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GLOBAL STRUCTURAL ANALYSIS OF HIGH-RISE HOSPITAL BUILDING USING EARTHQUAKE RESISTANT DESIGN APPROACH

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Abstract *-- Building designed has 1 to 8 floors with the quality of concrete f'c of 33.2 MPa, steel quality (fy) 400 MPa, and shear stress of 240 MPa. The building is analyzed by 3D structure modeling through ETABS Version 9.7 program by following all the rules and regulations applicable in Indonesia, such as the guidance of building structure and non-building, SNI 1726: 2012. This building design system is a high-rise building structure planned with a portal frame system with beams and columns as the main elements of structures made of conventional concrete. The beam carries the load transversely of its length and transfers the load to the vertical columns that accumulate it. The column accepts the load axially by the beam and transfers the load to the foundation. This building structure uses a special moment frame structure system (SRPMK) structure, considering that the hospital building is safe against earthquakes and complains about the strong column weak beam concept.*

Keywords: *Structure; Earthquake; Hospital Building*

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INTRODUCTION

The current population growth in a region is increasing. Increasingly also the sick. The sick person needs care and comfort in the building. A place to accommodate the sick in a region increasingly minimal due to population density. This density has implications for land use for buildings. One solution in solving the land problem for development is the high-rise building. The advantage is that it is more efficient in land use.

However, the analysis of high-rise buildings is very much into consideration. A prior building should start with interdisciplinary discussions and collaborations, consideration of the most economical structure design criteria, the type of soil conditions, the amount of loading to ensure the strength and stability of the structure. Strength begins with a strong foundation holding the load on it, sloop, columns, and beams that are resistant to the weight of the building itself, moving loads, wind loads, and earthquake loads. At the same time, stability is a way of analysis used to keep the building in place while the building is not cracked and does not collapse.

Some researchers carry out an analysis of building structures by applying software such as ETABS, STAAD Pro, etc. The aim is to understand the strength and stability of different discussions, such as focusing on the configuration of different analytical structures [1]. Another review is conducting a dynamic analysis of multistoried regular buildings [2] and other reviews observing the combination of Static and Dynamic Analysis of Special Buildings for review compared to the natural frequency of structures [3]. A review of other researchers is also looking at structural failures that occur. Structural failure is inadequate lateral stiffness, and irregularities occur in vertical irregularities [4]. Sudden earthquakes can make structural components such as beams, columns, plates, and roof collapse. This event needs to be revised by carrying out an improvement analysis in a multilevel building with earthquake resistant design [5]. In ensuring the strength and stability of a high-level building is also important to be considered in certain areas or sudden events occur because of strong winds because it gives an influence on axial forces, shear forces, moments, structural shifts and displacement of a structure.

In a high-rise building, it is also noted that soft storey, a soft storey between drifts and column seismic demands are very excessive, which causes severe damage or collapsed buildings during a massive earthquake [6, 7, 8, 9].

The Hospital Building is designed with eight floors, 32 m high with beams and columns as main elements of structures made of conventional concrete. The beam carries the load transversely of its length and transfers the load to the vertical columns that accumulate it. The column is loaded axially by the beam elements and transfer the load to the foundation. This high-rise hospital building using the structural system used is the Special Moment Frame System (SRPMK).

The purpose of an analysis of high hospital buildings in this paper is to make buildings that are strong, stable, and economical by paying attention to the requirements of building structure design using ETABS software [10]. Conditions in this analysis are stability requirements (static and dynamic), stiffness requirements (static and dynamic), ductility requirements, and eligibility requirements for ease of service. The analysis of the hospital building follows the building loading planning rules, building concrete requirements, earthquake resistance planning in the building [11, 12, 13], and follows modeling rules on load and global building considerations [14]. The analysis of high-rise reinforced concrete structures is commonly made easy by assuming a fixed base and disregarding the effect of soil structure interaction [15]. High-rise building structures that are made practical with regular structure models will be able to withstand the stability of the structure when the structure receives earthquake loads. The main key in structural design is the choice of an appropriate model that is able to reproduce with a good approximation of the actual behaviour of the building [16]. In high-rise buildings, beam and column dimensions work out large, and reinforcement at the beam-column joints is quite heavy [17]. Then in this paper, an observation is made in calculating tall structures globally by applying simple buildings and more regular structural models. The calculation is using earthquake-resistant design approaches to achieve stable structures, strong structural elements, and these calculated structures can deform well by following the regulatory procedures that apply to high-rise construction.

METHOD

High-Rise Building Structure

High-rise building structures have their challenges in design for structural development, especially when located in areas that have considerable risk factors for earthquake effects. For that in the design of a high-rise building structure should consider the basic elements of the building. These elements are linear in the form of columns and beams capable of withstanding axial forces and rotational forces, and surface elements consisting of walls and plates [18].

The selection of a high-rise structural system is not only based on the understanding of the structure in its context alone but rather the function factor related to the needs, social, economy, and technology. Several factors in the planning of high-rise structural building systems are general consideration of economics, soil condition, height ratio of building width, utility system consideration, and consideration of fire hazard level.

In high-rise structures greatly calculated a load of working directly by natural forces or humans, in other words, there are two basic sources of building load that is geophysical and man-made. The geophysical load is divided into three, namely gravity, meteorology, and seismology. Which includes the gravity load is a dead load. The load will be throughout the life of the building. Including meteorological loads are the time-varying loads of wind, rain, and snow. Which includes seismological loads are earthquake loads. While the load caused or created by humans is in the form of the human movement itself, the burden of life [19][20].

Building Construction

Building construction is a physical framework of the building that is designed to be able to withstand building loads. In the construction of the building, there are structural components such as beams, columns, floor plates, and stairs.

In the calculation of building construction should also be calculated loading that will be born structural components of the building. The loads that work on the structure are dead loads, live loads, and earthquake loads. The calculation is done to get magnitude and direction of the forces acting on each component of the structure. Later, the structural analysis is done to obtain the dimensions of the beams, columns, and reinforcement required by each structure.

The Moment Bearer Frame System

In search of an earthquake, the response factor needed parameters for earthquake design. The following parameters are as follows. The first is the location of the building will be built based on the earthquake zone in SNI 03-1726-2002. The second is the condition of the land where the building stands. The third is Natural Period (Natural Vibration Time, T) In a period of natural vibration time, it takes T with several equations. The T is calculated using the frame system only Special Moment Frame System (SRPMK):

$$T = 0{,}0731\ H^{3/4} \quad (1)$$

and using a frame system with a shear wall (double):

$$T = 0{,}0488\ H^{3/4} \quad (2)$$

where:
T = Natural Period (sec)
H = Height Building (m)

The fundamental natural vibration time limit is obtained on the condition and 1 < ζ, where:
T = Natural Period (sec)
ζ = Coefficient of vertical seismic response factor
n = Number of building levels
as listed in Table 1.

Table 1. The coefficient for calculating vertical earthquake response factor

Earthquake Area	ζ
1	0,20
2	0,19
3	0,18
4	0,17
5	0,16
6	0,15

From these conditions are taken the result of T with the smallest value. Next to get the value of C is determined from the following equations:

For $T \leq T_c$, $C = A_m$ (3)

For $T > T_c$, $C = \frac{A_r}{T}$ (4)

with, $A_r = A_m\,T_c$ (5)

Where,
T_c = Corner Natural Vibration Time (sec)
C = Earthquake response factor (sec)
A_m = Maximum response acceleration
A_r = The numerator in the hyperbolic equation factor earthquake response C

Structural Response Modification Factor (R)

The degree of ductility can be expressed in the R representative reduction factor, whose value can be calculated as the weighted mean value and the seismic reduction factor for two orthogonal coordinate axes with the base shear force. It is assumed by the structure of the building in each of these directions as the weighting quantities according to the equation:

$$R = \frac{v^o{}_x + v^o{}_y}{\frac{v^o{}_x}{R_x} + \frac{v^o{}_y}{R_y}} \quad (6)$$

where,
R = Earthquake Reduction Factor
$v^o{}_x$ = The nominal base shear force acting in the x-axis direction at the base level of the building structure is irregular
$v^o{}_y$ = The nominal base shear force acting in the y-axis direction at the base level of the building structure is irregular.
R_x = The seismic reduction factor for earthquake loading in the x-axis direction of the building structure is irregular

Structure System

The Building Structure System is designed with a portal frame system with beams and columns as the main elements of structures made of conventional concrete. The beam carries the load transversely of its length and transfers the load to the vertical columns that accumulate it.

The column is loaded axially by the block and transfer the load to the ground/foundation. This floored building using the structural system used is the Special Moment Frame System (SRPMK).

The Rules Use

The analysis of this building structure in all respects follows all applicable laws and regulations in Indonesia, especially those set out in the following rules: Procedure of Calculation of Concrete Structure for Building, SNI 03-2847-2002, Earthquake Resettlement Planning Procedure for Building Structure and Non Building, SNI 1726: 2012, and Guidelines for Planning for Home and Building Plans, SKBI-1.3.53.1987.

Structure Material

The structure of the building is a conventional reinforced concrete structure with the structural material used in the planning include Concrete Quality and Steel Quality.

The Concrete Quality parameters are: Columns and Beams using K400 (equivalent to f'_c = 33.2 MPa), Compressive strength of concrete, f'_c= 33.2 Mpa, Modulus of elasticity of concrete, E_c = 27081,137 Mpa, the plates use K300 (equivalent to f'_c = 24.9 Mpa) and Compressive strength of concrete, f'_c= 24.9 Mpa. The Steel Quality contains is the main reinforcement stress, fy = 400 Mpa with Shear melting stress, f_{ys} = 240 Mpa.

This research method uses dynamic response spectrum analysis with the help of the ETABS version 9.7 program analysis. Step analysis performed in accordance with established procedures. Dimensional data calculated in this study are data that are adapted to field conditions, then model 3-Dimensional structure in ETABS. Next, calculate and determine the type of load acting on the structure, including dead load, live load, and earthquake load. The ETABS output results provide information on the output of the analysis results including displacement and drift. The analysis process begins with structural modeling and is done with ETABS version 9.7 analysis.

RESULT AND DISCUSSION

The structure building that was built as a public hospital with a type of reinforced concrete structure. The concrete quality in the upper structure and the bottom structure is fc 33.2 Mpa. The quality of reinforced steel used is 400 Mpa, and the modulus of steel elasticity is 200,000 Mpa. The type of concrete weighs 2400 kg / m3, and the type of heavy steel is 7850 kg / m3 with a building of 8 floors 32 m. Then, the hospital building was calculated using earthquake resistant structures with strong earthquake areas, namely the earthquake area IV.

The structure of the hospital building model is done using the ETABS program. The structure model in this analysis is an asymmetric model by displaying the results of the run analysis. The result of this global structural analysis is a review of the overall components of the structural elements. This model can be seen in Figure 1 to Figure 8.

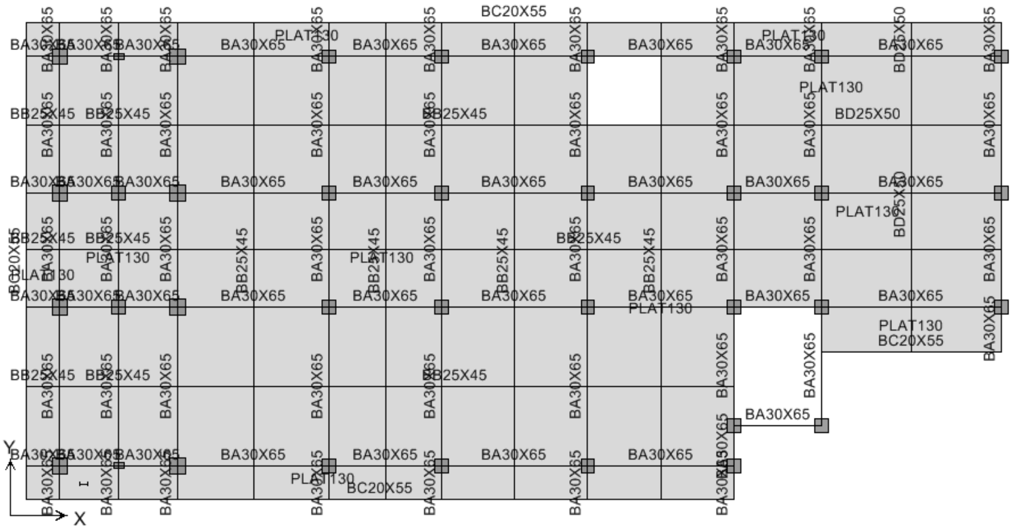

Figure 1. The 1st floor Model

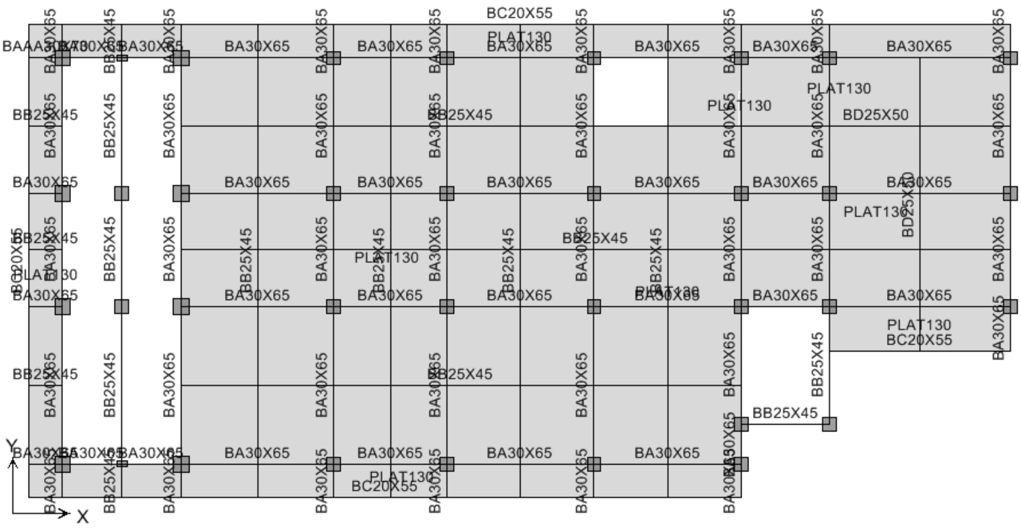

Figure 2. The 2nd floor Model

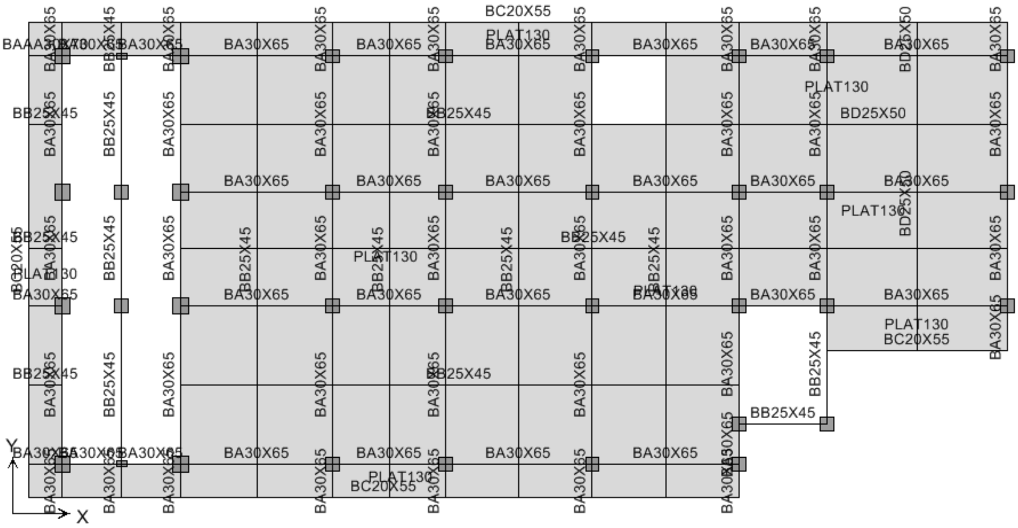

Figure 3. The 3rd floor Model

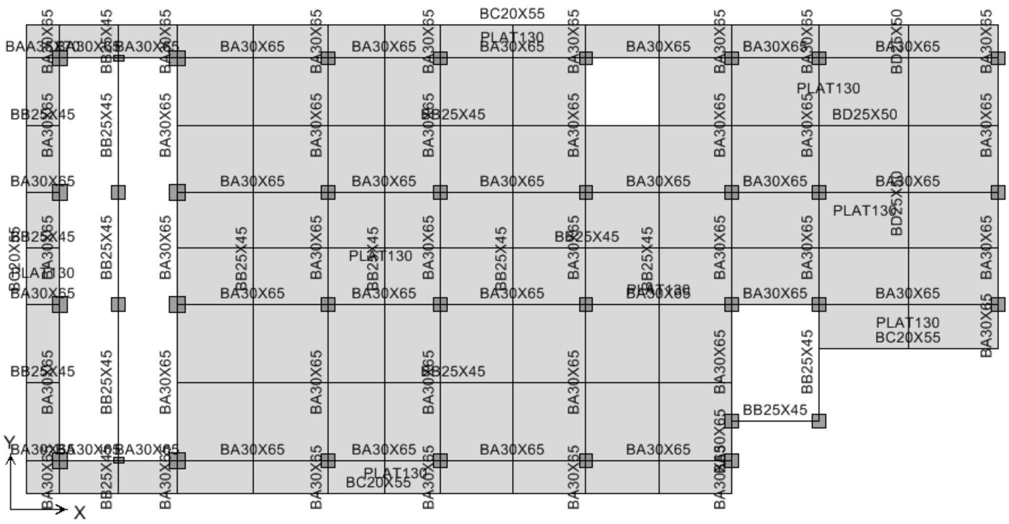

Figure 4. The 4th floor Model

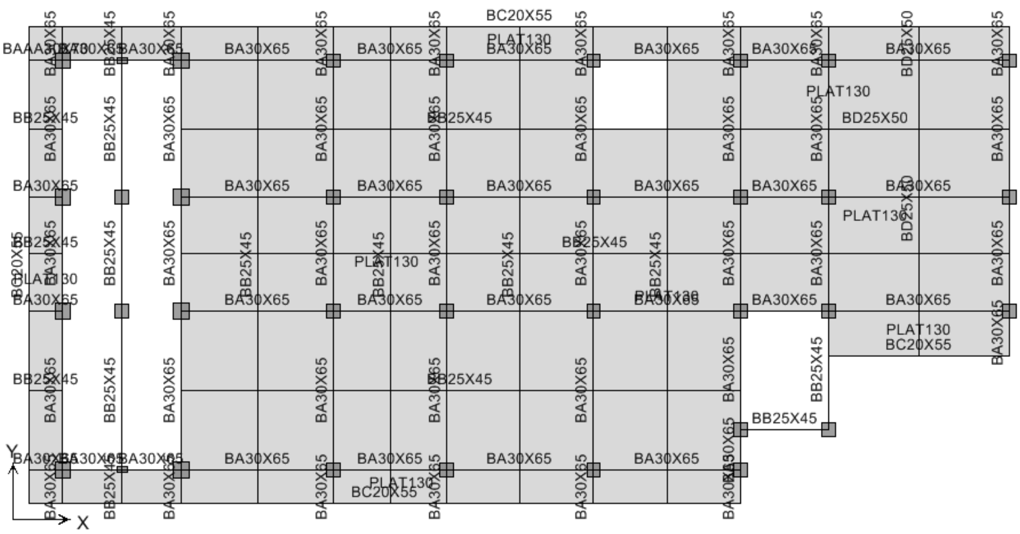

Figure 5. The 5th floor Model

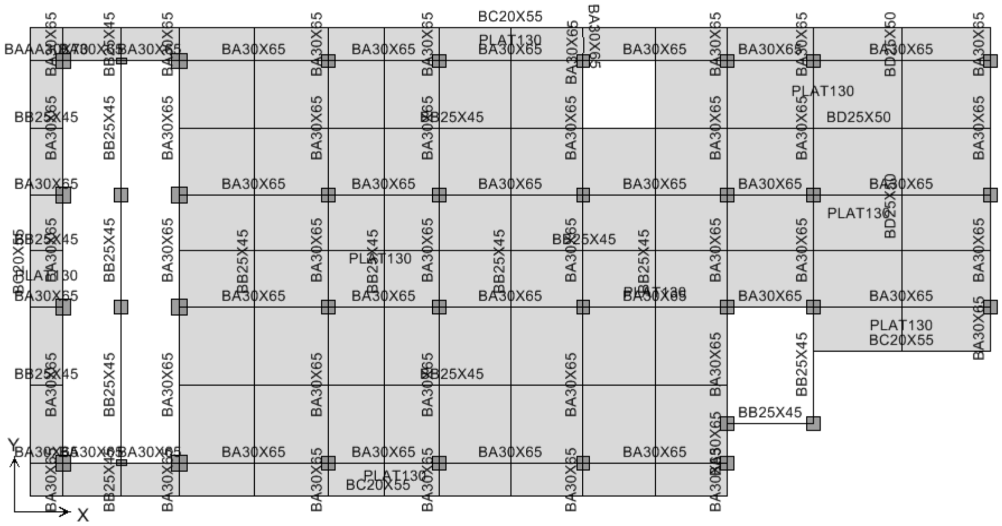

Figure 6. The 6th floor Model

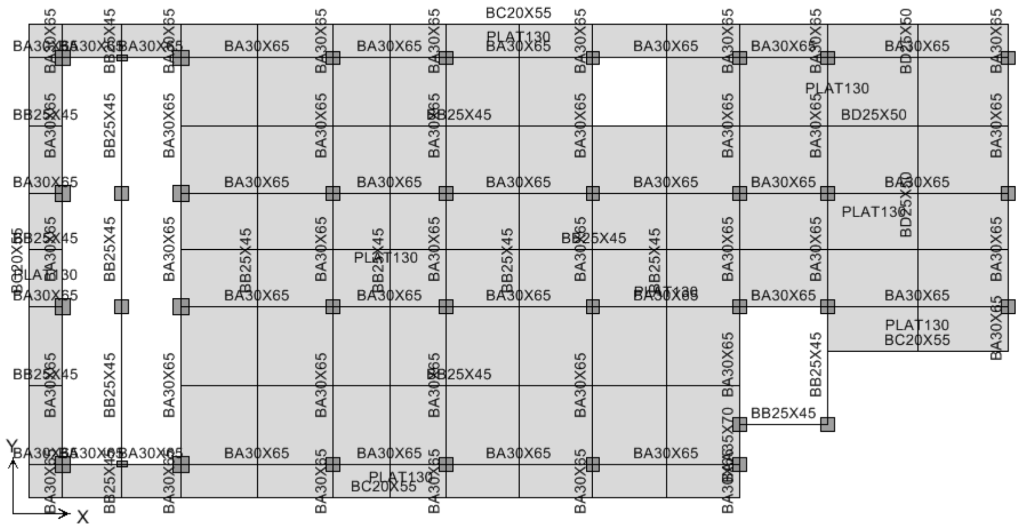

Figure 7. The 7th floor Model

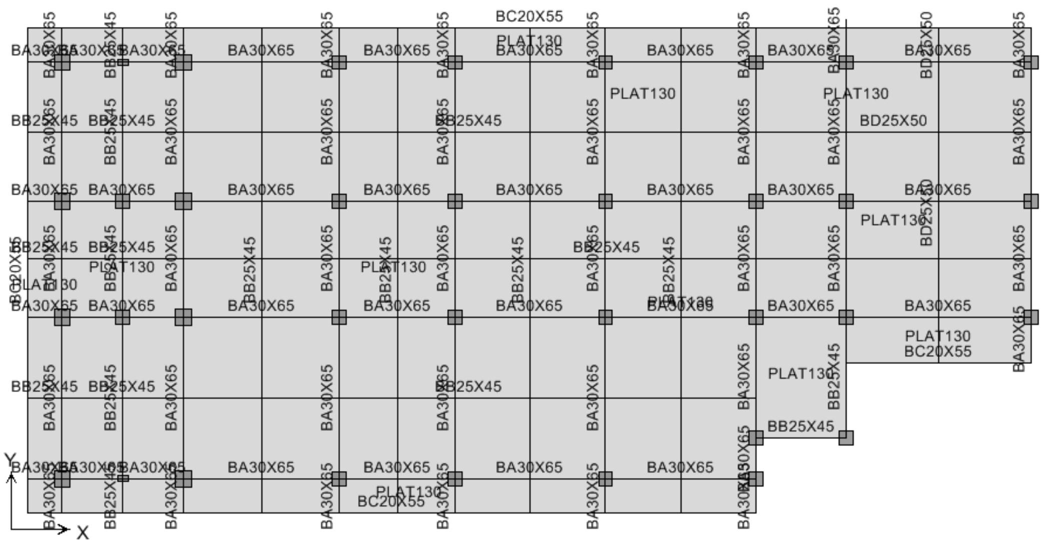

Figure 8. The 8th floor Model

Furthermore, modeling in the form of 3 Dimensions can be seen in Figure 9. The structure of the hospital building is modeled grid structure with beam element, used the element of the frame, and floor plate used plate element with shell element.

On the next floor, plate elements are also given dead load and live load according to the rules and functions of building use. For buildings, foundations are modeled as pedestals.

1. Loading of Structure

The loading on the hospital building structure consists of static loading and earthquake dynamics. Static loads include their weight structures (beams, columns, plates, walls), load from the roof (frames and roof coverings, ceilings and accessories), and loads. The loading of the earthquake is charged statically equivalent and dynamic with the Spectrum Response method in accordance with the regulations of SNI 1726-2012.

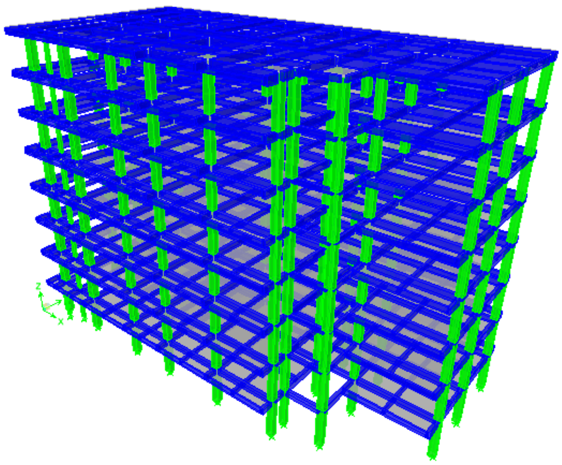

Figure 9. Modeling Results of 3 Dimensional

- Its weight of structural elements

The heavy loads of the structural elements on beams, columns, floor plates, and walls are calculated from the specific gravity of the structural element material and the total volume of the structural elements calculated. The weight itself has been calculated automatically by the computer program by activating its weight multiplier for load cases, dead loads, and heavy data inputs of structural material types.

- Live Load

The live load consists of the burden of people and equipment per area. The lifespan of the area taken is 250 kg/m2 = 2.5 kN/m^2 for the floor plate and 100 kg/m^2 for the plate not charged as the uniform load for the plate, in accordance with the Indonesian Household and Building Regulations.

- Earthquake Load

Earthquake loads given to structures follow SNI 03-1726-2012 regulations. Regarding the spectrum response of dynamic analysis and static equivalent analysis following the Earthquake Resistance

Planning Procedures for Building SNI 03-1726-2002. In the design of this structure, using the concept of capacity design, which means that the various structural collapse due to the large earthquake load is determined first with critical elements selected in such a way that the structure of the collapsed structure can radiate energy as much as possible. The design concept of capacity is used to plan the columns in the structure to be stronger than the beam element (*Strong Column Weak Beam*). This is done with the consideration that column collapse can lead to a total collapse of the entire building. In principle with the design concept of the main elements of earthquake resistant elements can be selected, planned, and detailed in such a way as to emit enormous earthquake energy without experiencing a total collapse of the structure. Then other elements are given sufficient strength so that the mechanism has been selected maintained during a strong earthquake. The graph of the spectral response is shown in Figure 10.

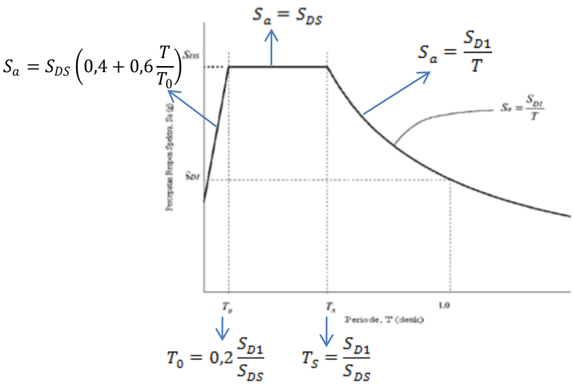

Figure 10. Spectrum Response of SNI 1726: 2012

2. Characteristics of Dynamic Structures

To know how the dynamic characteristics of the structure, 3-dimensional free vibration analysis is done by first determining the coordinate axis (x-axis, y-axis, and z-axis). The dynamic characteristic of the 12 characteristic structure can be seen from the participating mass ratios Ux, Uy nd Rz shown in Table 2.

Table 2. Characteristics of Dynamic Structures

Variety Number	Natural Vibrate Time (sec)	Modal Participating Mass Ratio (% mass)			Dominant Motion Patters
		UX	UY	RZ	
1	1,13	0,22	26,74	54,18	Rotation-Z
2	1,06	0,01	53,16	25,73	Translation-Y
3	1,03	79,35	0,11	0,12	Translation-X
4	0,38	0,02	0,01	0,00	
5	0,37	0,03	3,63	6,87	
6	0,34	0,02	7,07	3,63	
7	0,33	10,74	0,01	0,03	
8	0,22	0,00	0,01	0,00	
9	0,22	0,00	0,01	0,01	
10	0,21	0,00	1,30	2,61	
11	0,19	1,19	2,24	1,10	
12	0,19	3,19	0,73	0,56	

3. Characteristics of Dynamic Structures

The natural period (T) used has a minimum and maximum value, i.e.:

$T_{a\ minimum} = C_t\, h_n^x$

$T_{a\ maximum} = C_u\, T_a$

Because the structural system in both directions of the earthquake is the same, i.e., the Special Moment Frame System (SRPMK), then the coefficients used in both directions of earthquake loading are the same.

The natural period of the structure (T) in each direction obtained from the 3-Dimensional vibration analysis based on the intact cross-section using ETABS Version 9.7 is as follows:

$T_{X\ uncrack}$ = 1,133

$T_{Y\ uncrack}$ = 1,133

Checking T in the X direction:

$T_{a\ minimum} < \mathbf{T_{X\ uncrack}} < T_{a\ maximum}$

1,054 <**1,133**< 1,476 (Save)

Checking T in the Y direction:

$T_{a\ minimum} < \mathbf{T_{Y\ uncrack}} < T_{a\ maximum}$

1,054 <**1,133**< 1,476 (Save)

Period value of the structure (T) obtained from 3-dimensional vibration analysis using ETABS. Based on the value of the natural period of the structure can be calculated value of Cs. The value of Cs has a minimum and maximum limits, therefore the value of Cs to be used must be determined first. R value is taken by 8 in both directions because it has the same structure system that is Special Moment Resisting Frame System (SRPMK), and the value of Ie is taken 1.5 because the hospital building belongs in the risk category IV.

$C_{s\ minimum}$ = 0,004 $S_{DS}\, I_e \geq$ 0,01

Checking Cs in X direction:

$C_{s\ minimum} < \mathbf{C_{s\ count\ (x)}} < C_{s\ maximum}$

0,0528 <**0,0827**< 0,15 (Save)

Checking Cs in Y direction:

$C_{s\ minimum} < \mathbf{C_{s\ count\ (y)}} < C_{s\ maximum}$

0,0528 <**0,0827**< 0,15 (Save)

The value of Cs used is the Cs value of the count in each direction, since the Cs value of the count lies between the minimum Cs value and the maximum Cs. Equivalent lateral shear force values are calculated using the Cs value of the count.

$V_X = C_{s\ count\ (x)}\, W_t$ = 3822,203 kN

$V_Y = C_{s\ count\ (y)}\, W_t$ = = 3822,203 kN

Table 3. Earthquake Force Direction X and Y Each Level Floor

Floor	h_x	h_x^k (m)	w_x (KN)	$w_x h_x^k$ (KN.m)	c_{vx}	$F_x=F_y$ (KN)
Lt.8-1	32	181,02	5552,63	10005133,40	0,262	1002,185
Lt.7	28	148,16	5749,92	851,920,07	0,222	849,422
Lt.6	24	117,60	5748,95	675,935,72	0,176	673,953
Lt.5	20	89,44	5749,95	514,201,72	0,134	512,694
Lt.4	16	64,00	5745,92	367,994,88	0,096	366,916
Lt.3	12	41,60	5744,95	238,854,66	0,062	238,154
Lt.2	8	22,63	5744,99	129,994,28	0,034	129,613
Lt.1	4	8,00	6176,4	49,411,20	0,013	49,266
			Total	3833	vx = vy = 3822	

Table 3 shows the calculation results of the vertical distribution of earthquake forces and the direction of loading. Therefore, the actual earthquake direction cannot be ascertained. Then anticipation is carried out by assuming that the main direction earthquake loading is considered to be 100% effective and added to the earthquake loading by 30% in the perpendicular direction. Furthermore, the amount of force will be charged to the center of mass of each floor level structure.

4. Characteristics of Dynamic Structures

The final value of the dynamic response of the building structure to the nominal seismic load due to the impact of the earthquake plan in a particular direction, should not be taken less than 80% of the first response value. V value must be based on SNI 03-1726-2002 Section 7.1.3 is $V \geq 0.80\ V_1$. The value of V and the evaluation of earthquake load X direction and Y direction can be seen in Table 4.

Table 4. Evaluation of seismic load of X direction and Y direction

V_1 (first variety response)		Terms (KN)	Information
V_x (kN)	V_y (kN)		
3822	3822	2038	OK

Based on Table 4 shows the dynamic response level of the building to earthquake loading—unlawful SNI 03-1726-2002 section 7.1.3.

5. Performance Control Limit Building Service Structure

In order to meet the performance requirements of the service structure limit, in any case, the inter-level deviations calculated from the building structure deviation should not exceed 0.03/R multiplied by the height of the building level is calculated.

Table 5. Performance Controls Boundaries of X and Y Directions

No	Floor	H (m)	Δm Direction X (m)	Δm Between Level X (m)	Δm Between Level Y (m)	Δm Between Level Y (m)	Terms (m)	Information
1	8	32	0,0004	0,00028	0,0001	0,00006	0,12	SAVE
2	7	28	0,0007	0,00024	0,0002	0,00005	0,11	SAVE
3	6	24	0,0009	0,00020	0,0002	0,00004	0,09	SAVE
4	5	20	0,0012	0,00015	0,0003	0,00003	0,08	SAVE
5	4	16	0,0013	0,00009	0,0003	0,00002	0,06	SAVE
6	3	12	0,0014	0,00009	0,0003	0,00002	0,05	SAVE
7	2	8	0,0013	0,00053	0,0003	0,00011	0,03	SAVE
8	1	4	0,0008	0,00078	0,0002	0,00018	0,02	SAVE

The results of the performance control boundaries of X and Y directions shown in Table 5 can be seen that the floor structure 1 to 8 on the roof shows that this building has met the required limits. The condition indicates that when the structure experiences earthquake load, the structure can deform well. Performance controls boundaries are one of the controls in structural analysis with an earthquake resistant approach by providing information on the comfort level of each building floor.

6. Performance controls Ultimate Limit of Building Structure

To meet the performance requirements of the building's ultimate limit, in any case, the inter-grade deviation calculated from the structural deviation (Δ_m x ξ) should not exceed 0.02 times the corresponding level heights. For the ultimate boundary performance calculation, the X and Y directions are labeled in Table 6.

Based on the ultimate boundary performance control in Table 6. Deviation values between the levels of the hospital building structure in the X and Y direction of all floors are in a safe condition because the checking does not exceed the specified requirements. The calculation results shown in Table 6 are controls of a tall building that is calculated to ensure the building is in a safe condition.

Table 6. Ultimate Boundary performance control of X and Y direction

No	Floor	H (m)	Δm Direction X (m)	Δm Between Level X (m)	$\zeta.\Delta m$ Between Level X (m)	Δm Direction Y (m)	Δm Between Level Y (m)	$\zeta.\Delta m$ Between Level Y (m)	Terms (m)	Information
1	8	32	0,0004	0,00028	0,0016	0,0001	0,00006	0,0003	0,64	SAVE
2	7	28	0,0007	0,00024	0,0013	0,0002	0,00005	0,0003	0,56	SAVE
3	6	24	0,0009	0,00019	0,0011	0,0002	0,00004	0,0002	0,48	SAVE
4	5	20	0,0012	0,00015	0,0009	0,0003	0,00003	0,0002	0,40	SAVE
5	4	16	0,0013	0,00010	0,0005	0,0003	0,00002	0,0001	0,32	SAVE
6	3	12	0,0014	0,00009	0,0005	0,0003	0,00002	0,0001	0,24	SAVE
7	2	8	0,0013	0,00053	0,0030	0,0003	0,00011	0,0006	0,16	SAVE
8	1	4	0,0008	0,00078	0,0044	0,0002	0,00018	0,0010	0,08	SAVE

7. Control of Mass Participation

In Regulation SNI 03-1726-2002 section 7.2.1 says that the calculation of the dynamic response of structures shall be such that mass participation in generating a total response shall be at least 90%. Model Participation Mass can be seen 3-Dimensional building model in the picture below, and the results are shown in Table 7.

Table 7. Results of Capital Participation Mass

Mode	Period	UX	UY	UZ	SumUX	SumUY	SumUZ
1	1,133	0,221	26,74	0	0,221	267,36	0
2	1,055	0,003	53,12	0	0,224	798,51	0
3	1,029	79,35	0,106	0	795,73	799,56	0
4	0,384	0,020	0,000	0	795,93	799,57	0
5	0,366	0,026	36,28	0	796,19	835,85	0
6	0,337	0,019	70,65	0	796,38	90,65	0
7	0,331	10,74	0,001	0	903,75	90,65	0
8	0,222	0,000	0,000	0	903,75	90,65	0
9	0,215	0,000	0,002	0	903,75	90,65	0
10	0,207	0,009	12,96	0	903,84	919,49	0
11	0,188	11,85	22,40	0	911,89	941,89	0
12	0,187	31,83	0,734	0	949,23	949,23	0

Table 7 shows that mode 6 is able to meet the requirements of mass participation beyond 90% according to SNI 03-1726-2002 article 7.2.1. This relates to the number of vibratory variations taken in the calculation. Then, in Figure 11 below is mode 6 with a period of 0.3367 seconds, which is actually shown the calculation results through ETABS software version 9.7.

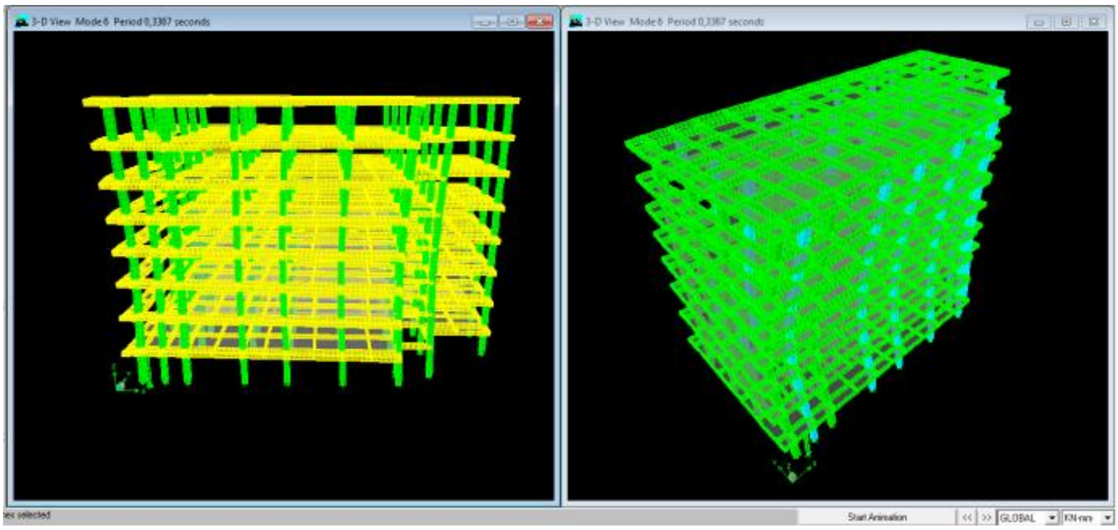

Figure 11. Mode 6 period 0.3367 seconds

8. Graph of Structured Structures on Earthquake Load

From the results of the program run, ETABS produce maximum displacement and maximum *Story Drift Displacement* due to the load of earthquake X can be seen in Figure 12.

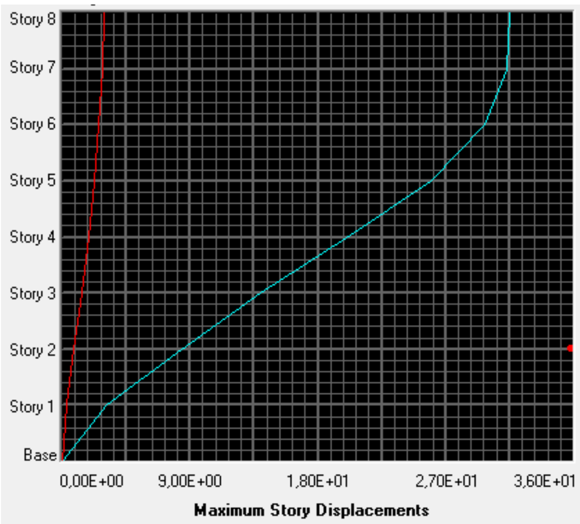

Figure 12. Displacement Due to Earthquake Load Direction X

Graph of Displacement due to Earthquake Load Direction Y can be seen in Figure 13.

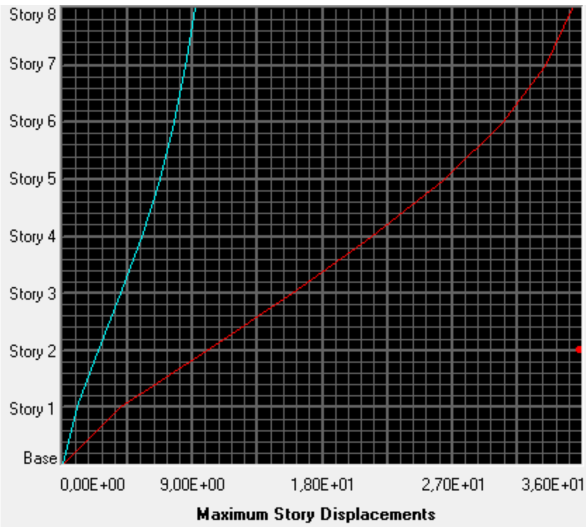

Figure 13. Displacement Due to Earthquake Load Direction Y

Figure 12 and Figure 13 gives a result of displacement due to earthquake load direction X of 0.0315 m and the result of displacement due to earthquake load direction Y of 0.0288. These results are in accordance with the maximum limit requirements of RSNI 1726-10 $[(0.015h_{sx})/\rho]$ = 0.396 m

For Story Drift Graph due to Earthquake Charge X Direction can be seen in Figure 14.

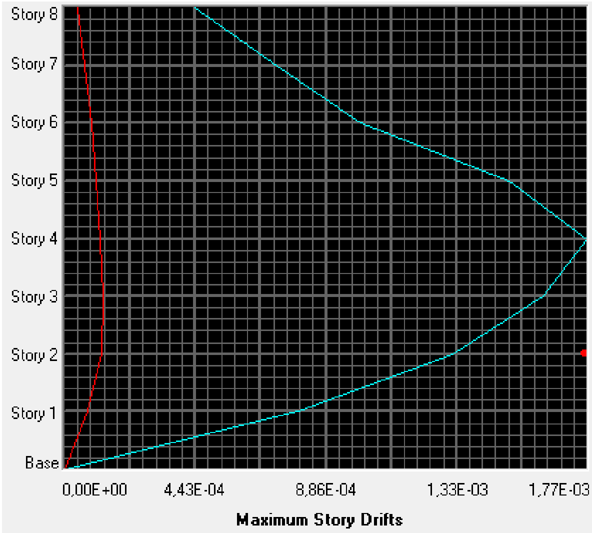

Figure 14. Story Drift Due to Earthquake Load Direction X

Story Drift Graph due to Earthquake Charge Y Direction can be seen in Figure 15.

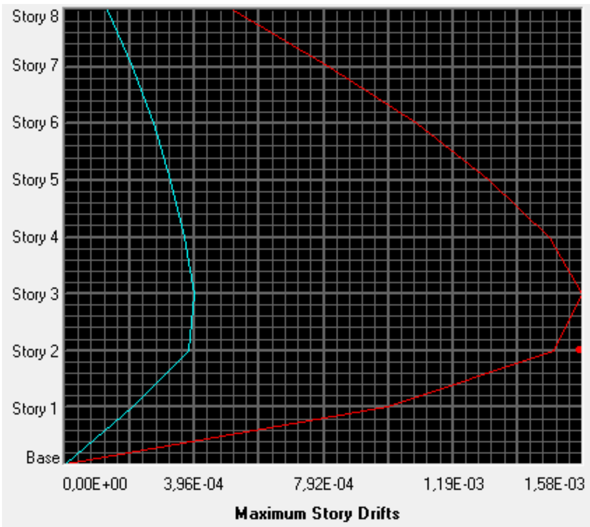

Figure 15. Story Drift Due to Earthquake Load Direction Y

Figure 14 and Figure 15 show that the story drift due to earthquake load direction X is 0.00177 m, and the story drifts due to earthquake load direction Y is 0.00156 m. The results based on ATC-40 regulations that the maximum total in-elastic drift at the next occupancy performance level is 0.005 m. These results indicate that the story drift due to earthquake load direction X and Y are in a safe condition.

9. Run Analysis Result ETABS version 9.7

Based on SNI 03-2847-2002 Article 11.3 the value of bending and shear reductions of 0.8 and 0.75. SNI 03-2847-2002 adopts the ACI 318-99 rule. Therefore, it is necessary to amend the reduction value of ACI 318-99 in the ETABS analysis. The structure calculated the capacity in retaining various combinations of loading. Checking of the structure due to the combination of loading can be seen in Figure 16 and Figure 17.

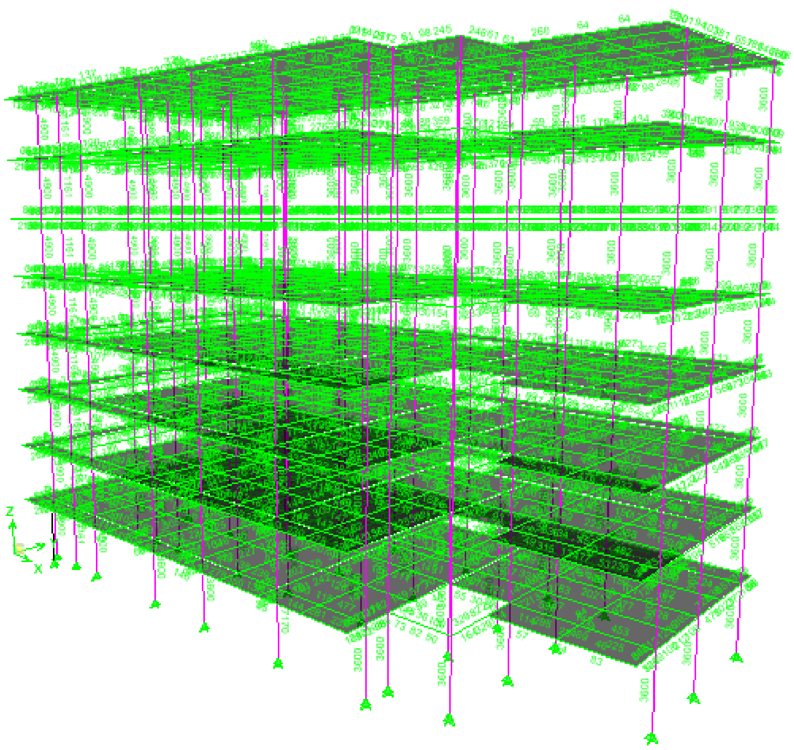

Figure 16. Global Structure Checking on Combination Load Model A

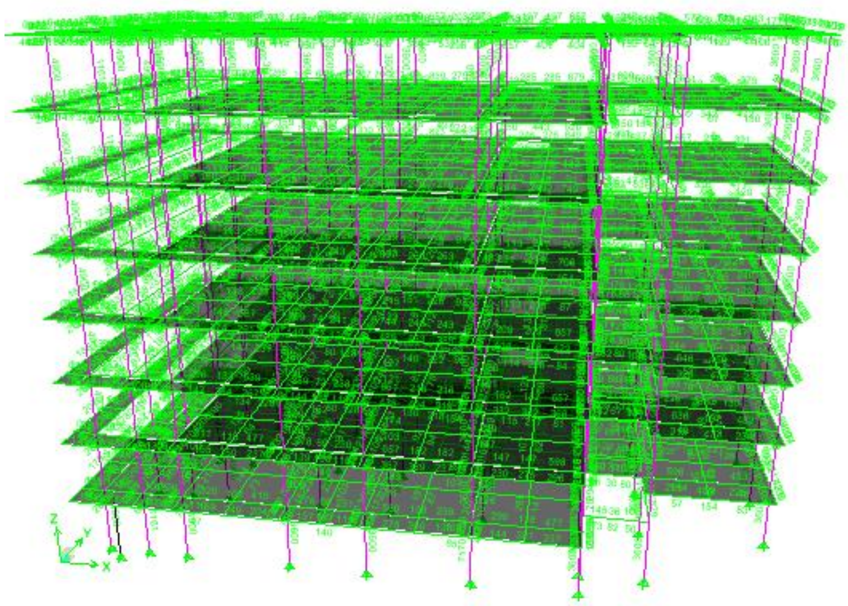

Figure 17. Global Structure Checking on Combination Load Model B

Figure 16 and Figure 17 show that the calculation of dimensions in beams and columns with a predetermined combination of loading can be seen that none of the beam or column elements experiencing over strength (OS) are marked in red on the elements. Thus, overall the structural components are safe from various combinations of predetermined earthquake loads.

CONCLUSION

The global structure is analyzed through the ETABS program version 9.7. Based on the analysis, it can be concluded that the beam, plate, and column structural components are able to withstand various loading combinations with the SRPMK structure, which has very tight detailing, which calculates the risk level of an earthquake that is likely to occur. Besides, the function of the structure of this building is included in the category of earthquake risk in region IV, with the priority factor of the earthquake being Ie = 1.5. For the calculation of vibration time limitation, the structure vibration time that occurs does not exceed the required time. Thus, the building structure is considered flexible. Finally, this research also reported that the deviation that occurred did not exceed the performance of the service limit and the performance of the ultimate boundary of the building structure.

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