Analysis about Planning and Modification of the Upper and Lower Structures of the 38 Floor Apartment SkyHouse Project with Equivalent Static Analysis

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Abstract

The modeled building structure is a regular building, with the number of levels being varied. The structural model is divided into 38-level portals. This research uses the help of the SAP2000 v21 program to facilitate the earthquake analysis process. The results of the study that will be compared are displacements between levels and base shear that occur due to earthquake forces. The results of the analysis have shown that static analysis produces greater results for the structural models compared to dynamic analysis. The difference in displacement between levels produced by the two methods in the three structural models is still included in the displacement limits between levels of permission required in B. & Wungo, (2012), so that the three models can still be analyzed by static analysis and dynamic analysis. Because the results of displacement and base shear in static analysis are greater than dynamic analysis, static analysis is safer if used for earthquake force loading in general structural calculations. Although in earthquake analysis, dynamic analysis is a more accurate analysis because the analysis process is closer to the actual situation.

Keywords:

Dynamic Analysis ,Static Analysis, SAP2000 v2, SNI 1726-2012.

1. Introduction

Indonesia is the fourth most populous country in the world with a population of around 269.6 million or 6% of the world's population. The large number of people in Indonesia causes the need for housing to increase. Therefore, there is a need for housing that does not require large land but can be used by many people, namely by the presence of high-rise buildings such as apartments.

The growth of apartments in Indonesia is increasing rapidly, the high demand for apartments in Indonesia is also due to land prices that are increasing from time to time. And this is in line with the increasing demand for housing for business people and professionals in the Alam Sutera areas. The type of housing chosen by the developer is an apartment with a residential concept that is in harmony with these conditions and is driven by regional conditions that can access entertainment centers, educational facilities and freeway facilities.

In planning this final project, it will focus on the discussion related to the comparison of the analysis of the modification of the upper and lower structures with earthquake static analysis in the planning of apartment buildings in the Alam Sutera area. This building has a 38-story building concept which must be taken into account against the loads acting on the building. The right method in analyzing earthquake loads, as well as planning shear walls that are able to withstand very large lateral forces and take into account the maximum forces that occur in structural elements both Columns, Shearwalls, Beams and Plates.

This study aims to compare the forces in the ultimate with the forces in the design and to determine whether the dimensions of the installed cross-section are able to withstand the forces in the ultimate due to the effects of external loading. Image of the structure of the SkyHouse AlamSutera Apartment project. Loading analysis refers to PBI 1983, and earthquake analysis uses equivalent static analysis method. Static analysis commonly used is the equivalent lateral force analysis. Dynamic analysis can be divided into two, namely analysis of variance response spectrum and analysis of seismic response history (time-history). Based on B. & Wungo, (2012), there are many limitations given in the static equivalent analysis procedure. This limitation is made because the results of the equivalent static analysis are less precise for various types of structures being built. Therefore, dynamic analysis is needed to obtain a building response that is closer to the actual structure response when an earthquake occurs. The results of the calculation of the structure of both plates, beams, and columns show that the value of the design bending moment (M_r) is greater than the ultimate bending moment (M_u).

Determination of the lower structure system must be based on the following data:

1. Architectural plans including the required number of basement layers.

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2. The condition and situation of the surrounding buildings.
3. Results of soil investigations which include:
4. Ground water conditions.
5. Research pumping test if the basement bottom is below ground water mica.
6. The layer of soil supporting the building foundation.
7. Recommendations for the foundation system along with the carrying capacity and estimated settlement of the building.

The shape of the building and the structural system of the building frame are closely related to each other both horizontally and vertically. A structural system is called good. Several things that must be considered in determining the structural system against lateral loads include:

1. Diaphragm stiffness and structural rigidity
2. Force distribution and resistance concentration
3. Resistance on the outer perimeter (perimeter) of the building structure
4. Vertical plane jump (vertical setback)
5. Structural irregularity
6. There is a large torque without sufficient resistance to accommodate the torque
7. Short column effect
8. Discontinuity of structural strength and stiffness due to transfer girders, transfer floors or structural walls that are not continuous downwards, and structural walls that are located alternating both in the vertical and horizontal directions.

The concept of selecting a structural system and the concept of planning/designing the structure of the building, such as the configuration of the floor plan and the loading that has been adjusted to the basic requirements for planning a high-rise building that applies in Indonesia so that it is hoped that the results that will be obtained will not cause structural failure.

2. Research Methodology

In making an analysis, data is needed as a reference material. To be able to perform a good analysis, data that includes information and basic concepts related to the object to be analyzed is needed. The data can be classified into two types of data, namely primary data and secondary data..

Primary Data is data obtained from the field or survey results that can be directly used as a source in structural analysis. Material specification data is used to determine the characteristics of the materials used in the structure. Namely as follows:

- a) Slab : $f'_c = 35 \text{ MPa}$
- b) Beam : $f'_c = 35/40 \text{ MPa}$
- c) Column : $f'_c = 35/40/45/50 \text{ MPa}$
- d) Foundation : $f'_c = 50 \text{ MPa}$
- e) Reinforcement : $f_y = 400 \text{ MPa}$, for main reinforcement
 $f_y = 240 \text{ MPa}$, for stirrup reinforcement
 $f_y = 520 \text{ MPa}$, for strand reinforcement and PC-wire

Land Data Soil data obtained from the results of investigations and soil testing in the laboratory, consisting of :

1. Boring
2. Direct Shear Test
3. Liquid Plastic Limit Test
4. Sondir
5. Grain Size Accumulation Curve

Figure 1. Final Project Compilation Flowchart

When modeling SAP 2000, the column elements will be released which will cause the moment in the bottom column to be 0. This is done because the connection between the precast columns is not pure clamping so that the modeling in SAP 2000 is expected to be close to the actual behavior in the field. But for connection analysis is based on P axial column tension (derived from the moment when the connection is purely clamped) and shear. With the help of this computer program, the program output will be obtained in the form of internal forces acting on the structure due to all existing load combinations including earthquake loads. The flowchart for portal mechanics calculations using SAP 2000 :

Figure 2. SAP2000 Analysis Compilation Flowchart

2.1. Slab Planning

Slabs are reinforced concrete panels which may be reinforced in two or one direction depending on the structural system. If in the slab structure the ratio of long span to short span is 3, it will experience deflection in both axes directions. The slab load is carried in both directions by the four supporting beams around the slab panels, thus the slab becomes a slab that flexes in both directions. The slab planning steps are :

- Determine boundary conditions, supports and span lengths.
- Determine the working loads
- Determine plate thickness

Figure 3. Plate Effective Height

2.2. Beam Planning

In the pre-designed beam height according to (SNI 03-2847-2002, n.d.) is the function and span and quality of the concrete used. In general, the pre-designed beam height is $L/10 - L/15$, and the beam width is taken as $1/2H - 2/3H$ where H is the beam height. Calculation of internal forces on the beam using Avizan & Koespiadi, (2020) software. From the results of the output of these internal forces, they are then used to calculate the reinforcement requirements.

$$d' = p + \emptyset \text{stirrup} + \frac{1}{2} \emptyset \text{ main reinforcement}$$

$$d = h - (p + \emptyset \text{stirrup} + \frac{1}{2} \emptyset \text{ main reinforcement})$$

Figure .4. Plate Effective Height

2.3. Coloumn Planning

Column elements receive bending loads and axial loads, according to (SNI 03-2847-2002, n.d.) article 11.3.2.2. for planning columns that receive bending and axial loads, the material reduction coefficient is set at 0.65, while the distribution of reinforcement in columns (rectangular cross-section) can be done by installing symmetrical reinforcement on two sides of the column (two faces) or installing reinforcement on four sides of the column (four faces).

In planning this apartment building, column planning is used using reinforcement on four sides of the column cross section (four faces). Calculation of internal forces on the column using the Avizan & Koespiadi, (2020) program.

Figure 5. Effective Length Factor (k)

3. Result And Analysis

The results and discussion contain the following descriptions:

3.1. Structure Data

The building characteristics data are as follows:

- 38-storey apartment building with a total height of 118.5 m
- The height of the basement floor and 1st floor is 4.5 m which is used for parking, the height of the 2nd and 3rd floors is 3 m which is used as a commercial area and the height of the 3rd to 37th floors is 3 m which is functioned as a residence.
- The main structure is planned to use the Special Moment Bearing Frame System with the construction of Shearwall, Columns and Beams using reinforced concrete structures, floor plates and roof plates using reinforced concrete slabs.

Figure 6. 3D Building Structure System

Figure 7. Layout Lt. 1 – 3

Figure 8. Layout Lt. 4

Figure 9. Layout Lt. 5 – 38

Figure. 10. Layout Lt. Roof

Table 1. Columns and ShearWall

Floor	TYPE COLOUMN (mm)								F'C (Mpa)
	C5	C8	C9	C10	C11	C11A	C11B	C12	
-1F	1200x700	1000x700	1200x600	1200x600	1200x600	1000x900	1100x800	1300x600	50
1F - 2F	1200x700	1000x700	1200x600	1200x600	1200x600	1000x900	1100x800	1300x600	50
3F - JC/4F	1200x600	1000x700	1200x600	1200x600	1200x600	1000x800	1100x800	1300x600	50
5F	1200x600	1000x700	1200x600	1200x600	1200x600	1000x700	1100x700	1300x600	50
6F - 7F	1200x600	1000x600	1100x600	1200x600	1100x600	1000x700	1100x700	1200x500	50
8F - 11F	1200x600	1000x600	1100x600	1200x600	1100x600	1000x700	1100x600	1200x500	45
12F - 13F	1200x500	1000x500	1000x600	1100x600	1000x600	1000x600	1100x600	1200x500	45
14F - 18F	1200x500	1000x500	1000x600	1100x600	1000x500	1000x600	1100x600	1200x500	40
19F	1200x500	1000x400	900x600	1100x600	1000x500	1000x500	1100x500	1200x500	40
20F - 23F	1200x500	1000x400	900x600	1100x600	1000x400	1000x500	1100x500	1200x500	35
24F - 29F	1100x500	1000x400	900x500	1000x600	1000x400	1000x400	1000x500	1100x500	35
30F - 38F	1100x500	1000x400	900x400	1000x600	900x400	1000x400	1000x400	1100x500	35

Floor	TYPE COLOUMN (mm)							F'C (Mpa)	
	C1	C1A	C1B	C2	C2A	C3	C4		C4A
-1F	1200x600	1300x600	1200x600	1200x600	1200x500	1300x600	1200x700	1200x600	50
1F - 2F	1200x600	1300x600	1200x600	1200x600	1100x500	1200x600	1200x700	1200x600	50
3F - JC/4F	1200x600	1200x600	1100x600	1100x600	1100x500	1200x600	1200x600	1200x600	50
5F	1100x600	1200x600	1100x600	1100x600	1100x500	1200x600	1200x600	1200x600	50
6F - 7F	1100x600	1200x600	1100x600	1100x600	1100x500	1200x500	1100x600	1100x600	45
8F - 11F	1000x600	1200x600	1100x600	1100x600	1100x500	1200x500	1100x600	1100x600	45
12F - 13F	1000x600	1100x600	1000x600	1000x600	1000x500	1100x500	1000x600	1000x600	40
14F - 18F	1000x600	1100x600	1000x600	1000x600	1000x500	1100x500	1000x600	1000x600	40
19F	1000x500	1100x500	1000x500	1000x500	1000x500	1100x500	1000x500	1000x500	35
20F - 23F	1000x400	1000x500	1000x500	1000x500	1000x500	1000x500	1000x500	1000x500	35
24F - 29F	1000x400	1000x500	1000x400	1000x400	1000x400	1000x400	1000x400	1000x400	35
30F - 38F	900x400	1000x400	900x400	900x400	900x400	1000x400	900x400	900x400	35

Floor	TYPE SHEARWALL (mm)				F'C (Mpa)
	SW1	SW2	SW3	SW4	
	P= 7500	P= 1600	P= 6400	P= 4250	
-1F - 11F	550	550	500	400	50
13F - 23F	450	450			45
24F - ROOF	350	350			40

Table 2. Beam

Lantai	Tipe Balok		Properti	F'C (Mpa)
Balok Lt. 1	B412	Beton	400 x 1200	40
Balok Lt. 1	B412A-2	Beton	400 x 1130	40
Balok Lt. 1	B311A	Beton	300 x 780	40
Balok Lt. 1	B73A	Beton	700 x 350	40
Balok Lt. 1	B66	Beton	600 x 600	40
Balok Lt. 1	B66A	Beton	600 x 650	40
Balok Lt. 1 - 4	B2A4	Beton	250 x 400	40
Balok Lt. 1 - 4	B2A5	Beton	250 x 500	40
Balok Lt. 1 - 4	B4A7A	Beton	450 x 750	40
Balok Lt. 1 - 4	B76A	Beton	700 x 650	40
Balok Lt. 1 - 4	B45	Beton	400 x 500	40
Balok Lt. 1 - 4	B47	Beton	400 x 700	40
Balok Lt. 1 - 4	B4A10	Beton	450 x 1000	40
Balok Lt. 5 - 24	B2A5A	Beton	250 x 550	35
Balok Lt. 5 - 24	B2A6A	Beton	250 x 650	35
Balok Lt. 5 - 24	B3A5A	Beton	350 x 550	35
Balok Lt. 5 - 24	B3A5A1	Beton	350 x 560	35
Balok Lt. 5 - 24	B2A7A3	Beton	250 x 780	35
Balok Lt. 5 - 24	B37A3	Beton	300 x 780	35
Balok Lt. 5 - 24	B57	Beton	500 x 700	35
Balok Lt. 5 - 24	B59	Beton	500 x 900	35
Balok Lt. 5 - 24	B410A3	Beton	400 x 1080	35
Balok Lt. 5 - 24	B612	Beton	600 x 1200	35
Balok Lt. 5 - 24	B69	Beton	600 x 900	35
Balok Lt. 5 - 24	B46	Beton	400 x 600	35
Balok Lt. 5 - 24	B103A	Beton	1000 x 350	35
Balok Lt. 5 - 24	B93A	Beton	900 x 350	35
Balok Lt. 25 - 38	B59	Beton	500 x 900	35
Balok Lt. 25 - 38	B46A	Beton	300 x 500	35
Balok Lt. 25 - 38	B55A	Beton	300 x 500	35
Balok Lt. 25 - 38	B56A	Beton	300 x 500	35
Balok Lt. 25 - 38	B47A	Beton	300 x 500	35
Balok Lt. 25 - 38	B45A	Beton	300 x 500	35
Balok Lt. 25 - 38	B35A	Beton	300 x 500	35
Balok Lt. 25 - 38	B83A	Beton	800 x 350	35
Balok Lt. 25 - 38	B45A	Beton	300 x 500	35
Balok Lt. 25 - 38	B35A	Beton	300 x 500	35
Balok Lt. 25 - 38	B2A6A	Beton	300 x 500	35
Balok Lt. 25 - 38	B34A1	Beton	300 x 500	35
Balok Lt. 5 - 38	B2A4	Beton	300 x 500	35
Balok Lt. 5 - 38	B23	Beton	300 x 500	35
Balok Lt. 5 - 38	B24	Beton	300 x 500	35
Balok Lt. 5 - 38	B24"	Beton	300 x 500	35
Balok Lt. 5 - 38	B25	Beton	300 x 500	35
Balok Lt. 5 - 38	B2A3A	Beton	300 x 500	35
Balok Lt. 5 - 38	B4A6	Beton	300 x 500	35

Table 3. Thickness of Concrete Slab

floor		Tebal (mm)
Graund flor	concrete	150
Floor 1	concrete	150
Floor 2	concrete	130
Floor 3-4	concrete	120
Floor 5-38	concrete	120
Ro of top	concrete	150

Table 4. Quality Material

Structure element	Cobcrete grade	Component character
Raft foundation	FC35	35
Coloumn and shearwall	FC /3540/45/50	35/40/45/50
Girder / beam	FC 35	35
slab	FC 35	35

Table 5. Structure element

Structure element	Cobcrete grade	Component character
Raft foundation	FC35	35
Coloumn and shearwall	FC /3540/45/50	35/40/45/50
Girder / beam	FC 35	35
slab	FC 35	35

3.2. Loading

1. Static Load

Static analysis in principle is to replace earthquake loads with seismic forces static equivalent which aims to simplify and simplify calculations. This method is also called the Equivalent Lateral Force Method, which assumes the magnitude of the earthquake force based on the product of a constant/mass of the element.

Table 6. Dead Load of Construction Materials and Building Components

No	Material konstruksi	(Kg/m ³)
1	Steel	7850
2	Conciete	2200
3	Reinforced ConCrete	2500
4	Wood (Everage Value of different types of wood)	1000
5	Red Bricks	1700
6	Pair Of split stones, cobblestones, mountain stones	2200
7	Sand (air dry to moist)	1600-1700
8	Sand (saturated with water)	1800
9	Soll,logam and still (dry – wet)	1700-2000
10	split	1450

Table 7. Self Weight of Building Components

NO	Komponen gedung	Beban mati (kg/m ²)
1	Stir (per cm think)	
	-From cement	21
	- Of lime, red cement or tras	17
2	Ceiling (including ribs, whithout hangers)	
	-Asbestos cement /plasterboard (max 4mm thick)	11
	Glass (3-5 mm Thick)	10
3	Red mas onry wall	
	-one stone	450
	-half a stone	250
4	Brick ma sonry wall	
	-perforated (20 cm thick)	200
	-perforated (10 cm thick)	120
	-no holes (15 cm thick)	300
	no holes (10 cm thick)	200
5	Wave asbestos cement (5mm think)11	11
6	Simple wooden floor , no ceiling	40
7	Wooden ceiling hanger (max 5 m span)	7
8	Cemment/concrete floor coverings (per cm thick)	24

Table 8. Live Load On Structure

Live loads on Floors of large building	Burden
Floor 250 kg m ²	250kg/m ²
Stairs and beban 300kg/m ²	300kg/m ²
Roof plate 100kg/m ²	100kg/m ²
Floor tool and marchine room 400kg/m ²	400kg/m ²

2. Dynamic Load

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Table 9. Definition of Soil Type (SNI 1726-2002)

Type of soil	Average shear wave velocity (vs)(m/s)	The average standard penetration test result value (N)	Average shear strength u (kPa)
Hard soil	$V_s \geq 350$	$N \geq 50$	$su \geq 100$
Medium ground	$175 \leq v_s < 350$	$15 \leq N < 50$	$50 \leq su < 100$
Soft soil	$V_s < 175$	< 15	
Soft soil	$V_s < 175$	< 15	
Or < all types of soft clay with a total thickness of more than 3 meter with $PI > 20$, $w_n > 40\%$ and $u < 25$ Kpa			
Special and	A special evaluation is required at each location

Figure 11 .Response Spectrum for the AlamSutera Areas

Table 10. Spectral Results Table for the AlamSutera Areas

Rock	Variable	Point	Hard	Variable	Point	Medium	Variable	Point	Soft	Variable	Point
	PGA (g)	0,373	Soil	PGA (g)	0,373	Ground	PGA (g)	0,373	Soil	PGA (g)	0,373
	S _S (g)	0,712		S _S (g)	0,712	/ Soil	S _S (g)	0,712		S _S (g)	0,712
	S ₁ (g)	0,311		S ₁ (g)	0,311		S ₁ (g)	0,311		S ₁ (g)	0,311
	C _{RS}	0,996		C _{RS}	0,996		C _{RS}	0,996		C _{RS}	0,996
	C _{R1}	0,936		C _{R1}	0,936		C _{R1}	0,936		C _{R1}	0,936
	F _{PGA}	1		F _{PGA}	1,027		F _{PGA}	1,127		F _{PGA}	0,98
	F _A	1		F _A	1,115		F _A	1,231		F _A	1,277
	F _V	1		F _V	1,489		F _V	1,778		F _V	2,756
	PSA (g)	0,373		PSA (g)	0,383		PSA (g)	0,421		PSA (g)	0,366
	S _{MS} (g)	0,712		S _{MS} (g)	0,794		S _{MS} (g)	0,876		S _{MS} (g)	0,909
	S _{M1} (g)	0,311		S _{M1} (g)	0,463		S _{M1} (g)	0,553		S _{M1} (g)	0,857
	S _{DS} (g)	0,474		S _{DS} (g)	0,529		S _{DS} (g)	0,584		S _{DS} (g)	0,606
	S _{D1} (g)	0,207		S _{D1} (g)	0,309		S _{D1} (g)	0,369		S _{D1} (g)	0,571
	T ₀ (detik)	0,087		T ₀ (detik)	0,117		T ₀ (detik)	0,126		T ₀ (detik)	0,189
	T _S (detik)	0,437		T _S (detik)	0,583		T _S (detik)	0,631		T _S (detik)	0,944

Table 11. Priority Factors For Various Categories Of Buildings

Building category	Priority favior		
	1	1	1
Public building such as for residential, commercial and office.	1	1,6	1,6
Monumentals and buildings monumentals	1,4	1	1,4
Important buildings after the earthquake such as hospitals, clean water installation, power plants ,emergency rescue centers, radio and television facility	1,6	1	1,6
Buildings for storing hazardous materials such as gas, petroleum product ,acids,toxic materials Chimney, tank on tower	1,4	1	1,5

Figure 12. Load Diagram (V) - Deviation (δ) of the Building Structure

Table 12. Peak acceleration of bedrock and peak ground acceleration for each Indonesian Earthquake Region

earthquake region	Peak acceleration of bedrock ('g')	Peak acceleration of bedrock ('g')			
		Hard soil	Medium Ground	Soft soil	Special land
1	0,03	0,04	0,05	0,08	A special evaluation is required at each location
2	0,1	0,12	0,15	0,2	
3	0,15	0,18	0,23	0,3	
4	0,2	0,24	0,28	0,34	
5	0,25	0,28	0,32	0,36	
6	0,3	0,33	0,36	0,38	

Table 13. Coefficient of Vibration Time of Earthquake Area Structure

Earthquake region	Limiting coefficient ('g')
1	0,2
2	0,19
3	0,18
4	0,17
5	0,16
6	0,15

Table 14. Estimated Amount of Ksv Price for Several Types of Land

Type of soil	Range price ksw (kN/m ³)
sand	
Loose sand	4500-15000
Medium sand	9000-75000
Dense sand	60000-120000
Clayey sand	30000-75000
Silty sand	22500-45000
Clay	
Qu<4kPa	11250-22500
4kPa<qu<8kPa	22500-45000
8kPa<qu	>45000

Table 15. Maximum Permit Deflection

Structural Component Type	Calculated Deflection	Limit Deflection
Flat roofs that do not support or are not attached to non-structural components that may be damaged by large deflections	Instantaneous deflection due to live load (LL)	$\frac{l^a}{180}$
Floors that do not support or are not attached to non-structural components that are likely to be damaged by large deflections	Instantaneous deflection due to live load (LL)	$\frac{l}{360}$
Roof or floor construction that supports or is attached to non-structural components that are likely to be damaged by large deflections	Part of the total deflection that occurs after the installation of non-structural components (sum of the long-term deflection, due to all fixed loads acting, and the instantaneous deflection, due to the addition of live loads)	$\frac{l^b}{480}$
Roof or floor construction that supports or is attached to non-structural components that are unlikely to be damaged by large deflections.		$\frac{l^d}{240}$
^a These limits are not intended to prevent possible waterlogging. The possibility of inundation should be checked by calculating the deflection, including the additional deflection due to the inundation, and taking into account the long-term effects of the always-acting load, deflection resistance, construction tolerances and the reliability of the drainage system.		
^b The deflection limit may be exceeded when steps have been taken to prevent damage to the supported or joined components.		
^c Long-term deflection shall be calculated according to the provisions of 11.5(2(5)) or 11.5(4(2)), but may be reduced by the value of the deflection occurring before the addition of non-structural components. The value of this deflection must be determined on the basis of acceptable technical data regarding the characteristics of the relationship between time and deflection of the structural member which is similar to that of the member under review.		
^d But it must not be greater than the tolerance provided for non-structural components. This limit may be exceeded if there is a counter deflection provided such that the total deflection minus the counter deflection does not exceed the existing deflection limit.		

3. Combination of Loading

the load combination becomes as described below:

- 1,4 DL
- 1,2 DL + 1,6 LL
- 1,2 DL + 1 LL $\pm 0,3 (\rho Q_e + 0,2 S DS DL) \pm 1 (\rho Q_e + 0,2 S DS DL)$
- 1,2 DL + 1 LL $\pm 1 (\rho Q_e + 0,2 S DS DL) \pm 0,3 (\rho Q_e + 0,2 S DS DL)$
- 0,9 DL $\pm 0,3 (\rho Q_e + 0,2 S DS DL) \pm 1 (\rho Q_e + 0,2 S DS DL)$
- 0,9 DL $\pm 1 (\rho Q_e + 0,2 S DS DL) \pm 0,3 (\rho Q_e + 0,2 S DS DL)$

For redundancy equal to 1.3 ($\rho = 1,3$) and $S DS = 0.457$, the translation results are as in Table 4.6.3.1 below

:

Table 16. Combination table based on results of SAP2000 v21

Combo Name	Combo Type	Case Name	Scale Factor				
1.4SDL + 1.4 DL	Linear Add	DEAD	1.4	1.34SDL+1.34DL+0.5L L+0.3EQX-1EQY		DX	0.3
1.4SDL + 1.4 DL		SUPERDEAD	1.4	1.34SDL+1.34DL+0.5L L+0.3EQX-1EQY		DY	-1.
1.34 SDL + 1.34 DL + 1.6 LL	Linear Add	DEAD	1.34	1.34SDL+1.34DL+0.5L L+1.0EQX+0.3EQY	Linear Add	DEAD	1.34
1.34 SDL + 1.34 DL + 1.6 LL		SUPERDEAD	1.34	1.34SDL+1.34DL+0.5L L+1.0EQX+0.3EQY		SUPERDEAD	1.34
1.34 SDL + 1.34 DL + 1.6 LL		Live	1.6	1.34SDL+1.34DL+0.5L L+1.0EQX+0.3EQY		Live	0.5
1.34SDL+1.34DL+0.5L L+0.3EQX+1EQY	Linear Add	DEAD	1.34	1.34SDL+1.34DL+0.5L L+1.0EQX+0.3EQY		DX	1.
1.34SDL+1.34DL+0.5L L+0.3EQX+1EQY		SUPERDEAD	1.34	1.34SDL+1.34DL+0.5L L+1.0EQX+0.3EQY		DY	0.3
1.34SDL+1.34DL+0.5L L+0.3EQX+1EQY		Live	0.5	1.34SDL+1.34DL+0.5L L-1.0EQX-0.3EQY	Linear Add	DEAD	1.34
1.34SDL+1.34DL+0.5L L+0.3EQX+1EQY		DX	0.3	1.34SDL+1.34DL+0.5L L-1.0EQX-0.3EQY		SUPERDEAD	1.34
1.34SDL+1.34DL+0.5L L+0.3EQX+1EQY		DY	1.	1.34SDL+1.34DL+0.5L L-1.0EQX-0.3EQY		Live	0.5
1.34SDL+1.34DL+0.5L L+0.3EQX+1EQY	Linear Add	DEAD	1.34	1.34SDL+1.34DL+0.5L L-1.0EQX-0.3EQY		DX	-1.
1.34SDL+1.34DL+0.5L L+0.3EQX+1EQY		SUPERDEAD	1.34	1.34SDL+1.34DL+0.5L L-1.0EQX-0.3EQY		DY	-0.3
1.34SDL+1.34DL+0.5L L+0.3EQX+1EQY		Live	0.5	1.34SDL+1.34DL+0.5L L+1.0EQX-0.3EQY	Linear Add	DEAD	1.34
1.34SDL+1.34DL+0.5L L+0.3EQX+1EQY		DX	-0.3	1.34SDL+1.34DL+0.5L L+1.0EQX-0.3EQY		SUPERDEAD	1.34
1.34SDL+1.34DL+0.5L L+0.3EQX+1EQY		DY	-1.	1.34SDL+1.34DL+0.5L L+1.0EQX-0.3EQY		Live	0.5
1.34SDL+1.34DL+0.5L L+0.3EQX+1EQY	Linear Add	DEAD	1.34	1.34SDL+1.34DL+0.5L L+1.0EQX+0.3EQY		DX	1.
1.34SDL+1.34DL+0.5L L+0.3EQX+1EQY		SUPERDEAD	1.34	1.34SDL+1.34DL+0.5L L+1.0EQX+0.3EQY		DY	-0.3
1.34SDL+1.34DL+0.5L L+0.3EQX+1EQY		Live	0.5	1.34SDL+1.34DL+0.5L L+1.0EQX+0.3EQY	Linear Add	DEAD	1.34
1.34SDL+1.34DL+0.5L L+0.3EQX+1EQY		DX	-1.	1.34SDL+1.34DL+0.5L L+1.0EQX+0.3EQY		SUPERDEAD	1.34
1.34SDL+1.34DL+0.5L L+0.3EQX+1EQY		DY	0.3	1.34SDL+1.34DL+0.5L L+1.0EQX+0.3EQY		Live	0.5

0.76SDL+0.76DL+0.3EQX+1.0EQY	Linear Add	DEAD	0.76	0.76SDL+0.76DL+1.0EQX+0.3EQY		QUAKE X	1.
0.76SDL+0.76DL+0.3EQX+1.0EQY		SUPERDEAD	0.76	0.76SDL+0.76DL+1.0EQX+0.3EQY		DY	0.3
0.76SDL+0.76DL+0.3EQX+1.0EQY		DX	0.3	0.76SDL+0.76DL-1.0EQX-0.3EQY	Linear Add	DEAD	0.76
0.76SDL+0.76DL+0.3EQX+1.0EQY		DY	1.	0.76SDL+0.76DL-1.0EQX-0.3EQY		SUPERDEAD	0.76
0.76SDL+0.76DL-0.3EQX-1.0EQY	Linear Add	DEAD	0.76	0.76SDL+0.76DL-1.0EQX-0.3EQY		DX	-1.
0.76SDL+0.76DL-0.3EQX-1.0EQY		SUPERDEAD	0.76	0.76SDL+0.76DL-1.0EQX-0.3EQY		DY	-0.3
0.76SDL+0.76DL-0.3EQX-1.0EQY		DX	-0.3	0.76SDL+0.76DL+1.0EQX-0.3EQY	Linear Add	DEAD	0.76
0.76SDL+0.76DL-0.3EQX-1.0EQY		DY	-0.3	0.76SDL+0.76DL+1.0EQX-0.3EQY		SUPERDEAD	0.76
0.76SDL+0.76DL+0.3EQX-1.0EQY	Linear Add	DEAD	0.76	0.76SDL+0.76DL+1.0EQX-0.3EQY		DX	1.
0.76SDL+0.76DL+0.3EQX-1.0EQY		SUPERDEAD	0.76	0.76SDL+0.76DL+1.0EQX-0.3EQY		DY	-0.3
0.76SDL+0.76DL+0.3EQX-1.0EQY		DX	0.3	0.76SDL+0.76DL-1.0EQX+0.3EQY	Linear Add	DEAD	0.76
0.76SDL+0.76DL+0.3EQX-1.0EQY		DY	-1.	0.76SDL+0.76DL-1.0EQX+0.3EQY		SUPERDEAD	0.76
0.76SDL+0.76DL-0.3EQX+1.0EQY	Linear Add	DEAD	0.76	0.76SDL+0.76DL-1.0EQX+0.3EQY		DX	-1.
0.76SDL+0.76DL-0.3EQX+1.0EQY		SUPERDEAD	0.76	0.76SDL+0.76DL-1.0EQX+0.3EQY		DY	0.3
0.76SDL+0.76DL-0.3EQX+1.0EQY		DX	-0.3	1.34SDL+1.34DL+0.5L-0.3EQX+1EQY	Linear Add	DEAD	1.34
0.76SDL+0.76DL-0.3EQX+1.0EQY		DY	-1.	1.34SDL+1.34DL+0.5L-0.3EQX+1EQY		SUPERDEAD	1.34
0.76SDL+0.76DL+1.0EQX+0.3EQY	Linear Add	DEAD	0.76	1.34SDL+1.34DL+0.5L-0.3EQX+1EQY		Live	0.5
0.76SDL+0.76DL+1.0EQX+0.3EQY		SUPERDEAD	0.76	1.34SDL+1.34DL+0.5L-0.3EQX+1EQY		DX	-0.3
				1.34SDL+1.34DL+0.5L-0.3EQX+1EQY		DY	1.

3.3. Results of Analysis Static

The results from the SAP2000 v21Avizan & Koespiadi, (2020) program, the floor shear force due to dynamic earthquake loads is generated by inputting the seismic response spectrum used based on the earthquake zone used. The following is a graph of the SAP2000 v21 input spectrum response.

Figure 13. Density Change of Concrete Samples (kg/m³)

Table 17. Response Spectrum SkyHouse Alam Sutera

case	Load type	Load name	Coord sys	funtion	Angle degrees	Tran AccSF mm/sec2
DX	Acceleration	U1	GLOBAL	Alam Sutera	0.	1226.25
DY	Acceleration	U2	GLOBAL	Alam Sutera	0.	1226.3
QUAKE X	Acceleration	U1	GLOBAL	Alam Sutera	0.	1226.25
QUAKE Y	Acceleration	U2	GLOBAL	Alam Sutera	0.	1226.3

Table 18.. Dynamic Earthquake Response Based on SAP2000 V21 . Results

OutputCase	StepType	GlobalFX	GlobalFY	GlobalFZ	GlobalMX	GlobalMY	GlobalMZ
Text	Text	KN	KN	KN	KN-m	KN-m	KN-m
MODAL	Mode	0,04	-0,04	0,00	1,30	-4,77	-1,06
MODAL	Mode	-0,02	-0,04	0,00	6,11	2,18	-1,06
MODAL	Mode	0,00	0,08	0,00	-2,95	-0,40	-0,57
MODAL	Mode	0,00	0,00	-0,01	-0,11	0,30	0,20
MODAL	Mode	0,19	-0,06	-0,01	-1,21	-4,70	-4,50
MODAL	Mode	0,00	0,00	-0,02	-0,33	0,01	-0,03
MODAL	Mode	-0,06	-0,21	0,02	1,15	0,52	-5,32
MODAL	Mode	-0,01	0,00	0,02	0,38	-0,05	0,13
MODAL	Mode	-0,01	0,01	-0,05	-0,98	1,86	0,43
MODAL	Mode	0,00	-0,01	-0,02	-0,07	0,82	-0,36
MODAL	Mode	0,03	-0,39	0,02	6,65	0,54	3,33
MODAL	Mode	0,00	-0,01	0,03	0,51	-0,01	-0,06
SUPERDEAD		9618,34	-153662,91	3850049,57	72629247,20	-101615971,00	-2566202,52
DX	Max	9207,20	6323,26	248,40	297282,26	888095,30	206368,46
DY	Max	3175,18	8380,25	451,65	831265,92	332334,09	201556,47
QUAKE X	Max	9206,82	6323,00	248,39	297270,14	888059,09	206360,05
QUAKE Y	Max	3175,18	8380,25	451,65	831265,92	332334,09	201556,47

Table 19. Earthquake Period Based on SAP2000 V21 Results

Output Case	Step Type	Step Num	Period	Frequency	CircFreq	Eigenvalue
Text	Text	Unitless	Sec	Cyc/sec	rad/sec	rad2/sec2
MODAL	Mode	1	19,49909	0,051284	0,32223	0,10383199
MODAL	Mode	2	16,87373	0,059264	0,372365	0,13865567
MODAL	Mode	3	13,41779	0,074528	0,468273	0,21927939
MODAL	Mode	4	6,943229	0,144025	0,904937	0,81891103
MODAL	Mode	5	5,919126	0,168944	1,061506	1,12679422
MODAL	Mode	6	4,939493	0,20245	1,272031	1,61806163
MODAL	Mode	7	4,858961	0,205805	1,293113	1,67214096
MODAL	Mode	8	4,416993	0,226398	1,422503	2,02351411
MODAL	Mode	9	4,200074	0,238091	1,49597	2,23792645
MODAL	Mode	10	3,97254	0,251728	1,581654	2,50163061
MODAL	Mode	11	3,578329	0,27946	1,755899	3,08318161
MODAL	Mode	12	3,418921	0,29249	1,837769	3,37739306
Modus Min :			19,49909	0,29249	1,837769	3,37739306
Modus Max :			3,418921	0,051284	0,32223	0,10383199

Table 20. Modal Participation Factors

OutputCase	StepType	StepNum	Period	UX	UY	UZ	SumUX	SumUY	SumUZ	RX	RY	RZ	SumRX	SumRY	SumRZ
Text	Text	Unitless	Sec	Unitless	Unitless	Unitless	Unitless	Unitless	Unitless	Unitless	Unitless	Unitless	Unitless	Unitless	Unitless
MODAL	Mode	1	19,499087	0,59446	0,06909	0,00001845	0,59446	0,06909	0,00001845	0,03465	0,29144	0,00317	0,03465	0,29144	0,00317
MODAL	Mode	2	16,873728	0,06741	0,5613	0,00005235	0,66187	0,63039	0,00007079	0,26316	0,03449	0,07326	0,29781	0,32592	0,07643
MODAL	Mode	3	13,417789	0,00089	0,05051	0,00003582	0,66276	0,68089	0,00011	0,05028	0,00033	0,58756	0,34809	0,32625	0,66399
MODAL	Mode	4	6,943229	5,274E-11	4,673E-07	0,00018	0,66276	0,6809	0,00028	7,746E-07	0,00001928	7,375E-08	0,3481	0,32627	0,66399
MODAL	Mode	5	5,919126	0,14896	0,00614	0,00008868	0,81173	0,68704	0,00037	0,02116	0,18873	0,00131	0,36926	0,515	0,6653
MODAL	Mode	6	4,939493	7,295E-09	6,105E-08	0,00022	0,81173	0,68704	0,0006	0,000001082	0,00011	5,784E-08	0,36926	0,51511	0,6653
MODAL	Mode	7	4,858961	0,01079	0,10876	0,00029	0,82252	0,7958	0,00089	0,24769	0,01888	0,00776	0,61695	0,53399	0,67306
MODAL	Mode	8	4,416993	6,238E-08	0,000001161	0,00016	0,82252	0,7958	0,00105	0,00001169	0,00007062	5,177E-08	0,61696	0,53406	0,67306
MODAL	Mode	9	4,200074	1,908E-08	3,781E-08	0,00083	0,82252	0,7958	0,00187	0,00002259	0,00012	5,184E-09	0,61699	0,53418	0,67306
MODAL	Mode	10	3,97254	1,147E-07	6,959E-07	0,00013	0,82252	0,7958	0,002	0,00003362	0,00002323	0,00000137	0,61702	0,5342	0,67306
MODAL	Mode	11	3,578329	0,00039	0,01444	0,00011	0,82291	0,81024	0,00212	0,00872	0,00198	0,14158	0,62573	0,53619	0,81464
MODAL	Mode	12	3,418921	4,811E-08	5,469E-07	0,00019	0,82291	0,81024	0,00231	0,000001773	0,0001	0,0000107	0,62574	0,53629	0,81465
Modus Min :			19,499087	0,59446	0,5613	0,00083	0,82291	0,81024	0,00231	0,26316	0,29144	0,58756	0,62574	0,53629	0,81465
Modus Max :			3,418921	5,274E-11	3,781E-08	0,00001845	0,59446	0,06909	0,00001845	7,746E-07	0,00001928	5,184E-09	0,03465	0,29144	0,00317

4. Conclusion

After analyzing using the response spectrum method, the authors can draw the following conclusions based on the results of the SAP2000 v21 program.

1. comparison of the upper structure between planning data and modification data (For Construction) The results of the maximum displacement in the X direction are 0.02373 m and the Y direction is 0.181128 m so that it still meets the maximum limit $[(0.015hsx)/\rho] = 1.662$ m
2. Because the displacement and base shear results in the equivalent lateral force analysis are greater than in the variance response spectrum analysis, the results of the equivalent lateral force analysis are safer if used for the application of earthquake force loading in structural calculations.
3. The result of the comparison between the calculation of the nominal static shear force and the nominal dynamic shear analysis is greater.

References

- Avizan, A. B., & Koespiadi, K. (2020). Comparison of Building Structure Planning with SNI 2847-2013 Method and SAP2000 V.19 Software Code ACI 318-14. *IJTI (International Journal of Transportation and Infrastructure)*, 3(1), 1–10. <https://doi.org/10.29138/ijti.v3i1.1050>
- B. & Wungo, W. C. (2012). *Analisis beban gempa statik ekuivalen*. SNI 03-2847-2002. (n.d.). "Pedoman Perhitungan Struktur Beton untuk Bangunan Gedung."

Biography

Agus Fernando

I am Agus Fernando, born in Jakarta, August 10, 1992. I started studying at Mercubuana University in 2016/2017 Now I work at the North Jakarta Administration of Water Resources Sub-dept. as PPJU. My work experience was mostly in engineering before I worked at the Water Resources Sub-Department, I worked as an Engineer for several projects including Structural Engineering at PT. Hyundai Aluminum Internasional, Head Engineer at PT. AluMakro Korea, Structural Draftsman at PT. Wijaya Karya and many more of my work experiences.

Syafwandi

He was born in Jakarta, October 13, 1956. As Professor at UMB, Bachelors Degree at University Indonesia (1984), Masters degree at Instute Teknologi Bandung and University college London, 1988 and finish S3 as doctor at University Satyagama (2005).

Agung Sumarno

He was born Samarinda, July 5, 1990. Teaching at the Civil Engineering undergraduate program, Univ. Mercubuana Bachelors Degree at Univ. Mulawarman Samarinda, Engineering faculty majoring in civil engineering, Masters degree at Bandung Institute of Technology, Faculty of Civil and Environmental Engineering majoring in Civil Engineering Structural Engineering. And He also as a Researcher at the LIPI, biomaterials research center.

Resi Aseanto

He was born Cilacap, June 23, 1980. Teaching at the Civil Engineering undergraduate program, Univ. Mercubuana Bachelors Degree at Diponegoro University, Faculty of Civil Engineering, majoring in Civil Engineering, Masters degree at University of Indonesia majoring in Engineering, Master in Management IPMI International Business School, Gajahmada University Engineering Profession Program. And He also as Served as Director of Operations & Commercial and concurrently as Acting. President Director at PGNMAS. He also had many work experience including Kalija Project as Procurement and Contract Manager (2014), CP 16 Project as Procurement and Contract Manager (2015), Commercial General Manager of PT PGAS Solution (2016), Head of Business Development and Risk Management Division and Performance Control PT PGAS Solution (2017)