

Comparative Analysis Study Of ATC-40 and SNI 1726-2012 Guidelines for Beam Structure Performance and Column Trans Studio Apartments Applications Using Dynamic Response Spectrum Analysis Methods

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Abstract

The earthquake that often hit Indonesia caused thousands of lives and caused damage to buildings. These earthquakes often occur because Indonesia is in two regions, namely the Pacific earthquake path (Circum Pacific Earthquake Belt) and the Asian earthquake lane (Trans Asiatic Earthquake Belt). Earthquake disasters cause damage to building structures. When an earthquake occurs, it is expected that the building can accept earthquake force at a certain level without significant damage to its structure. In general, earthquake analysis is divided into two major parts, namely static earthquake analysis and dynamic earthquake analysis. In buildings that are very high, irregular, multilevel and buildings that require enormous accuracy are used dynamic analysis planning, which consists of a variety of spectral response analysis and dynamic time response dynamic analysis. This study aims to determine the building's security in terms of displacement, drift and base shear. The method used is a dynamic analysis of the response spectrum using the ETABS program. The maximum total drift in the X direction is 0.0200475 m and in the Y direction is 0.020405 m, so the building is safe against ultimate boundary performance (0.02h) and service boundary performance $\{(0.03 / R) \times h\}$. So that the displacement in the building does not exceed the maximum displacement, the building is safe from earthquake plans.

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Keywords: Response Spectrum, ATC-40, SNI 1726-2012.

1. Introduction

Natural disasters are natural events that can occur at anytime and anywhere and in unexpected periods. Natural disasters also cause negative impacts such as material and non-material losses for people's lives.

Earthquake planning on the Trans Studio Cibubur Apartment building uses SNI 1726-2012 regulations. Evaluation of

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the structure is needed to determine the security of the building structure. This regulation is used to determine the design parameters for earthquake risk, earthquake risk.

In this analysis research method uses the earthquake response spectrum plan as a basis for determining the response. In the spectrum response analysis is only used to determine the shear force of the nominal dynamic level due to the effect of the earthquake plan. Internal forces in building structure elements are obtained from 3-dimensional analysis based on equivalent static earthquake loads. Manuscripts should be written in English. Invited contributions may exceptionally be in Portuguese. This template for preparation of manuscripts for Cienc. Tecnol. Mater. should be followed.

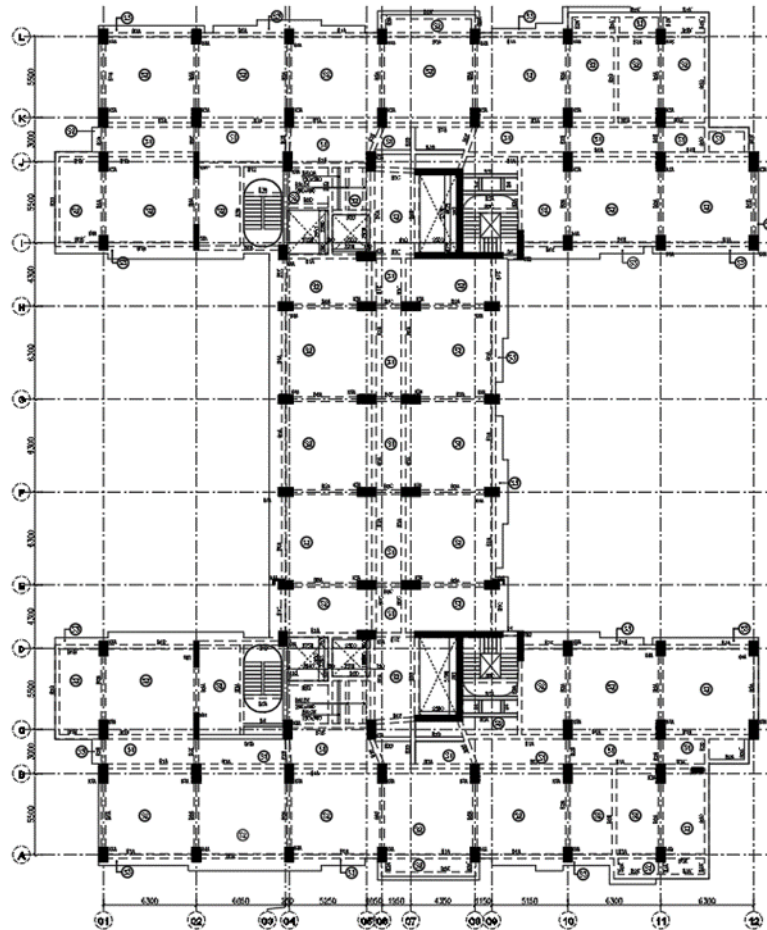


Fig. 1. Denah Struktur Tower C Proyek Transtudio Cibubur

2. Methodology

2.1 Stages of Analysis

Make a spectrum response curve based on various lateral force distribution patterns, especially those equivalent to the distribution of the inertia force, so that it is expected that the deformation that occurs is almost the same or close to the deformation that occurs due to an earthquake. Because the nature of the earthquake is uncertain, several lateral loading patterns need to be made to get the most decisive conditions.

The estimated magnitude of lateral displacement during planned earthquake (displacement target). The control point is pushed up to the level of displacement, which reflects the maximum displacement caused by the intensity of the specified earthquake plan.

Evaluating the level of structure performance when the control point is precisely at the target displacement: is the main thing of performance-based planning. The structural components and their behavioral actions can be considered satisfactory if they meet the criteria that were set from the start, both for deformation and strength requirements. Because the components evaluated are relatively large in number, therefore this process must be done entirely by the computer.

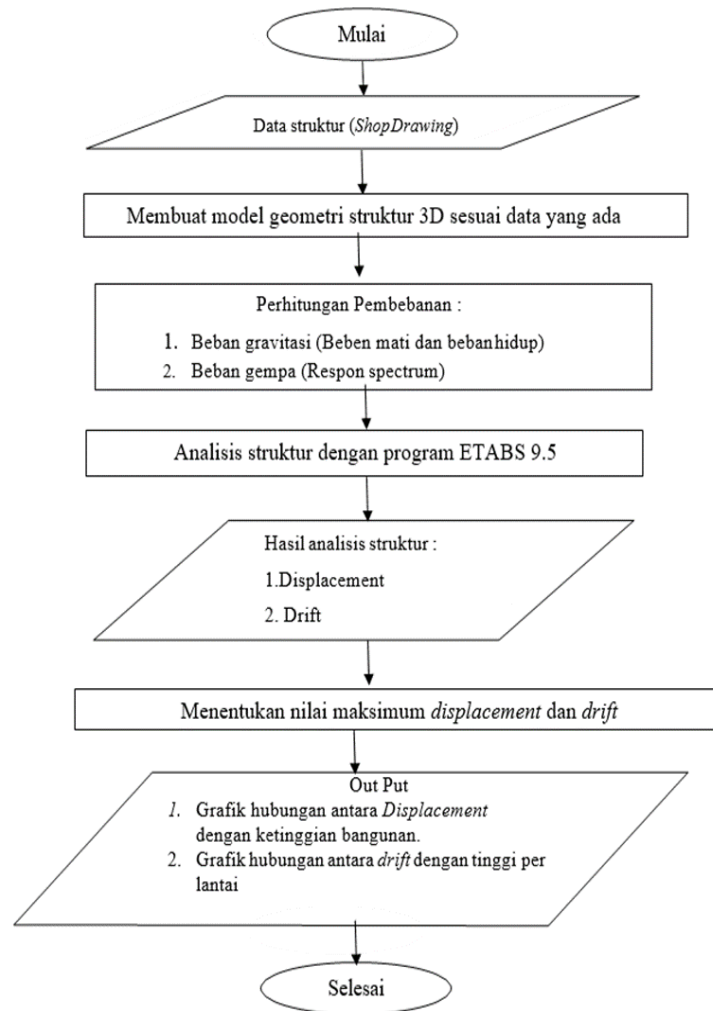


Fig 2. Research Flow Diagram (in Indonesia)

2.2 Structure Geometry

- a. Building Name : Apartemen Tower C Trans Studio Cibubur
- b. Location : Jl. Alternatif Cibubur No.230 A, Harjamukti, Kec. Cimanggis, Kota Depok, Jawa Barat 16454
- c. Building Function: Apartment
- d. Site Type: Soft Soil
- e. Number of Floors: 30 Stories

- f. Floor to floor height
 - Lantai 1 ~ Lantai 2 : 3,5 m
 - Lantai 2 ~ Lantai 29 : 3.2 m
 - Lantai 29 ~ Lantai 30 Atap : 3.2 m
- g. Total Height: 96 m
- h. Seismic Restraint System: Special moment reinforced concrete frame bearers

2.3 Earthquake Loads

Based on SNI 1726-2012, the earthquake loading for this building located in Harjamukti, Depok has the following data.

2.4 Risk Categories and Priority Factors

The function of the building as a Residential Apartment. Based on table 1 and table 2 of SNI 1726-2012, the risk category value = II and the priority factor (Ie) are obtained as 1.0

2.5 Site Class

Due to limited data, this report uses the type of soil used as stated in the as-built drawing, namely soft soil. In table 3 SNI 1726-2012 soft soil is categorized as SE.

2.6 Earthquake Parameter Value

The earthquake parameter values are taken from the Indonesian spectra Design online application which can be accessed through <http://puskim.go.id/Aplikasi/desainpektraindonesia2011> on January 3, 2020, by inputting the name of the city or the coordinates of the location of the building site type of soft rock.

Table 1. Spectral Value of Earthquake Acceleration on the Surface of Harjamukti Area, Depok

Variable	Nilai
PGA (g)	0.382
SS (g)	0.752
S1 (g)	0.317
CRS	1.012
CR1	0.938
FPGA	1
FA	1
FV	1
PSA (g)	0.382
SMS (g)	0.752
SM1 (g)	0.317
SDS (g)	0.501
SD1 (g)	0.211
T0 (second)	0.084
TS (second)	0.422

Source: Indonesian Spectra Design Application

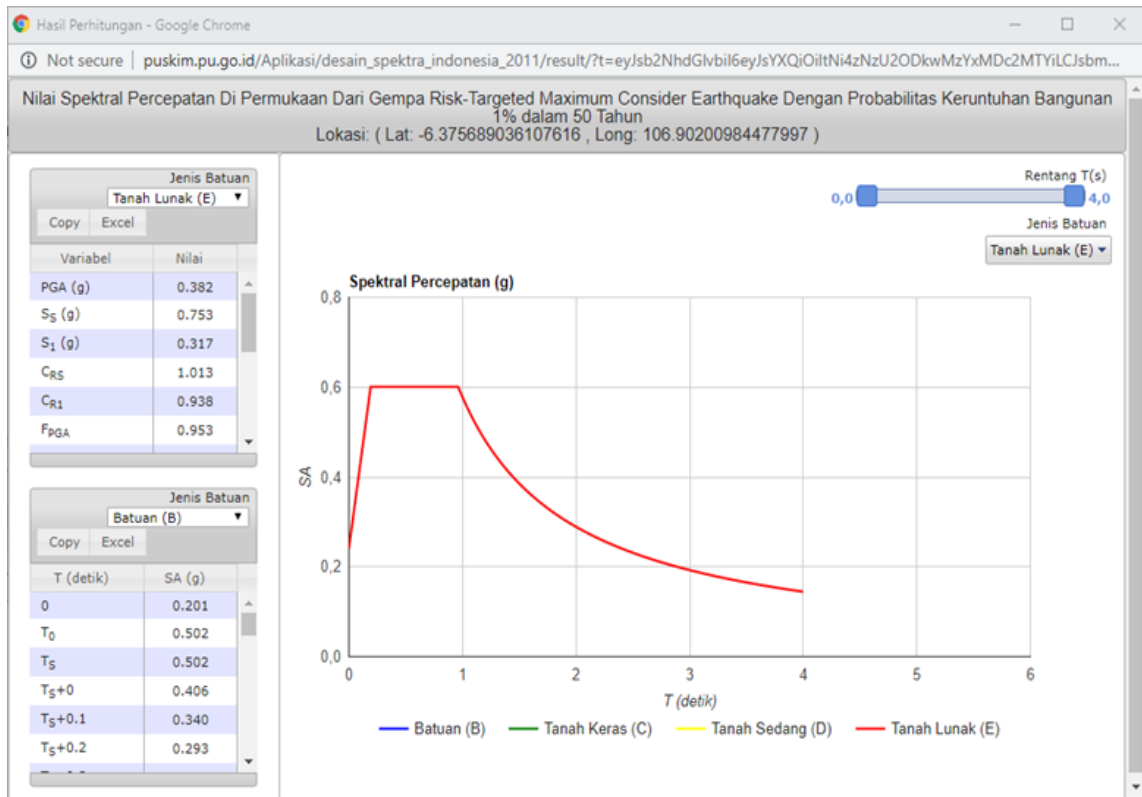


Fig 3. Spectral Acceleration for Harjamukti Area, Depok

Table 2. The Spectral Period Value of Earthquake Acceleration on Harjamukti Surface, Depok

T (detik)	SA (g)
0	0.24
T ₀	0.6
T _S	0.6
T _S +0	0.544
T _S +0.1	0.497
T _S +0.2	0.458
T _S +0.3	0.424
T _S +0.4	0.395
T _S +0.5	0.37
T _S +0.6	0.347
T _S +0.7	0.328
T _S +0.8	0.31
T _S +0.9	0.294
T _S +1	0.28
T _S +1.1	0.267
T _S +1.2	0.255

T (detik)	SA (g)
TS+1.3	0.244
TS+1.4	0.235
TS+1.5	0.225
TS+1.6	0.217
TS+1.7	0.209
TS+1.8	0.202
TS+1.9	0.195
TS+2	0.189
TS+2.1	0.183
TS+2.2	0.177
TS+2.3	0.172
TS+2.4	0.167
TS+2.5	0.162
TS+2.6	0.158
TS+2.7	0.153
TS+2.8	0.15
TS+2.9	0.146
4	0.144

Source : Indonesian Spectra Design Application

2.7 Seismic Design Category

The building seismic design category is taken from the value of the acceleration response parameter in the short period (SDS) and the acceleration response parameter in the 1 second period (SD1). Based on table 4.3, the SDS value = 0.501g and SD1 = 0.211g are obtained. Then the seismic design category is determined based on the table 3.

Table 3. Building Seismic Design Risk Categories

Value		Risk Category	
		I atau II atau III	IV
SDS = 501g	SDS >/ 0.500	D	D
SD1 = 0.211g.	SD1 >/ 0.200g	D	D

Source : SNI 1726-2012

2.8 Structure System

The existing structural system in principle uses a frame system to hold gravity loads, while lateral loads caused by earthquakes are shouldered using a bending mechanism. The moment bearing frame system is divided into three namely SPRMB (Ordinary Moment Resisting Frame System) SPRMM (Order System Medium Moment Bearer, SPRMK (Special Moment Bearer Frame System). The structure reviewed in this study has a D type seismic design category then based on table 4.6 the coefficient of response modification obtained (R), the strength of the system over (Ω_0), the deflection magnification factor (Cd). The structural parameter data for the earthquake barrier system is as table 4.

Table 4. R, Ω_0 , and Cd Factor

Earthquake Retaining System	Modified response coefficient	More Strong Factors	Enlargement Factors Deflection	System Structure Limits and Structure Height Limits				
				Seismic Design Category				
				R	Ω_0	Cd	B	C
Moment bearing frame system								
1. Frame reinforced concrete moment bearer	5	3	4 ½	TB	TI	TI	TI	TI
2. Frame Reinforced concrete that bear ordinary moments	3	3	2 ½	TB	TI	TI	TI	TI
3. A special moment-bearing reinforced concrete frame	8	3	5 ½	TB	TB	TB	TB	TB

The structural system used in this building is a medium moment reinforced concrete frame system. Based on the discussion in table 4, the parameter values of R, Ω_0 , Cd are respectively 8, 3, 5 ½.

2.9 Make a Combination Load

In the ultimate design, the load combination given to the building structure must refer to SNI 1727: 2013 so that the load combination given to the building is a combination of 1 to a combination of 18. To facilitate the calculation of reinforcement, 1 (one) Gravity load is added with a value of 1.2 DL + 1 LL. 18 (eighteen) combinations and 1 gravity load combination as follows:

1. Comb 1 : 1.4 DL
2. Comb 2 : 1.2 DL+ 1.6 LL
3. Comb 3 : 1.2 DL + 1.0 EQx + 0.3 EQy + 0.5 LL
4. Comb 4 : 1.2 DL+ 1.0 EQx – 0.3 EQy +0 .5 LL
5. Comb 5 : 1.2 DL – 1.0 EQx +0.3 EQy + 0.5 LL
6. Comb 6 : 1.2 DL – 1.0 EQx - 0.3 EQy + 0.5 LL
7. Comb 7 : 1.2 DL + 1.0 EQy + 0.3 EQx + 0.5 LL
8. Comb 8 : 1.2 DL + 1.0 EQy – 0.3 EQx + 0.5 LL
9. Comb 9 : 1.2 DL – 1.0 EQy + 0.3 EQx + 0.5 LL
10. Comb 10 : 1.2 DL – 1.0 EQy – 0.3 EQx + 0.5 LL
11. Comb 11 : 0.9 DL + 1.0 EQx + 0.3 EQy
12. Comb 12 : 0.9 DL + 1.0 EQx – 0.3 EQy
13. Comb 13 : 0.9 DL – 1.0 EQx + 0.3 EQy
14. Comb 14 : 0.9 DL – 1.0 EQx – 0.3 EQy
15. Comb 15 : 0.9 DL + 1.0 EQy + 0.3 EQx
16. Comb 16 : 0.9 DL + 1.0 EQy – 0.3 EQx
17. Comb 17 : 0.9 DL – 1.0 EQy + 0.3 EQx
18. Comb 18 : 0.9 DL – 1.0 EQy – 0.3 EQx
19. Graff : 1.2 DL + 1.0 LL

2.10 Fundamental Natural Vibration Time (T)

Following SNI 1726-2012 earthquake regulations article 7.8.2 for determining the period of natural vibration structure (T) using the following coefficients:

a. Period Upper Limit Coefficient

Table 5. The coefficient for the upper limit for the period calculated

The parameters of the design spectral response acceleration at 1 second, S_{D1}	C_u
0.2	1,5

Source: SNI 1726-2012 Pasal 2.2.11c

Period upper limit coefficient C_u with S_{DI} 0,211 g is **1.5**

b. Parameter Value for Approach Period C_t dan x

Table 6. Parameter Value for Approach Period C_t and x

Structure Type	C_t	x
Momentary concrete frame	0,0466	0,9

Source: SNI 1726 : 2012 Pasal 2.2.11c

Approximate parameter C_t adalah **0.0466^a**

Approximate parameter x adalah **0.9**

a. The period of fundamental approach (T_a) in second can be determined by the following equation:

$$T_a = C_t h_n^x$$

$$T_{maks} = C_u \cdot T_a \text{ atau } T_a < T_{maks} = C_t \times h_n^x \times C_u$$

where:

C_t and x = coefficient based on the type of structure used

C_u = the coefficient for the upper bound for the calculated period

h_n = the height of the structure in meters, above the base of the highest level of the structure.

b. Fundamental period value limits obtained as follows :

$$T_a (T_{min}) = 0.0466 \times 96.1^{0.9} = \mathbf{2.834197 \text{ detik}}$$

$$T_{maks} = 1.5 \times 2.834197 = \mathbf{4.2512955 \text{ detik}}$$

Controls the fundamental vibration time limitation viz:

If T_x and $T_y < T_{maks}$, then the vibration time limitation control is fulfilled.

If T_x and $T_y > T_{maks}$, then the vibration time limitation control is Not fulfilled.

c. The natural period values from the ETABS program results are as follows :

Table 7. Natural Period Results of the Etabs Program

	T_x	T_y	Note
Design	3.933 second	3.933 second	Fulfilled

1. Results and Analysis

Based on SNI 1726: 2012 earthquake 7.8.6 in the determination of intersections between floors the design level (Δ) must be calculated as the difference in deflection at the center of mass at the top and bottom levels reviewed. Deflection of the center of mass at x (δ_x) (mm) must be determined according to the following equation:

$$\delta_x = \frac{C_d \delta_{xe}}{I_e}$$

with :

C_d = The magnification factor of deflection amplification is determined by the type of earthquake retaining structure chosen (SRPMK = 8).

δ_{xe} = deflection at the required location (mm).

I_e = earthquake priority factors, (Risk category II = 1)

Type of structure is a structure using shearwall, so the intersection between permit floors Δ_a

$$\Delta_a = 0.015 \times h_{sx}/\rho$$

Following are the displacement data from ETABS 2017:

Table 8. Inter-floor Deviation

Lantai	H (m)	H commulative (m)	UX Spektrum Response	UY Spektrum Response	Requirement [(0,015 h _{sx})/ρ]	Note
Floor30	3.2	96.3	0.0200475	0.020405	0.71615	safety
Floor29	3.2	93.1	0.0208945	0.0211255	0.69154	safety
Floor28	3.2	89.9	0.0217415	0.021703	0.66692	safety
Floor27	3.2	86.7	0.02266	0.0222695	0.64231	safety
Floor26	3.2	83.5	0.0235235	0.0227645	0.61769	safety
Floor25	3.2	80.3	0.024288	0.0232045	0.59308	safety
Floor24	3.2	77.1	0.0247445	0.023386	0.56846	safety
Floor23	3.2	73.9	0.0252395	0.023639	0.54385	safety
Floor22	3.2	70.7	0.0256245	0.023804	0.51923	safety
Floor21	3.2	67.5	0.0259435	0.0239085	0.49462	safety
Floor20	3.2	64.3	0.0261965	0.0239635	0.47000	safety
Floor19	3.2	61.1	0.0264055	0.02398	0.44538	safety
Floor18	3.2	57.9	0.0265705	0.0239525	0.42077	safety
Floor17	3.2	54.7	0.0267025	0.0238865	0.39615	safety
Floor16	3.2	51.5	0.026829	0.0238095	0.37154	safety
Floor15	3.2	48.3	0.0268015	0.0236005	0.34692	safety
Floor14	3.2	45.1	0.026884	0.0234685	0.32231	safety
Floor13	3.2	41.9	0.026928	0.023287	0.29769	safety
Floor12	3.2	38.7	0.0269445	0.0230505	0.27308	safety
Floor11	3.2	35.5	0.0269115	0.022748	0.24846	safety
Floor10	3.2	32.3	0.026807	0.0223355	0.22385	safety
Floor9	3.2	29.1	0.0265705	0.0217855	0.19923	safety
Floor8	3.2	25.9	0.0261525	0.0210485	0.17462	safety
Floor7	3.2	22.7	0.025454	0.0200585	0.15000	safety
Floor6	3.2	19.5	0.024332	0.018744	0.12538	safety
Floor5	3.2	16.3	0.0227755	0.017193	0.10077	safety
Floor4	3.2	13.1	0.020504	0.01518	0.07615	safety
Floor3	3.2	9.9	0.0172975	0.0126555	0.05154	safety
Floor2	3.2	6.7	0.0128865	0.0095095	0.02692	safety
Floor1	3.5	3.5	0.0056045	0.004411	0	safety

Structural Performance Evaluation According to ATC-40

According to the ATC-40, the drift ratio limit is as follows:

Table 9. Roof drift ratio limitations according to ATC-40

Parameter	Performance Level			
	IO	Damage Control	LS	Structural Stability
Maximum Total Drift	0.01	0.01 - 0.02	0.02	$0.33 \frac{V_i}{P_i}$
Maximum Total Inelastic Drift	0.005	0.005 - 0.015	No limit	No limit

Building performance according to ATC-40 for X direction

Maximum Drift = $Dt / H_{total} = 0.0200475 / 96.3 = 2.0817$

So the level of building performance is Life Safety

Maximum Inelastic Drift = $Dt - D1 / H_{total} = (0.0200475 - 0.0056045) / 96.3 = 1.4997$

The level of performance of nonlinear buildings is Life Safety

Building performance according to ATC-40 for Y direction

Maximum Drift = $Dt / H_{total} = 0.020405 / 96.3 = 2.1188$

So the level of building performance is Life Safety

Maximum Inelastic Drift = $Dt - D1 / H_{total} = (0.020405 - 0.004411) / 96.3 = 1.6608$

The level of performance of nonlinear buildings is Life Safety

Note: Dt = roof displacement

$D1$ = 1st floor displacement

4. Conclusions

After analyzing using the spectrum response method in chapter 4, the writer can draw the following conclusions:

1. Drift between X and Y directions is declared safe against service boundary performance.
2. Drift between X and Y directions is declared safe against Ultimate boundary performance.
3. The results of the maximum displacement X-direction obtained 0.0200475 m and Y direction obtained 0.020405 m so that it still meets the maximum limit $[(0.015h_{sx}) / \rho] = 0.71615$ m.
4. According to the ATC-40 performance level based on Dynamic Analysis of Response Spectrums in the X and Y direction the building performance level is Life Safety.

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