material select material concrete and input concrete compressive strength data (f'c), elastic modulus and weight type of concrete.

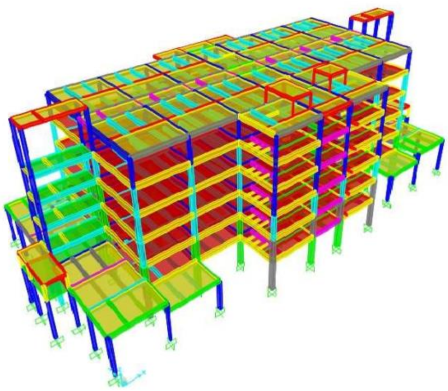

Figure 3. 3D Structural modeling soil site class

Based on the results of soil data (N SPT) in the construction of an integrated laboratory building [11], the average N value in the soil layer of 1 meter to 16.37 meters is 55.839, so the soil site class in this laboratory building construction project is included in the hard soil site class (SC).

3.1 Results of Column Reinforcement

Referring to the results of the column reinforcement calculation above, after planning the reinforcement of the column using second order elastic analysis, the following area of reinforcement is obtained:

Table 1. Results of column reinforcement

No	Type Kolom	Dimensi Kolom	As mm²	P
1	K2	30/30	1134,11	0,0126
2	K3	40/40	2268,23	0,0141
3	K4	50/50	13210,4	0,0528
4	K5	60/60	5284,16	0,0146
5	K6	70/70	13210,4	0,0269

3.2 Column Stiffness (EI)

Based on the results of the calculation of column reinforcement using the Order Two Elastic Analysis, the column stiffness is obtained as follows:

Table 2. Column stiffness

No	Tipe Kolom	EI mm⁴	EIeff mm⁴	Stiffness Ratio
1	K2	1,59E+13	7,1E+12	45,07%
2	K3	5,01E+13	1,17E+12	23,33%
3	K4	1,22E+14	7,79E+13	63,63%
4	K5	2,54E+14	6,42E+13	25,28%
5	K6	4,70E+14	1,77E+14	37,74%

3.3 Period of Shakes

For the period of natural shakes (T) in the Integrated Laboratory Building, Faculty of Engineering, University of Jember with the help of the SAP 2000 software as follows [12]:

For the K2 column the moment magnification factor (δns) is 1.845 with the difference in the effect of P-Δ the column stiffness uses 0.7 Ec Ig and uses Second Order Elastic Analysis of 1.292 mm, so that in column K2 the moment magnification factor (δns) is large because for column K2 value klu / r = 53> (klu / r) lim = 40, so that the effect of the slenderness of the column is taken into account and the moment magnification factor is also enlarged. For the moment magnification factor on the K3 column of 1.053 with the difference in the effect of P-Δ, the stiffness of the column used 0.7 Ec Ig and using the Second Order Elastic Analysis was not too large, namely 1.257 mm. For Column K4, the difference in the effect of P-Δ to column stiffness is 0.7 Ec Ig and uses Second Order Elastic Analysis, which is 1.913 mm, so that the moment magnification factor (δns) in column K4 is 1.151. For column K5 the moment magnification is quite large with a difference of P-Δ effect, the stiffness of the column uses 0.7 Ec Ig and uses the Second Order Elastic Analysis, which is 1.349 mm, so the moment magnification factor (δns) in column K5 is 1.478, for column K5 is at 2nd floor, so that the shear force that occurs in the column is large enough so that the moment magnification factor that occurs due to the earthquake load is also large, this is in line with the KIYOSHI MUTO theory that the earthquake load is assumed to be an inverted triangle so that the upward the shear force is getting bigger. For column K6, the moment magnification factor is not too large or considered constant because δns <1 so that the moment magnification is considered non-existent because the difference in the effect of P-Δ is the column stiffness using 0.7 Ec Ig and using the Second Order Elastic Analysis is not too large, namely 1.481

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mm and column K6 is on the 1st floor so that the shear force that occurs due to the earthquake load is small and the moment that occurs in column K6 is also small.

4. Conclusion

Based on the data and the results of the calculation of column reinforcement planning using the Order Two Elastic Analysis at the Integrated Laboratory Building, Faculty of Engineering, University of Jember, it can be concluded as follows:

1. Based on the calculation of column reinforcement using elastic second order analysis, the reinforcement area is obtained as follows:

Table 3. Columns dimensions and reinforcement area

No.	Type Column	As Existing	As Plan	ρ existing	ρ Plan
		mm²	mm²		
1	K2	1134,11	1134,11	0,01260	0,01260
2	K3	2268,23	2268,23	0,01418	0,01418
3	K4	5284,16	13210,40	0,02114	0,05284
4	K5	5284,16	5284,16	0,01468	0,01468
5	K6	7926,24	13210,40	0,01618	0,02696

2. Based on the results of the calculation of column reinforcement, the comparison of the area of the existing column reinforcement and the area of the column reinforcement using the Second Order Elastic Analysis, the results are shown as follows:

Table 4. Comparison of ρ column reinforcement

No.	Type Column	Dimensi Column	As Plan
			mm²
1	K2	30/30	1134,11
2	K3	40/40	2268,23
3	K4	50/50	13210,40
4	K5	60/60	5284,16
5	K6	70/70	13210,40

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