p–ISSN: 2723 - 6609 e-ISSN: 2745-5254
Vol. 4, No. 8, August 2023 http://jist.publikasiindonesia.id/

COMPARATIVE STUDY OF DYNAMIC EARTHQUAKE ANALYSIS WITH SPECTRAL DESIGN AND TIME HISTORY METHODS

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INFO ARTIKEL

Accepted : 11-08-2023
Revised : 19-08-2023
Approved : 20-08-2023

Keywords: SNI 1726:2019; Base Shear; Displacements; Drift Ratio; Static and Dynamic

ABSTRACT

Earthquakes are natural events that cannot be prevented by humans and their occurrence is very difficult to predict. In civil engineering, especially in the structural field, earthquake loads are a major problem in planning economical and safe building structures. This study aims to determine the comparison of earthquake structures with the Response Spectrum, Response Spectrum Matched, Time Histories, and Time Histories Matched methods on the magnitude of the natural vibration period of the structure, the basic shear force, mass participation, displacement, and deviation between levels. The results of this study that the period of natural vibration of the structure with the earthquake method RS 1.412 seconds, RSM 1.453 seconds, TH 1.453 seconds, and THM 1.453 seconds is between the lower limit of 1.054 seconds and the upper limit of 1.476 seconds, so it meets the requirements of SNI 1726:2019. The results of the base shear analysis showed that dynamic analysis is greater than static and the structural model meets the requirements that VDynamics > 100%. VStatic. The results of the analysis of building mass participation in various earthquake methods meet the provisions with results of more than 90%. The results of the analysis of displacements are obtained for the x-direction, the largest THM is 41.945 mm and for the y-direction, TH is 57.330 mm. The results of the drift ratio analysis are obtained for the results of the y-direction drift which is greater than the x-direction drift and permit control for all earthquake methods is safe and meets the requirements of SNI 1726:2019.

Introduction

Earthquakes a natural events that cannot be prevented by humans and their occurrence is very difficult to predict (Pusponegoro & Sujudi, 2016). Therefore, what humans can do is plan a security system for building structures that can reduce the number of victims when an earthquake occurs (Murtiadi, Sasmito, Agustawijaya, Sulistiyono, & Akmaluddin, 2022).

In civil engineering, especially in the field of structures, earthquake loads are a major problem in planning economical and safe building structures (Mukhsin & Ramdani, 2017). The purpose of this study is to determine the comparison of earthquake structures with the methods, RSM, TH andTHM on the natural vibration period of the structure, mass participation of the building, base shear, displacement (Displacement), and floor drift (drift ratio).

The benefit of this research is that it has various identifiable benefits, both in the field of structural engineering and in understanding the response of structures to dynamic earthquakes. Some of the potential benefits of this research are: This research will provide deeper insight into the two analytical methods, namely the spectral design method and the time history method, as well as the advantages and limitations of each. This will help professionals and researchers understand the most appropriate context of use for each method. Comparison results from this study can assist engineers or architects in choosing the most appropriate and accurate analytical method for designing structures in certain earthquake situations. This will help improve the safety and resistance of the structure to earthquakes. By understanding the differences in the results of the two methods, this study can guide how to optimize structural design for dynamic earthquake situations. This will lead to structures that are more efficient and effective in responding to earthquakes. This research can contribute to the validation and further development of earthquake analysis methods. The comparison results obtained can help understand to what extent the results of these methods are consistent with the actual behavior of the structure during an earthquake. If this research reveals weaknesses or potential improvements in existing design guidelines, then the results of this research can be used to improve existing design guidelines, which in turn will affect overall structural engineering practice. The results of this study can be the basis for further research in the field of earthquake analysis and structural response. Further research may explore aspects that are not yet understood or develop more sophisticated comparison methods. The results of this study can be used as teaching materials in civil engineering education or related fields, helping students to better understand the concept of earthquake analysis. This research can provide useful information for city planners and governments in designing earthquake risk mitigation policies and actions in certain areas.

Overall, this research has the potential to make a significant contribution to the field of structural engineering and the understanding of how structures respond to dynamic earthquakes, with far-reaching impacts on engineering practice, public safety, and scientific developments.

Research methods

This research method is carried out on a quantitative approach which will produce numbers from the structural analysis process with an auxiliary program software SAP2000.

The steps in carrying out structural analysis calculations with auxiliary programs software SAP2000 are as follows:

a. Preliminary Design

This research was conductedPreliminary Design to determine the dimensions of slabs, beams, and columns.

1. Plate

Based on SNI 2847:2019 the minimum plate thickness is not less than 100 mm for roof plates and 125 mm for floor plates (Aridiansyah, Rasidi, & Riskijah, 2021).

Table 1 Plate Dimension Type

Plate Type	Dimension (mm)
Floor Plate	125
Roof Plate	100

2. Beam

Table 2 Beam Dimension Types

Plate Type	Dimension (mm)
S1	200/300
S2	300/400

3	B1	300/500
4	B2	400/500
5	BA	300/400

3. Column

Table 3 Column Dimension Type

Plate Type	Dimensi (mm)
K1	600/600
K2	500/500

b. Structure Modeling

In this research, the structural modeling consists of 4 types of earthquake load models with a length of 28 meters and a width of 28 meters for the building structure and the same number of floors, namely (Ramadhani & Arystianto, 2022) eight floors, but different earthquake load models using different methods.RS, RSM, TH andTHM (Ariyanto, 2020). The building structure in this study functions as a hotel facility. The building type configuration is shown in Figures 1 to 4.

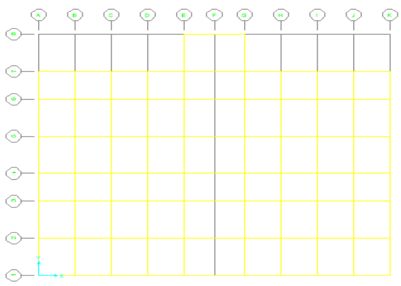


Figure 1 Floor plans 1 and 2 in the x-y direction

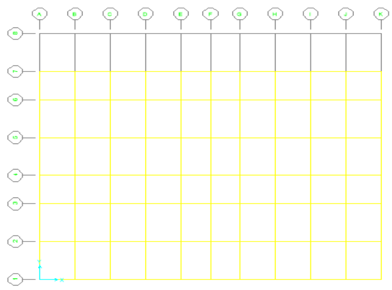


Figure 2 Floor plans 3 and 8 in the x-y direction

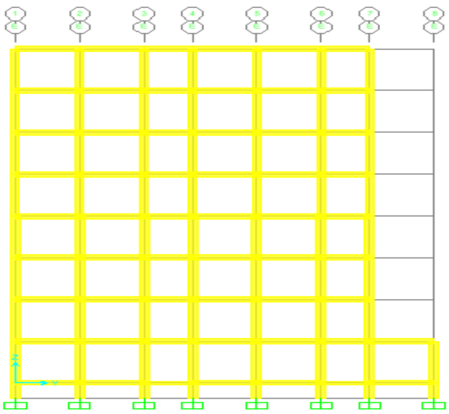


Figure 3 Longitudinal section in the y-y direction

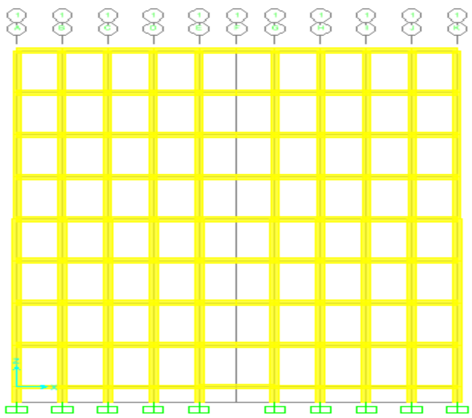


Figure 4 Cross section in the x-x direction

c. Gravity Load

The gravity loads used to model hotel buildings in this study include dead loads (Dead Load/DL) and live load (Live Load/LL) (Suhardin, Ansya, Ashad, Utina, & Fadhil, 2019). Gravity load refers to SNI 1727:2020, with the following description.

d. Dead Load

The dead load consists of the self-weight of all structural elements with a concrete specific gravity of 24 kNm3 which is calculated directly with SAP2000 (Sholeh, 2021) and additional dead load (Superimposed Dead Load) includes permanent fixtures such as floor slabs, roof slabs, ceilings, partitions, and walls. Additional total dead load (Superimposed Dead Load) on the floor plate of 1.49kNm^2, roof plate of 0.73kNm2, and additional dead load (Wall) 5 kNm.

e. Live Load

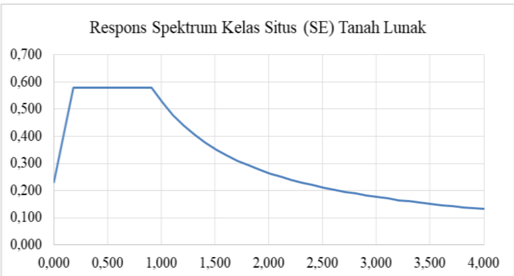
Live load is a load acting on the structure but is not permanent which occurs during the service life of the structure (Kurniawan, Ridwan, Winarto, & Candra, 2019). In this study it is planned for hotel buildings and the live load used for floor plates is 1.92kNm^2 and roof plate 0.96kNm^2 (Umi, 2022).

f. Earthquake Load

In this study, earthquake loads will be modeled into 4 types namely Spektrum, Response Spectrum Matched, *Time Histories*, and *Time Histories Matched* (Rahayu & Pawirodikromo, 2023) Table 4. CurveResponse Spectrum, Response Spectrum Matched, Time Histories, and Time Histories Matched are shown in Figures 5 to 12.

Table 4 Earthquake load data

Location	:	Indramayu
Latitude	:	-6.343012254828473
Longitude	:	108.3349463873224
Site Class	:	SE
SS	:	0,5223
S1	:	0,2749
T0	:	0,18 second
TS	:	0,91 second
SDS	:	0,58g
SD1	:	0,53g



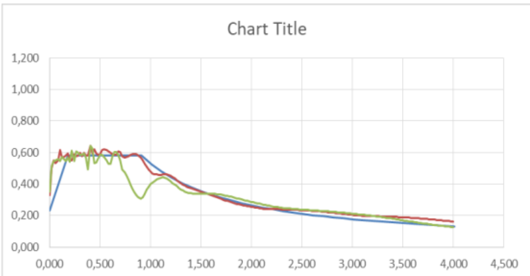


Figure 5 Response Spectrum Figure 6 Curvesresponse spectrum

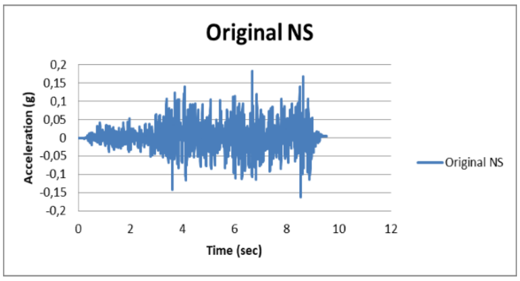


Figure 7 Original curve north-south

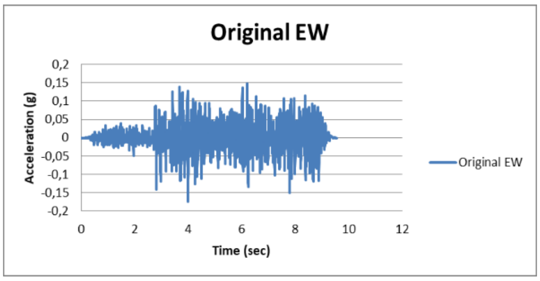


Figure 8 Original curve east-west

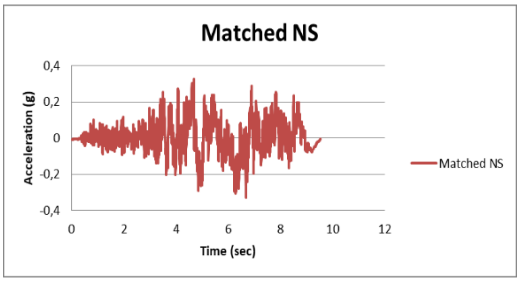


Figure 9 Curvesmatched north-south

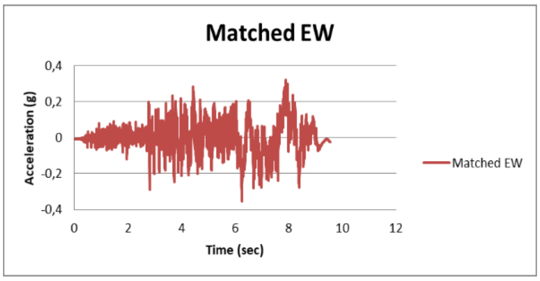


Figure 10 Curvesmatched east-west

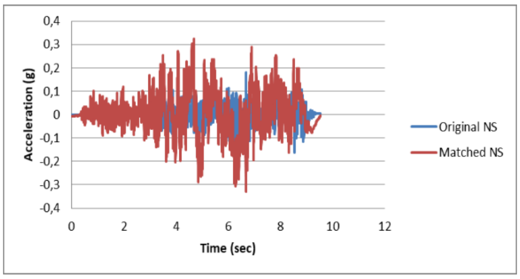


Figure 11 Original curve and matched North South

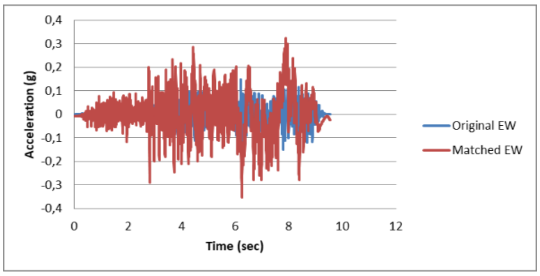


Figure 12 Original curve and matched east-west

Periods of Natural Vibration of Structures

In a building structure, the more the number of floors, the value of the natural period of vibration of the structure increases**.** (Pratama, Putri, & Santoso, 2021).

The fundamental period of approach (Ta) seconds must be determined from the following equation 2.1:

$$T_a = C_t \; x \; h_n^x \qquad (2.1)$$

C_t and x are the estimated vibration time parameter coefficients and in the height of the building structure

Base Shear

Based on SNI 1726:2019 article 7.8.1 base shear (V), the direction determined must be according to equation 2.2 as follows:

$$V = C_s W \qquad (2.2)$$

Where (C_s) is the seismic response coefficient and (W) is the effective seismic weight.

Building Mass Participation

According to SNI 1726:2019 article 7.9.1.1, the analysis is permitted to include the minimum number of variants to achieve a combined mass of at least 90% of the actual mass. (Tabar, Sudarsono, & Mulyawati, 2022).

Displacement (Displacement)

Transfer or displacement is a change in the position of a building structure from rest after being given gravity loads including earthquake loads (Felix, 2022).

Difference Between Levels

Based on SNI 1726:2019 article 7.8.6 the determination of the deviation between the design levels (D) must be calculated as the difference in the deviation at the center of mass above and below the level under review. The amount of deflection vel x, δx, an e is calculated by Equion (2.3). $\delta_x = \frac{C_d . \delta_{xe}}{I_e}$ (2.3)

Cd is the enlargement factor of the lateral drift, δxe is the deviation at the x-level and Y is the structural primacy factor.

Results and Discussion

From the results of structural analysis in this study with 4 types of methods Spektrum, Respons Spectrum Matched, Time Histories, and Histories Matched a comparison of parameter values is obtained as follows:

Periods of Natural Vibration of Structures

On model analysis Respons Spektrum, Respons Spektrum Matched, Time Histories dan Time Histories Matched that has been carried out, the results of the period of vibration of the structure are obtained where in Figure 13 the four types of earthquake load models are between the lower and upper limits (Yudi, Bayzoni, Wirawan, & Nadaek, 2019). Therefore, the value of the vibration time (Tc) from the analysis software SAP2000 meets SNI 1726:2019 requirements.

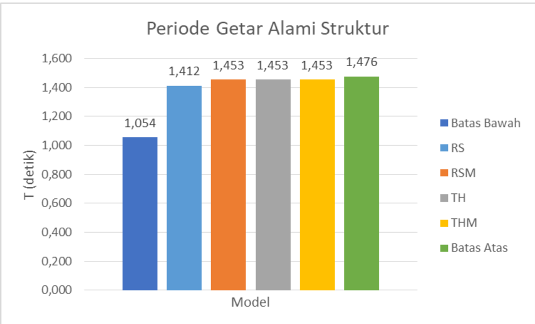


Figure 13 Graph of the natural vibration period of the structure in various methods

Base Shear

ResultsBase shear Maximum static and dynamic analysis for each of the observed earthquake directions is shown in Table 5 and the results of the control recapitulationbase shear are in Table 6. The recapitulation results show that the base shear forces for several RS, RSM, TH, and THM methods comply with the provisions of SNI 1726: 2019 (Soekarno & Hari Murti, 2022).

Table 5 Base shear results

Base Shear		**RS**	**RSM**	**TH**	**THE**
Statik	X (kN)	3376,948	3481,336	3481,336	3481,336
	Y (kN)	3349,276	3452,531	3452,531	3452,531
Dinamik	X (kN)	3377,200	3481,422	3481,469	3482,316
	Y (kN)	3349,384	3452,735	3452,671	3452,580

Table 6 Results of base shear control recapitulation

Base Shear	**Dinamik (VD)**	**Statik (VS)**	**100% x Static (VS)**	**Fakto r Skala VS / VD**	**Kontro l VD > 100% VS**
	Base Shear (kN)	**Base Shear (kN)**	**Base Shear (kN)**		
RS X	3377,2	3376,95	3376,95	1	OK
RS Y	3349,384	3349,28	3349,28	1	OK
RSM X	3481,422	3481,34	3481,34	1	OK
RSM Y	3452,735	3452,53	3452,53	1	OK
THE X	3481,469	3481,34	3481,34	1	OK
THE Y	3452,671	3452,53	3452,53	1	OK
THM X	3482,316	3481,34	3481,34	1	OK
THE Y	3452,58	3452,53	3452,53	1	OK

Building Mass Participation

The results of this research analysis in Table 7 show that the participation of building masses in the four types of models meets the requirements of SNI 1726: 2019, which is more than 90% of the actual mass.

Table 7 Results of building mass participation recapitulation

Axis	Building Mass Participation			
	RS	RSM	TH	THE
X	95%	95%	95%	95%
Y	95%	95%	95%	95%

Displacement(displacements)

Calculation results analysis with software in this study displacement(displacements) the x and y directions are shown in graphs 14 and 15.

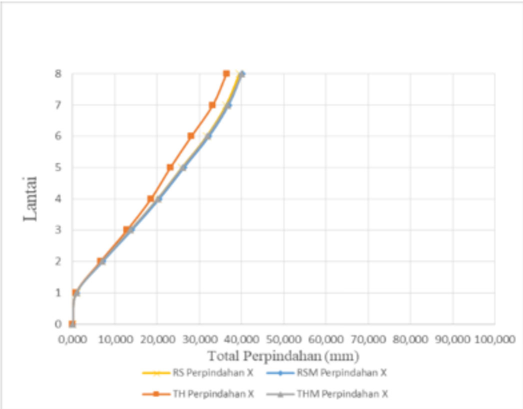


Figure 14 Comparison graph of the displacement in the x direction south

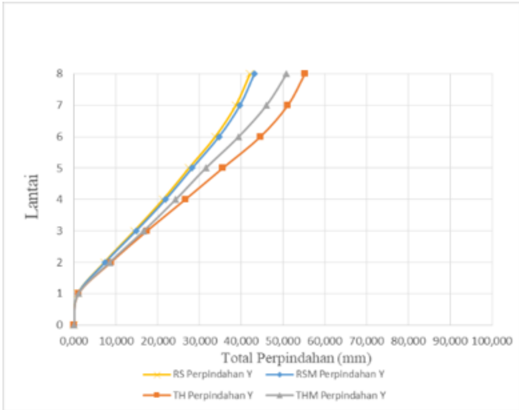


Figure 15 Comparison graph of the displacement in the y direction south

For a comparison graph of the displacement results(displacements) in the x and y directions shown in picture 16.

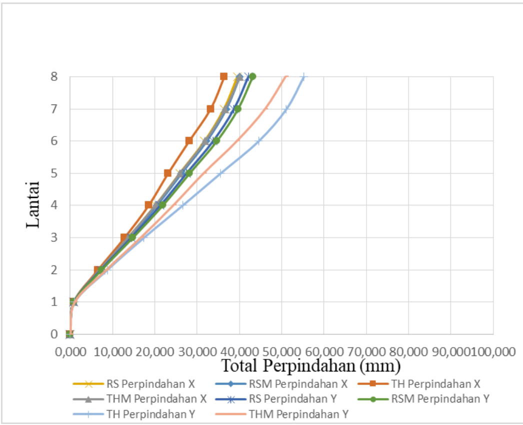


Figure 16 Comparison graph of the displacement between the X and Y directions

Based on Figures 14, 15, and 16 it is known that for displacement(displacements) the y direction is greater than the displacement(displacements) x direction.

Difference Between Levels

From the results of this research analysis, the deviation values between levels are shown in Figure 17 for the X direction and Figure 18 for the Y direction.

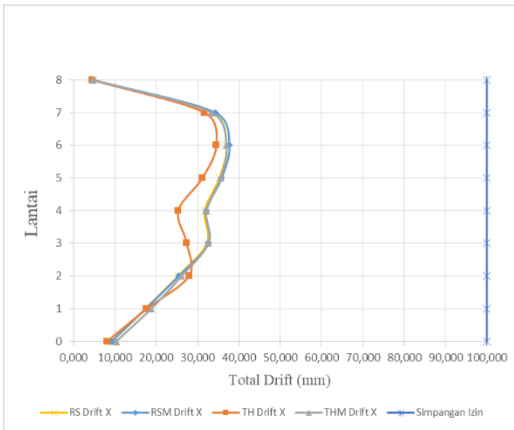


Figure 17 Graphdrift x direction

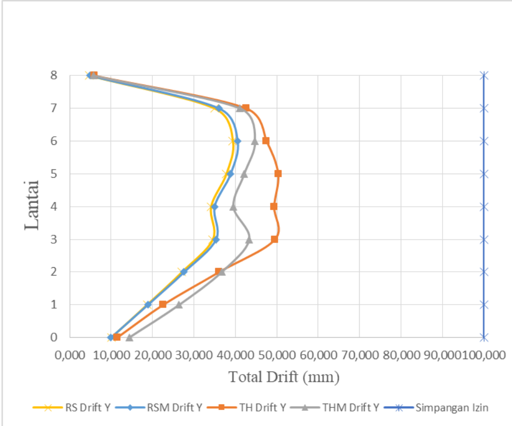


Figure 18 Graphdrift arah y

For a comparison image of the total results in the x and y directions shown in picture

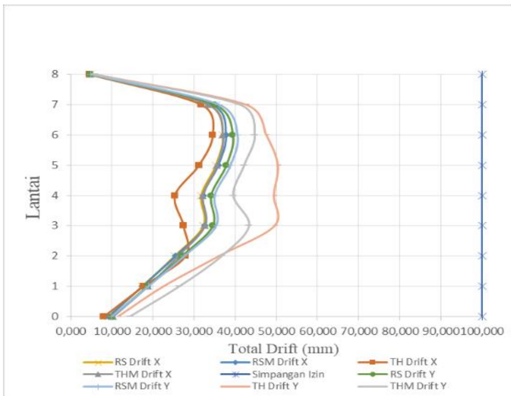


Figure 19 compares the results in the x and y direction

The results of graphs 17, 18, and 19 above show that, for the total drift, the y direction is greater than the total yield drift x direction.

Based on the results and discussion, it can be concluded that the analysis of the natural vibration period of the structure using the RS, RSM, TH, and THM methods is between the lower and upper limits. Therefore, the value of the results of the analysis of the natural vibration period of the structure meets the provisions of SNI 1726: 2019. From the results of the shear analysis, the results of the dynamic analysis are greater than the dynamic analysis > 100% Static. The results of the analysis of building mass participation in various earthquake methods meet the requirements with results of more than 90%. deformation result and drift ratio that the y direction is greater than the x direction and the various earthquake methods comply with the provisions of SNI 1726:2019.

Conclusion

Based on this study, it was concluded that the results of the analysis of the natural vibration period of structures using the compression method RS 1.412 seconds, RSM 1.453 seconds, TH 1.453 seconds, and THM 1.453 seconds are between the lower limit of 1.054

seconds and the upper limit of 1.476 seconds. Therefore, the value of the natural period of vibration (Tc) of the software SAP2000 with the RS, RSM, TH, and THM earthquake methods meets the requirements of SNI 1726:2019. The results of the recapitulation of the basic shear analysis control obtained for the dynamic analysis results are greater than the static analysis and building structure models using the RS, RSM, TH, and THM earthquake methods have fulfilled the requirements based on SNI 1726: 2019 that Dynamics > 100% Static. The results of the analysis of mass participation in the RS, RSM, TH, and THM earthquake methods obtained a value of 95% and fulfilled the requirements of SNI 1726:2019 article 7.9.1.1. Displacement analysis(displacements) with the analysis of the RS, RSM, TH, and THM seismic methods obtained for the results of the direction x RS 41,187 mm, RSM 41,757 mm, TH 37,904 mm, and THM 41,945 mm while for the analysis results the y directions RS 43,924 mm, RSM 44,943 mm, TH 57,330 mm and THM 53,460mm. Therefore, the results of the displacement analysis(displacements) for the largest x direction THM 41,945 mm and the y direction TH 57,330 mm. The results of the analysis of deviations between levels using the RS, RSM, TH, and THM earthquake methods were obtained for the total results drift in the y direction is greater than the total drift in the x direction and the deviation control between levels $\Delta x < \Delta a$ (permit) for all seismic methods are safe and meet the requirements according to SNI 1726:2019.

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