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MODELING AND ANALYSIS OF THE STRUCTURE OF THE MITRA SMART CITY PALOPO GENERAL HOSPITAL BUILDING (RSU) BASED ON SAP 2000

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Abstract

The modeling and analysis of building structures in this research aims to provide information about modeling techniques and structural analysis of multi-storey buildings that function as hospitals. Buildings standing with medium soil conditions (stiff soil profile) in Palopo City are included in the moderate earthquake area. Structural modeling and analysis was made using the SAP2000 program to obtain the magnitude of the loads acting on the building structure. The building dimensions are determined based on the condition of the columns, beams and plates based on the provisions of SNI 2847:2013. The results of the structural analysis show that the B80 beam element and C30 column element have a load case deviation of 12-16 mm and a load combination of 32-36 mm. The maximum deviation in terms of each floor is based on the earthquake load referring to SNI 1726:2012. The results of this research have been adapted to applicable regulations to produce a safe and comfortable building as a city hospital.

Keywords: ***Modeling; analysis; structural loading; earthquake load***

1. INTRODUCTION

Palopo City is one of the municipalities in South Sulawesi Province which is currently developing in creating a clean, peaceful, and serene environment in order to improve the quality of life of its people. This is supported by the availability of public services and facilities for its people, both in the fields of education, industry, trade, and health. The development of a city will have an impact on the increasing number of residents which is directly proportional to the community's need for health services.

Mitra Smart General Hospital (RSU) is a general hospital with private status located in the Dr. Ratulangi Street Area, Salobulo Village, Wara Utara District, Palopo City. The hospital building with an area of 3,709 m3 standing on an area of 2,081 m2 has facilities in the form of basic/general medical services, dental and oral medical services, KIA/KB services, emergency services, internal medicine, surgery, radiology, microbiology laboratory, medical records, digestive surgery, and waste management/environmental health.

The construction of Mitra Smart General Hospital (RSU) was carried out to add health facilities and services and improve comfort for the general public. The construction plan includes one semi-basement with a height of 2.50 m and 4 floors with a height of 3.75 m each with a reinforced concrete frame structure that resists ordinary moments.

The construction of Mitra Smart General Hospital (RSU) was carried out based on the planning regulations in force in Indonesia, namely SNI 1727:2013 concerning minimum loads for planning of buildings and other structures, SNI 1729-2015 concerning specifications for structural steel buildings, SNI 1726-2012 concerning procedures for earthquake resistance planning for building and non-building structures, and SNI 2847:2013, structural concrete requirements for building structures. In addition, the construction also reviews the functional aspects of the use and aesthetic functions of the building by prioritizing service and security.

2. METHOD

Structural load analysis using SAP 2000 software based on SNI 1727:2013 concerning Minimum Loads for Building Design. The structure used in structural planning is an ordinary moment-resisting reinforced concrete frame. The quality of concrete used consists of a 12 cm floor plate, a 7 cm roof plate. The concrete plate consists of cross-stacked steel reinforcement with a diameter of 8 mm. The floor plate has a thickness of 25 cm which is supported by double steel reinforcement above and below. The main reinforcement is 2.5 – 20 cm or 2 times the thickness of the plate encased in concrete with a minimum thickness of 1 cm.

2.1 Loading

The analysis stage is carried out in several stages, starting from analyzing the live load (LL). Live load is a large load that arises due to the use of a structure with a load position that can move. Live load refers to SNI - 1727-2013. Based on the function of the Hospital building, it is 250 kg / m2 with additional floors in the form of a basement (parking lot 800 kg / m2), 1st floor (corridor 300 kg / m2 and road / parking 400 kg / m2), 2nd floor (corridor 300 kg / m2 and office 240 kg / m2), 3rd floor (office 250 kg / m2), 4th floor (office 250 kg / m2, corridor 300 kg / m2, shop 300 kg / m2), permanent floor 300 kg / m2, and roof 100 kg / m2. While for the dead load (DL) is the result of the self-weight of the structure, finishing weight, ceiling load, and wall load. The self-weight of structural components in the form of beams and columns is calculated automatically using SAP 2000 software.

2.2 Earthquake Load

Earthquake load is a load that appears on a building structure due to ground movement in the form of an earthquake. Earthquake load is highly dependent on the mass of a building from the inertial mass effect of the upper part of the building that provides resistance to movement. Calculation of earthquake load using Response Spectrum and making response spectrum based on acceleration Ss and S1 (SNI Earthquake 2012) as follows.

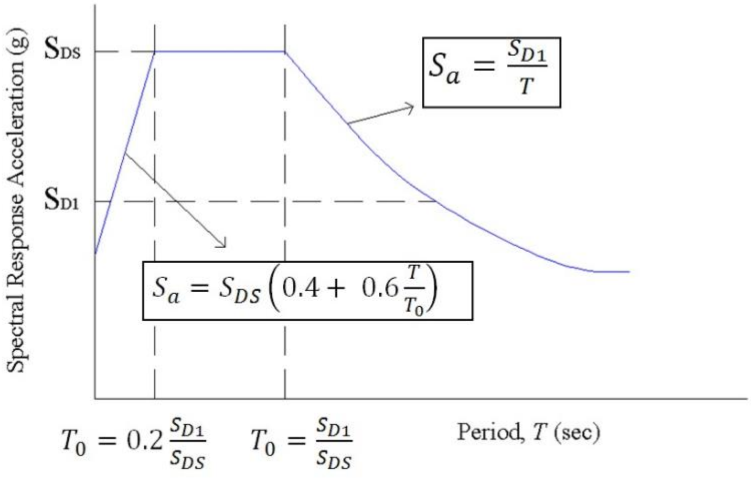

Figure 1. Spectral Design

Information:

SD1 : Design acceleration spectrum response parameters (2/3.Fv.¬S1)
SDS : Design acceleration spectrum response parameters (2/3.Fa.¬SS)
SMS : Spectral design on short
Sa : Spectral acceleration
SS : Response parameters of acceleration spectra at short periods obtained from the Earthquake Area Map in Indonesia for SS
S1 : Acceleration spectrum response parameters at a period of 1 second obtained from the Earthquake Area Map in Indonesia for S1
Fa : The acceleration spectrum response parameters for the maximum earthquake under consideration depend on the location class and SS value.
FV : The acceleration spectrum response parameters for the maximum earthquake under consideration depend on the location class and the S1 value.
T : Period

In the calculation of earthquake loads, the soil profile determines the magnitude of the spectrum response. Types of soil based on SNI 1726-2010, as follows.

Table 1. Table Name. The table name and description are written above the table.

Location Class	Soil Profile (General Description)	Average Soil Properties for the Top 30 m		
		Wave Propagation Speed (m/s)	NSPT (coherence soil layers)	Non-Flow Shear Strength (KPa)
A	Hard Rock	>1500	Assumed not to exist in Indonesia	
B	Rock	760 – 1500		
C	Very Dense Soil and Soft Rock (Hard Soil)	360 – 760	> 50	> 100
D	Stiff Soil Profile (Medium Soil)	180 – 360	15 – 50	50 – 100
E	Soft Soil Profile (Soft Soil)	< 180	< 15	< 50
F	Requires special evaluation (special land)			

The type of soil used in this study is Stiff Soil Profile or medium soil type with a wave propagation speed of 180 - 360 m/s with NSPT (cohesionless soil layers) of 15 - 50 and non-flowing shear strength of 50 - 100 KPa.

3. DISCUSSION AND DISCUSSION

3.1 Load Analysis

Building structure analysis**Mitra Smart General Hospital (RSU) was carried out using a finite element-based computer for various loading combinations including dead loads, live loads, and earthquake loads with 3D structural modeling (space frame) based on the Extented Three-Dimensional Analysis of Building System (ETABS) v9.6.0 program as shown in the image below.**

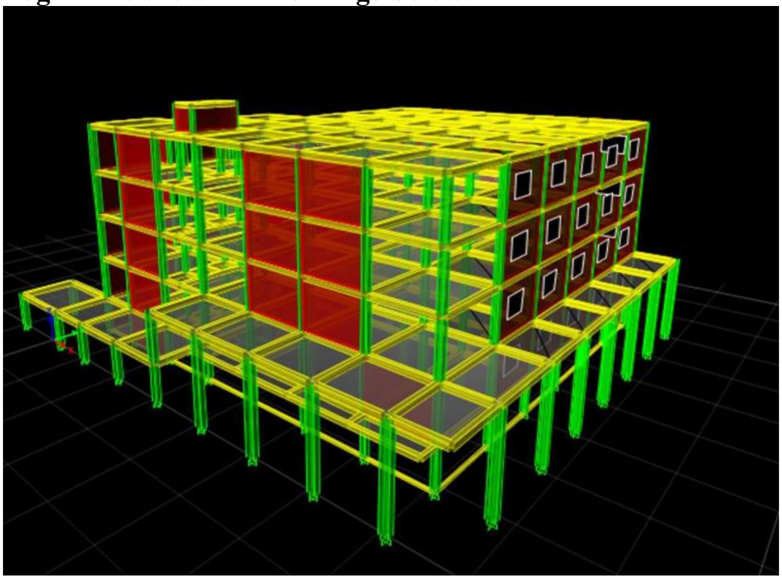

Figure 1. Structural Model of Mitra Smart Hospital

The static equivalent method is used to analyze the irregular shape of the building structure by taking into account the torsion due to the eccentricity of the building in the form of loading on each floor of the RSU Mitra Smart building. The following are the results of the analysis of the floor loading of the RSU Mitra Smart building.

Table 1. Analysis of Floor 1 Loading of Mitra Smart Hospital Building

Load Type	Category	Pressure (kg/m2)
Burden of Life	Corridor	300
	Road/Parking	400
Dead Load	Ceiling + Hanger	20
	Mechanical, Electrical and Plumbing	50
	Ceramics	24
	Sand 5 cm (0.05 x 1700)	85
	Spec 3 cm (0.05 x 2200)	66
Beam Load	Curtain Wall + Frame (60 x 5.5)	330
	Partition (60 x 5.5)	330

The data above shows that the live load has greater pressure than other loads on the RSU Mitra Smart building structure on the 1st floor. The magnitude of the pressure load on the 2nd floor can be seen in the table below.

Table 2. Analysis of Loading of the 2nd Floor of the Mitra Smart General Hospital (RSU) Building

Load Type	Category	Pressure (kg/m2)
Burden of Life	Corridor	300
	Road/Parking	400
Dead Load	Ceiling + Hanger	20
	Mechanical, Electrical and Plumbing	50
	Ceramics	24
	Sand 5 cm (0.05 x 1700)	85
	Spec 3 cm (0.05 x 2200)	66
Beam Load	Curtain Wall + Frame (60 x 4.2)	252
	Partition (60 x 4.2)	252

Table 3. Analysis of Floor Loading of the 3rd Floor of the Mitra Smart General Hospital Building

Load Type	Category	Pressure (kg/m2)
Burden of Life	Office	240
	Corridor	383
Dead Load	Ceiling + Hanger	20
	Mechanical, Electrical and Plumbing	50
	Ceramics	24
	Sand 5 cm (0.05 x 1700)	85
	Spec 3 cm (0.05 x 2200)	66
Beam Load	Curtain Wall + Frame (60 x 4.2)	252
	Partition (60 x 4.2)	252

Table 4. Load Analysis of the 4th Floor of the Mitra Smart General Hospital Building

Load Type	Category	Pressure (kg/m2)
Burden of Life	Office	240
	Shop (Convenience Store)	240
	Corridor	383
Dead Load	Ceiling + Hanger	20
	Mechanical, Electrical and Plumbing	50
Beam Load	Curtain Wall + Frame (60 x 5.5)	252
	Partition (60 x 5.5)	252

Table 5. Stair Load Analysis of Mitra Smart General Hospital Building

Load Type	Category	Pressure (kg/m2)
Burden of Life	Frame and Casting	400
Dead Load	Ceramics	24
	Spec 3 cm (0.05 x 2200)	66

Based on the function of the building, the risk factor is in category IV (hospital) with a priority factor of 1.5. The reinforced concrete structural system with ordinary moment resistance is R: 3, Cd: 2.5, and Ωo: 3 with the criteria of fixed foundation modeling. Seismic weight in the effective category with a rigid diaphragm.

The load combination used according to SNI 2847 – 2012 is:

$$U = 1{,}4\ D \quad (1)$$
$$U = 1{,}2\ D + 1{,}6\ L \quad (2)$$
$$U = 1{,}2\ D + 1{,}0\ L + 1{,}0\ W \quad (3)$$
$$U = 0{,}9\ D + 1{,}0\ E \quad (4)$$
$$U = 1{,}2\ D + 1{,}0\ L + 1{,}0\ E \quad (5)$$
$$1.405\ D + 1.3\ Qex + 0.39\ Qey + L \quad (6)$$
$$1.405\ D - 1.3\ Qex + 0.39\ Qey + L \quad (7)$$
$$1.405\ D + 1.3\ Qex - 0.39\ Qey + L \quad (8)$$
$$1.405\ D - 1.3\ Qex - 0.39\ Qey + L \quad (9)$$
$$0.695\ D + 1.3\ Qex + 0.39\ Qey \quad (10)$$
$$0.695\ D - 1.3\ Qex + 0.39\ Qey \quad (11)$$
$$0.695\ D + 1.3\ Qex - 0.39\ Qey \quad (12)$$
$$0.695\ D - 1.3\ Qex - 0.39\ Qey \quad (13)$$

Where:
U = Strong Need
D = Dead Load
L = Live Load
E = Earthquake Load

The maximum displacement is after applying a load case or load combination.

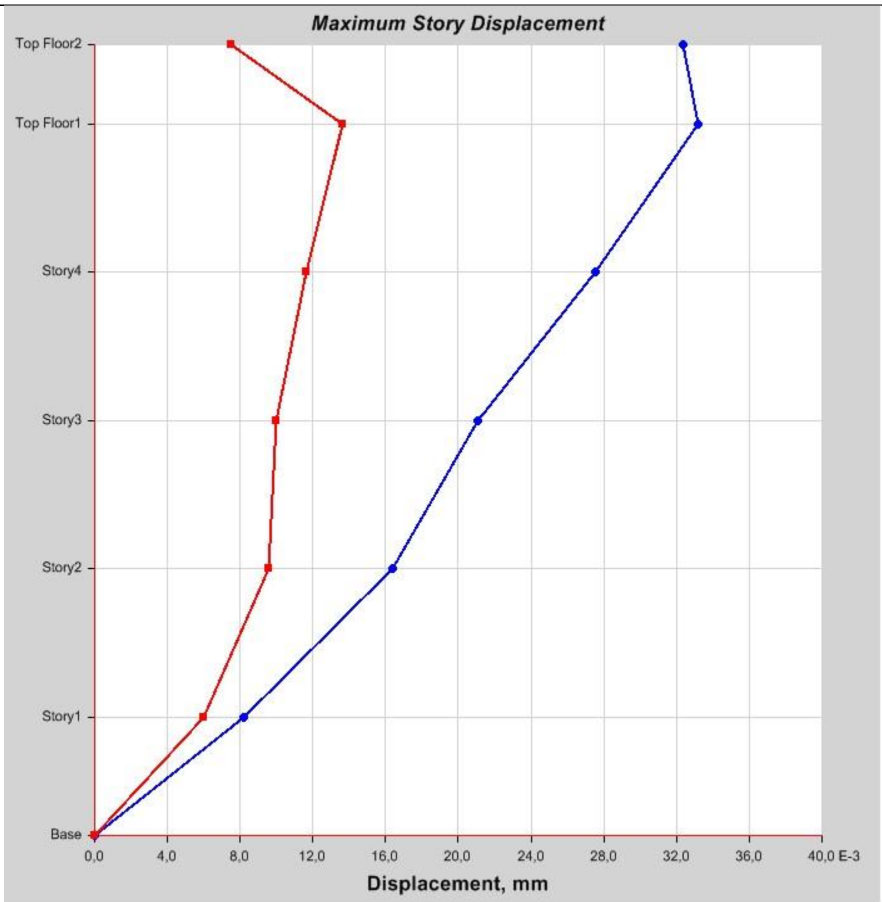

Figure 2. Story Response – Maximum Story Displacement

The maximum displacement is in the range of 12.0 - 16.0 mm for load cases and a range of 32.0 - 36.0 mm for load combinations. This indicates that the dimensions of the structure used have met the requirements based on the needs of the building's loading needs. So it can be used as a reference in making structural drawings of the RSU Mitra Smart building.

3.2 Earthquake Load Analysis

Analysis of the results of earthquake load calculations using the Response Spectrum based on acceleration Ss and S1 (SNI Earthquake 2012), as in the following figure.

a. Response Spectrum

$S_S = 0{,}785$ gram
$S_1 = 0{,}323$ gram
$F_a = 1$
$F_V = 1$

The calculation results are as follows.

$$S_{MS} = F_a . S_S = 1 \times 0{,}785 = 0{,}875 \quad (1)$$

$$S_{DS} = \frac{2}{3} S_{MS} = \frac{2}{3} \times 0{,}785 = 0{,}523 \quad (2)$$

$$S_{M1} = F_V . S_1 = 1 \times 0{,}323 = 0{,}323 \quad (3)$$

$$S_{D1} = \frac{2}{3} S_{M1} = \frac{2}{3} \times 0{,}323 = 0{,}215 \quad (4)$$

$$T_S = \frac{S_{D1}}{S_{DS}} = \frac{0{,}215}{0{,}523} = 0{,}411 \quad (5)$$

$$T_O = 0{,}2 \frac{S_{D1}}{S_{DS}} = 0{,}2 \times 0{,}411 = 0{,}082 \quad (6)$$

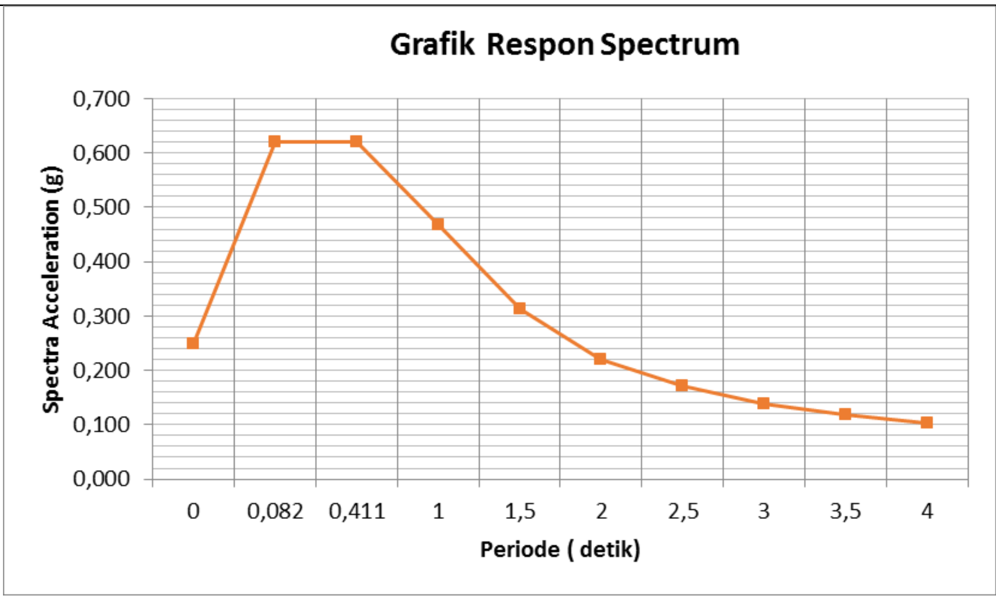

Figure 1. Response Spectrum Graph

The data above shows that the highest response spectrum peak in the Mitra Smart Hospital building is at the 0.6 gram point which is shown in less than the first second, and then decreases in the following seconds to 0.1 grams.

b. Structural Planning

1. Beam Design

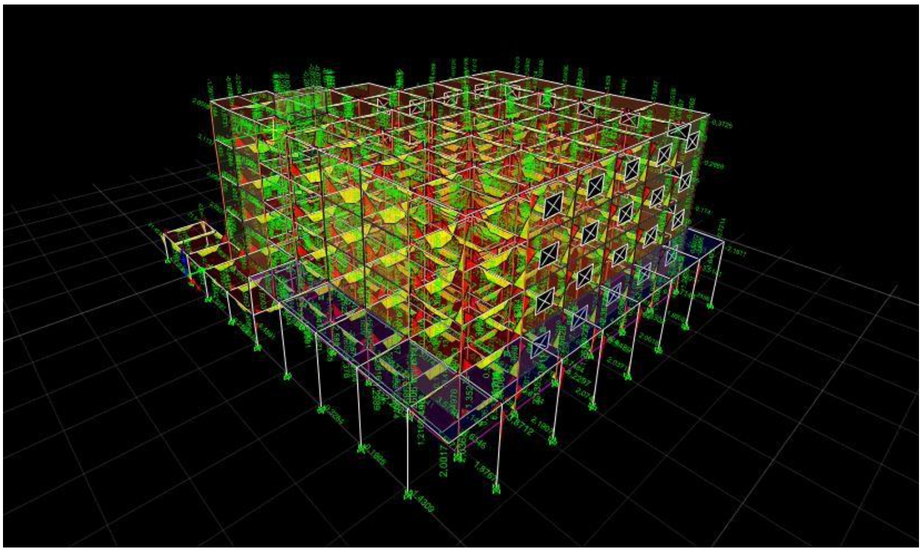

Figure 3. Moment 3-3 is visible

Table 6. Beam Element Details (Shear Details)

Element	Sect.n ID	Combo ID	Stationn Loc	Lengthh (mm)	LLRF	Typee
B80	40 x 30 beam	combinasi1-1	98	5000	1	Sway Special

Table 7. Section Properties

b (mm)	h (mm)	b_f(mm)	d_s(mm)	d_{ct}(mm)	d_{cb}(mm)
300	400	300	0	60	60

Table 8. Material Properties

E_c(MPa)	f'_c(MPa)	Lt.Wt Factor (Unitless)	f_y(MPa)	f_{ys}(MPa)
25742	30	1	35	35

Table 9. Design Code Parameters

Φ_T	Φ_{Ctied}	$\Phi_{CSpyramid}$	Φ_{Vns}	Φ_{Vs}	Φ_{Vjoint}
0.9	0.65	0.75	0.75	0.6	0.85

Table 10. Torsion Design VU2 and TU

Rbar Avs mm²/m	Rbar At /S mm²/m	Rbar Al mm²	Designn Vu2 kN	Designn T_u kN-m	Designn M_{u3} kN-m	Designn P_u kN
888.32	0	0	148,8667	0.1617	-55,1774	0

Table 11. Design Forces

Designn Vu2 kN	Designn Mu3 kN-m
148,8667	-86,1787

2. Column Design

Table 11. Column Element Details (Envelope)

Level	Element	Section ID	Lengthh (mm)	LLRF	Typee
Story2	C30	Column 40x60	3750	0.552	Sway Special

Table 12. Section Properties

b (mm)	h (mm)	d_c(mm)	Cover (Torsion) (mm)
600	400	60	27.3

3.

Table 13. Material Properties

E_c(MPa)	f'_c(MPa)	Lt.Wt Factor (Unitless)	f_y(MPa)	f_{ys}(MPa)
25742	30	1	3500	350

Table 14. Design Code Parameters

Φ_T	Φ_{CTied}	$\Phi_{CSpyramid}$	Φ_{Vns}	Φ_{Vs}	Φ_{Vjoint}
0.9	0.65	0.75	0.85	0.6	0.85

Table 15. Longitudinal Reinforcement Design for Pu – Mu2– Mu3 Interaction

Column End	Rebar Area mm2	Rebar %
Top	5796	2.42
Bottom	3317	1.38

Table 16. Beam / Column Capacity Ratios

	6/5(B/C) Ratio	**Column/ Beam Ratio**	**Sum Beam Cap**Moments kN-m	**Sum Col Cap Moments kN-m**	**Controlling Combo**
Momjor33	0.448	2,678	73,3714	196.5	Combination 6
Minor22	0.695	1,726	140,6583	242,7881	Combination 6

c. Plate Design

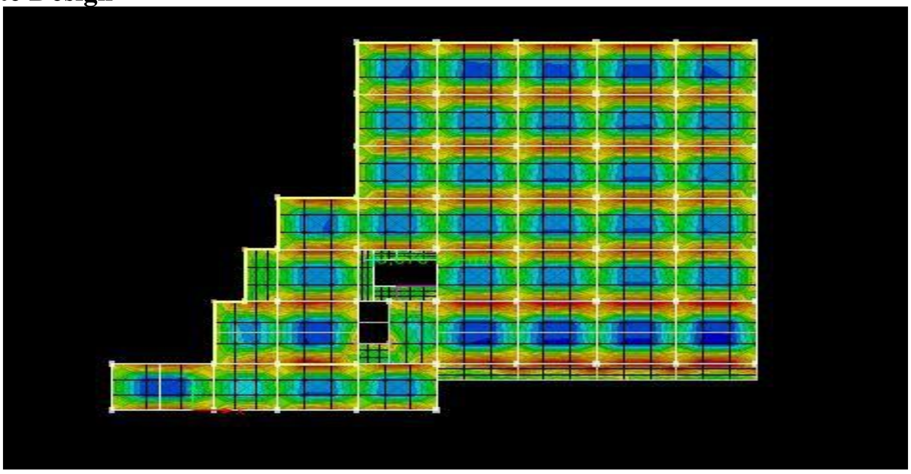

Figure 4. Plate Design

From the results of direct analysis of loading, the data is used as a reference in checking the dimensions of the secondary structure. The reinforcement design is assembled in the program to form each beam and column element based on the load received on the building. The area of reinforcement required will be indicated by the number of reinforcement requirements to produce flexural, shear, and torsional strength. Structural elements that do not meet the requirements or have a capacity value that is smaller than the requirements will be marked with a red beam or column color indicating an overstress condition (code o/s)

Figure 3 shows that some structural elements are still visible in red so that it is necessary to improve the dimensions of the beams and columns. One form of improving the dimensions of the building can be done by enlarging its dimensions in the application program, and then re-analyzing and checking the dimensions. This method is a trial and error until you get dimensions that meet the requirements so that there is no overstress or the rods are not red.

4. CONCLUSION

Modeling and analysis of the Mitra Smart Hospital building structure using the SAP2000 program by considering the main Indonesian standards in designing building structures with reinforced concrete materials, namely SNI 1726 2012, SNI 2847 2013, and SNI 1727 2013. Modeling of the building structure in the form of a plan layout, load definition, and input of model data in the program. The modeling results are then analyzed through an examination of the dimensions and needs of the building structure as reviewed from the loading and earthquake loads.

From the analysis results obtained B80 beam elements and C30 column elements with major 33 and minor 22. The analysis results indicate that the strength of the structure depends on the size of the dimensions of the structural elements. The larger the design dimensions of the structural elements, the greater the strength of the building structure. Column strength is important in earthquake-resistant building structures as a retainer of lateral building forces. Building planning calculations are carried out to obtain a strong, safe and efficient structural design so that it can withstand the loads acting on the building structure in accordance with applicable planning regulations.

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