

# Structural Performance Evaluation of the Ra Suites Simatupang Hotel Subjected to Dynamic Seismic Loads

Juan Jullian Pranatha<sup>1</sup>, Budi Kudwadi<sup>1</sup>, and Ben Novarro Batubara<sup>1</sup>

<sup>1</sup>Civil Engineering Study Program, Indonesia University of Education  
Corresponding Author: Juan Jullian Pranatha. Email: jullianpjuan@gmail.com

## Abstract

The construction of high-rise buildings in Indonesia, particularly in densely populated urban areas, requires serious attention to earthquake-resistant structural design, given the country's geographical location in an earthquake-prone region. Therefore, this study focuses on the performance analysis of the RA Suites Simatupang Hotel structure, a 16-story building in Jakarta, to evaluate its response to dynamic earthquake loads. The analysis was conducted using two methods: response spectrum and time history. The aim of this study is to determine the maximum interstory drift values and to assess the structural performance level based on ATC-40. The results show that the maximum interstory drift under the response spectrum method is 69.867 mm in the X-direction and 69.443 mm in the Y-direction, while without shear walls, the maximum drift increases to 80.058 mm in the X-direction and 111.006 mm in the Y-direction. Meanwhile, the time history method produces maximum interstory drifts due to the Iwate earthquake of 73.85 mm in the X-direction and 68.34 mm in the Y-direction, the 2016 New Zealand earthquake of 73.85 mm in the X-direction and 68.34 mm in the Y-direction, and the Tohoku earthquake of 60.58 mm in the X-direction and 59.61 mm in the Y-direction. Based on the structural performance evaluation using ATC-40 guidelines, all results indicate that the RA Suites Simatupang Hotel is at the Immediate Occupancy (IO) performance level, suggesting that the building's structure has adequate earthquake resistance, remains functional, and is safe for occupancy.

Keywords: Seismic Performance , High-Rise Building , Dynamic Analysis , SNI 1726:2019 , ETABS.

## 1. INTRODUCTION

The increasing global population has spurred the construction of high-rise buildings, optimizing land use and meeting diverse urban needs such as offices, residences, and commercial centers. However, these structures present significant technical challenges, particularly in seismically active regions like Indonesia. Indonesia's geographical location at the convergence of major tectonic plates frequently exposes its territory to high-magnitude earthquakes. Consequently, ensuring the seismic resilience of tall buildings is paramount.

Earthquakes induce significant inertial forces on structures, proportional to building height and ground acceleration. Uncontrolled displacement, or "drift," during seismic events can compromise structural stability and occupant safety. Therefore, high-rise building designs must explicitly address lateral loads from earthquakes, emphasizing ductility, redundancy, and uniform mass distribution to prevent structural failure.

The Hotel RA Suite Simatupang, a 16-story building in Jakarta, is subjected to considerable dead, live, and especially lateral (seismic) loads. To ensure its stability and safety, a comprehensive structural performance analysis is indispensable. This study employs two dynamic analysis methods: response spectrum and time history. The response spectrum method evaluates structural response to earthquake accelerations represented graphically, linking vibration period and maximum acceleration. The time history method assesses dynamic structural response using actual earthquake records, providing detailed information on displacement, velocity, and acceleration changes over time. Structural elements, including columns, beams, slabs, and shear walls, are modeled in 3D using ETABS v18.1.1 software for strength and performance evaluation. The analysis adheres to SNI 1726:2019, the Indonesian standard for earthquake-resistant building design.

The primary objectives of this research are to quantify the maximum interstory drift under both response spectrum and time history earthquake loads and to assess the building's structural performance level according to ATC-40 guidelines. This investigation aims to contribute to the understanding of high-rise building behavior under seismic loads and enhance knowledge in civil engineering concerning lateral load analysis.

An earthquake is a vibration or tremor that occurs on the Earth's surface due to the sudden release of energy from within the Earth, usually caused by tectonic plate movement, volcanic activity, or the collapse of rocks beneath the surface. The energy released propagates in the form of seismic waves, which can cause damage to buildings, landslides, or tsunamis if they occur underwater (Indonesian Meteorological, Climatological, and Geophysical Agency [BMKG], 2023). Technically, earthquakes are measured using a magnitude scale (e.g., the

Richter scale) to describe the amount of energy released, and an intensity scale (e.g., the Mercalli scale) to describe its impact on the Earth's surface (United States Geological Survey [USGS], 2023).

Spectrum response is a graphical representation presented in the form of a curve, illustrating the relationship between the structure period  $T$  and the maximum response such as acceleration, velocity, or displacement based on the damping ratio and specific earthquake characteristics. Spectrum response dynamic analysis provides a more accurate distribution of shear forces along the height of a building compared to equivalent static analysis methods. (Mulyo & Utami, 2019)

Dynamic time history analysis is a method for determining the dynamic response of a building structure to ground motion or ground acceleration caused by past earthquakes, both in linear and non-linear structural behaviour. In seismic load analysis using a dynamic approach, this calculation produces a "time history" of displacement (as well as acceleration and velocity if required) along with the forces associated with the degrees of freedom of the structure. (Fadilah & Walujodjati, 2020)

Horizontal drift is the relative lateral movement between two adjacent building levels due to lateral loads, such as earthquakes or wind. In other words, horizontal drift refers to the difference in horizontal displacement that occurs on each floor of a multi-storey structure. (Lestari, 2016)

ATC-40 is one of the guidelines used to determine the level of damage to structures. This level of damage can be used as a basis for evaluating the safety of buildings after an earthquake. (Dewi, 2020)

ATC-40 (Applied Technology Council-40) is a guideline document published by the Applied Technology Council in the United States, titled 'Seismic Evaluation and Retrofit of Concrete Buildings.' This document is widely used in the field of civil engineering, particularly in evaluating the performance of concrete building structures under earthquake loads.

## 2. METHOD

The research methodology employed quantitative descriptive approach to analyze the seismic performance of the Hotel RA Suite Simatupang building structure under dynamic earthquake loads. This approach aims to describe phenomena based on numerical data representing object characteristics. The execution of the method involved a computational analysis system utilizing data acquired through observational study, with discussions based on established theories from various literature sources

### 2.1 Tools and Research Materials

The primary instrument used for structural modeling and analysis was ETABS (Extended Three-Dimensional Analysis of Building Systems) software version 18.1.1. Microsoft Excel was utilized for processing and organizing computational data. The research data for the Hotel RA Suite Simatupang building comprised as-built structural and architectural drawings.

Key structural properties and dimensions modeled in ETABS included:

1. Building Name : Ra Suites Simatupang Hotel
2. Number of Floors : 16 floors, 3 basement floors, and 1 roof floor
3. Building Length : 84.6 metres
4. Building Width : 54 metres
5. Building Height : 77 metres
6. Concrete Strength ( $f_c'$ )
  - Beam Strength : 35 MPa
  - Column Strength : 40 MPa
  - Slab Strength : 35 MPa
7. Steel Strength : D10, D19, D22 → BJTS 420
  - :  $F_y$  420 MPa
  - :  $F_u$  570 MPa

#### 8. Element Dimensions

Dimensions for columns, slabs, and beams were adopted directly from the as-built drawings

### 2.2 Research Work Steps

The research workflow involved the following analytical stages:

#### 1. Structural Modeling

The Hotel RA Suite Simatupang building was modeled in 3D using ETABS v18.1.1. Only structural elements (columns, beams, slabs, shear walls) were explicitly modeled.

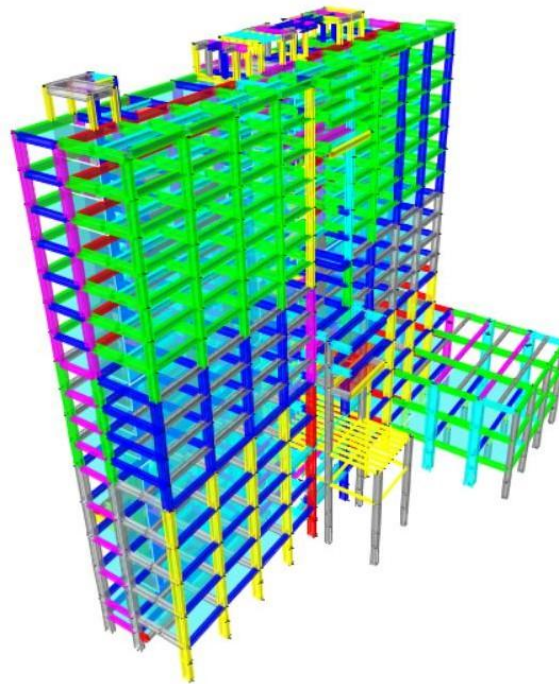


Figure 1. Struktur Modeling Hotel Ra Suites Simatupang ETABS

2. Structural Loading:
  - a. Dead Load (DL):

Self-weight of the structure was automatically calculated by ETABS. Superimposed dead loads (SIDL) were manually input based on material unit weights (e.g., 2400 kg/m<sup>3</sup> for reinforced concrete) and permanent additional components (e.g., ceramic, mortar, ME, plumbing, gypsum plafond, wall loads)
  - b. Live Load (LL):

Applied based on SNI 1727:2020, with specific values for floor slabs (1.92 kN/m<sup>2</sup>) and roof slabs (0.96 kN/m<sup>2</sup>)
  - c. Rain Load (R):

Applied as 0.5 kN/m<sup>2</sup>
  - d. Earthquake Load:

Analyzed using both Response Spectrum and Time History methods as per SNI 1726:2019.
3. Response Spectrum:

Steps included determining risk category, importance factor ( $I_e$ ), site class (assumed SE due to lack of geotechnical report), ground motion parameters ( $S_S$ ,  $S_1$ ), site coefficients ( $F_a$ ,  $F_v$ ), design acceleration parameters ( $S_{DS}$ ,  $S_{D1}$ ), seismic design category ( $D$ ), and  $R$ ,  $C_d$ ,  $\Omega_0$  factors for the dual system. Structural periods ( $T_0$ ,  $T_S$ ,  $S_a$ ) were calculated to define the design response spectrum curve.
4. Time History  
This involved compiling target spectra, determining period requirements (PGA for  $T < T_0$ , 0.2s for  $T_0 < T < T_S$ , 3s for  $T > T_S$ ), identifying magnitude and distance from the Indonesian disaggregation map for Jakarta (1000-year return period, 3-second spectral acceleration), obtaining ground motion records (shallow crustal from [ngawest2.berkeley.edu](http://ngawest2.berkeley.edu); Benioff from [ec2-35-167-122-9.us-west-2.compute.amazonaws.com](http://ec2-35-167-122-9.us-west-2.compute.amazonaws.com)), and performing spectral matching as per SNI 1726:2019 Section 7.9.2.3.1.
5. Structural Analysis  
The modeled structure in ETABS was run to obtain internal forces and assess safety. Both Response Spectrum and Time History analyses generated base shear and displacement values.
6. Structural Control and Checking:
  - a. Period and Mode Shapes  
Determined fundamental period ( $T_a$ ), maximum period ( $T_{max}$ ), and verified modal participating mass ratios (MPMR) against SNI 1726:2019's 90% threshold.
  - b. Seismic Base Shear  
Calculated coefficients ( $C_s$ ,  $C_{s,max}$ ,  $C_{s,min}$ ) and total base shear ( $V$ ) based on effective seismic weight ( $W$ ).

- c. Base Shear Scaling  
Applied scaling factors ( $V/V_t$ ) to dynamic analysis results if they were less than 100% of the equivalent static base shear, following SNI 1726:2019 Section 7.9.1.4.1.
- d. Irregularity Check  
Assessed horizontal (torsional, re-entrant corner, diaphragm discontinuity, out-of-plane offset, non-parallel systems) and vertical (soft story stiffness, mass, geometric, in-plane discontinuity, weak story strength) irregularities as per SNI 1726:2019.
- e. Interstory Drift  
Evaluated elastic and inelastic drifts against allowable limits set by SNI 1726:2019
- f. Structural Performance Level:  
Determined based on total and inelastic drift ratios in accordance with ATC-40 criteria (Table 3.6).

### 3. RESULTS AND DISCUSSION

#### 3.1 General Overview

This section presents the findings from the structural analysis of the Hotel RA Suite Simatupang building. The analysis was conducted utilizing ETABS Version 18.1.1 for structural computations and Microsoft Excel for data processing and organization. The building was subjected to both response spectrum and time history dynamic analysis methods. Controls performed include structural period, mode shapes and participation, seismic base shear, force scaling, irregularities, interstory drift, and P-Delta effects.

#### 3.2 Loading and Earthquake Parameters

The calculation of reference loads adhered to SNI 1727:2020 regarding minimum loads for building design and SNI 1726:2019 for earthquake resistance design procedures. The total effective seismic weight was derived from the summation of the effective seismic weight of each floor, obtained from ETABS. These values were then converted to kilonewtons (kN) using a coefficient of 0.00980665. For example, the weight for the roof floor (3) was calculated as  $235134.64 \times 0.00980665 = 2305.8831$  kN. The soil at the Hotel RA Suite Simatupang location was assumed to be soft soil (Site Class SE) due to the absence of a geotechnical investigation report.

#### 3.3 Response Spectrum

In earthquake analysis using the response spectrum method, several stages must be passed through. Through these stages, structural control is also carried out. Response spectrum analysis includes determining the structure period, structure mode, type of structural irregularity, seismic base shear force, force scaling, displacement scaling, and consideration of P-delta effects.

The determined earthquake parameters based on SNI 1726:2019 were:

- Short Period Spectral Acceleration, SS = 0.8555 g
- 1-Second Period Spectral Acceleration, S1 = 0.4077 g
- Short Period Vibration Amplification Factor, Fa = 1.2156 g
- 1-Second Period Vibration Amplification Factor, Fv = 2.3846 g
- Design Spectral Acceleration for Short Periods, SDS = 0.693297 g
- Design Spectral Acceleration for 1-Second Period, SD1 = 0.648134 g

The structure was classified under Seismic Design Category D, indicating a high seismic risk. The design response spectrum curve parameters were determined, with

$$T_0=0.213936 \text{ s and } T_S=0.934858 \text{ s.}$$

### 3.4 Time History

Based on the book Peta Deagregasi Bahaya Gempa Indonesia (Map of Earthquake Hazard Disaggregation in Indonesia) taken from ASCE 41-17, a minimum evaluation is required for a 1000-year earthquake recurrence period with a Collapse Prevention (CP) performance level target and a 250-year period with a Life Safety (LS) performance level target for buildings in risk categories I and II. Strategically, the 3-second vibration period is considered representative of structures with medium and long vibration periods, such as bridges and tall buildings. Ground motion data is obtained from three earthquake sources: earthquakes caused by shallow crustal movements, earthquakes caused by deep plate movements (Benioff), and megathrust earthquakes. The process of selecting ground motion recording data is as follows.

Determining the response spectrum acceleration based on the following values

$$T < T_0 \quad = \text{PGA}$$

$$T_0 < T < T_S = 0.2 \text{ seconds}$$

$$T > T_S \quad = 3 \text{ seconds}$$

The determination of the vibration period used is as follows:

$$T_{c,X} = 1.635 \text{ seconds}$$

$$T_{c,Y} = 1.553 \text{ seconds}$$

$$T_0 = 0.194 \text{ seconds}$$

$$T_S = 0.970 \text{ seconds}$$

Since the value of  $T > T_S$ , the 3-second recurrence period is used.

#### 1. Magnitude and distance values

In the book 'Indonesia Earthquake Hazard Deaggregation Map,' for the location of Jakarta, specifically at the research site of the Ra Suites Simatupang Hotel, data on magnitude (M) and distance (R) were obtained for a 1,000-year recurrence period and a 3-second vibration period, as presented in Table 1 below.

Table 1: Magnitude and distance at the research location

3-second period		
Earthquake source	Magnitude (SR)	Distance (km)
Shallow Crustal	6.6-6.8	50-60
Benioff	7.4-7.6	120-150
Megatrush	8.6 - 8.8	150-200

#### 2. Search for ground motion recording data

The data entered into the site includes magnitude, distance, and  $V_{S30}$  values sourced from Table 2.7. In this case, for soft soil types (SE),  $V_{S30}$  values range from 0 to 175 m/s. As a result, suitable ground motion history data was obtained based on the magnitude, distance, and  $V_{S30}$  values, as listed in Table 2 below.

Table 2: Ground Motion Time History Data

Source	RSN	EVENT	LOCATION	YEAR	M	DISTANCE (KM)	VS30
Shallow Crustal	5666	IWATE	Japan	2008	6.9	45.55	166.75
Benioff	5004170	New Zealand 2016	New Zealand	2016	7.85	101.7	155
Megatruss	4001037	TOHOKU	Japan	2011	9.12	168.26	106

### 3. Spectral Matching

Based on SNI 1726:2019, each component of the ground acceleration history data used must be spectrally matched in the range of  $0.8T_{lower}$  to  $1.2T_{upper}$ . Within this period range and in each direction, the average value of the pseudo acceleration with 5% damping, calculated using the spectrally matched recordings, must not exceed 10% of the target spectrum.

$$T_{lower} = 0.225 \text{ s} \quad 0.8 T_{lower} = 0.180 \text{ s}$$

$$T_{upper} = 2.980 \text{ s} \quad 1.2 T_{upper} = 3.576 \text{ s}$$

Spectral matching is performed using the ETABS programme. Analysis is conducted on the output values from the spectral matching results in the programme.

After spectral matching, it was determined that the earthquake above the target spectrum did not exceed 10%. For the Iwate earthquake, the target error was only 9.7%, the 2016 New Zealand earthquake error was 7.3%, and the Tohoku target error was only 8.7%. It can be stated that the selected earthquake recordings can be used.

### 3.5 Seismic Base Shear and Scaling

The calculated approximate fundamental period ( $T_a$ ) was 2.324 seconds, and the maximum period ( $T_{max}$ ) was 3.254 seconds. As the calculated periods ( $T_c$ ) for both X (2.71s) and Y (2.98s) directions were less than  $T_a$ , the period used for analysis was  $T_a$ . The seismic response coefficient ( $C_s$ ) was 0.09904.

Seismic Response Coefficient,	$C_s$	=	$SDS/(R/I_e)$	=	0.09904
Upper Limit,	$C_{s,max}$	=	$SD1/[T*(R/I_e)]$		
	$C_{s,maxX}$	=	0.03422		
	$C_{s,maxY}$	=	0.03111		
Lower Limit,	$C_{s,min,l}$	=	$0.044 SDS \times I_e$ (must be $\geq 0.01$ )		
	$C_{s,min}$	=	0.03051		
Seismic Response Coefficient Used, $C_s > C_{s,max}$ , then	$C_s = C_{smax}$				
	$C_{s,used,x}$	=	0.03422		
	$C_{s,used,y}$	=	0.03111		
	Effective Seismic Weight,	$W$	=	246047.12 kN	
	Seismic Base Shear Force	$V$	=	$C_s \cdot W$	
	$V_x$	=	8410.49 kN		
	$V_y$	=	7649.031 kN		
	Static Base Shear Force (ETABS)				
	$V_x$	=	8411.2783 kN		
	$V_y$	=	7649.031 kN		

Based on SNI 1726:2019 section 7.9.1.4.1 on force scaling, if the combination of responses for the basic shear force resulting from the variance analysis ( $V_t$ ) is less than 100% of the shear force ( $V$ ) calculated using the equivalent static method, then the force must be multiplied by  $V/V_t$ , where  $V$  is the equivalent static shear force and  $V_t$  is the shear force obtained from the combination analysis results.

Initial Scaling Factor	$SF$	=	$g/(R/I)$		
		=	1.4095 $m/s^2$		
		=	1,409.5 $mm/s^2$		
Static Basic Shear Force	$V_x$	=	8,411.2783 kN		
	$V_y$	=	7,649.031 kN		
Combined Variance Basic Shear Force	$V_{t,X}$	=	6529.6506 kN		
	$V_{t,Y}$	=	6280.1028 kN		
Earthquake Force Scaling	$f$	=	$V/V_t$		
	$F_x$	=	1.28817		
	$F_y$	=	1.21798		
New Scale Factor	$S_{fx}$	=	Initial SF $\times F_x$		
		=	1.409,5 $\times$ 1.28817		
		=	1804.66 $mm/s^2$		
	$S_{fy}$	=	Initial SF $\times F_y$		
		=	1.409,5 $\times$ 1.21798		
		=	1706.33 $mm/s^2$		

Table 3: Output Case Scale Factor V Dinamic Respon Spectrum

Output Case	Vx (kN)	Vy (kN)
Scaled Spec Ey	452.2415	7732.7869
Scaled Spec EX	8077.8028	467.5655
Static Ex	-8077.0418	-5.51E-06
Static Ey	0	-7729.733
Spec Ey	376.6752	6440.6943
Spec EX	6507.5318	376.6739

Table 4: Output Case Scale Factor V Dinamic Times History

Output Case	Statik		Unscaled		Scaled	
	X	Y	X	Y	X	Y
IWATE OFF	8411.28	7649.03	8027.95	6824.52	8411.596	7649.48
Neazealand 2016	8411.28	7649.03	6180.41	5850.99	8411.701	7649.402
Tohouku	8411.28	7649.03	6365.8124	7331.02	8411.306	7649.436

### 3.6 Interstory Drift

interstory drift values, obtained from ETABS output, must not exceed the allowable displacement. The allowable inelastic story drift ( $\Delta_{max}$ ) was determined as 0.0154h. For floor 7  $\Delta_{max}$  was 60.00 mm. For example, on floor 7 (with shear walls), the elastic drift was

$\delta_{ex}$  = 7.642 mm and  $\delta_{ey}$  = 8.171 mm. The inelastic story drift was

$\Delta_x$  = 42.031 mm and  $\Delta_y$  = 44.941 mm. Both values were less than

$\Delta_{max}$  (60.00 mm), indicating compliance. A full recapitulation of displacement and drift checks for all floors (Table 2.5) shows that all values are within the allowable limits for the structure with shear walls.

Table 5: Interstory Drift Respon Spectrum

Story	Displacement		Elastic Drift		h (mm)	Inelastic Drift		Drift Limit (mm)	Cek
	$\delta_{ex}$	$\delta_{ey}$	$\delta_{ex}$	$\delta_{ey}$		$\Delta_x$	$\Delta_y$		
	(mm)	(mm)	(mm)	(mm)		(mm)	(mm)		
LMR	97.732	122.2	3.119	4.278	3600	17.155	23.529	55.385	OK
Atap	100.85	117.92	1.515	5.210	3900	8.333	28.655	60.000	OK
Lt.16	99.336	112.71	2.762	5.413	3900	15.191	29.772	60.000	OK
Lt 15	96.574	107.3	2.979	5.705	3900	16.385	31.378	60.000	OK
Lt.14	93.595	101.6	3.439	5.992	3900	18.915	32.956	60.000	OK
Lt 13	90.156	95.603	4.066	6.309	3900	22.363	34.700	60.000	OK
LT.12	86.09	89.294	4.400	6.620	3900	24.200	36.410	60.000	OK
Lt. 11	81.69	82.674	5.076	6.958	3900	27.918	38.269	60.000	OK
Lt. 10	76.614	75.716	5.447	7.303	3900	29.959	40.167	60.000	OK
Lt. 9	71.167	68.413	5.411	8.056	3900	29.761	44.308	60.000	OK
Lt. 8	65.756	60.357	6.326	8.054	3900	34.793	44.297	60.000	OK
Lt.7	59.43	52.303	7.642	8.171	3900	42.031	44.941	60.000	OK

Story	Displacement		Elastic Drift		h	Inelastic Drift		Drift Limit	Cek
	$\delta_{ex}$	$\delta_{ey}$	$\delta_{ex}$	$\delta_{ey}$		$\Delta_x$	$\Delta_y$		
	(mm)	(mm)	(mm)	(mm)		(mm)	(mm)		
Lt. 6	51.788	44.132	12.364	12.626	6000	68.002	69.443	92.308	OK
Lt. 5	39.424	31.506	12.078	10.471	6000	66.429	57.591	92.308	OK
Lt. 4	27.346	21.035	12.703	10.537	6000	69.867	57.954	92.308	OK
Lt. 3	14.643	10.498	9.699	7.045	6000	53.345	38.748	92.308	OK
Lt. 2	4.944	3.453	3.308	2.299	3000	18.194	12.645	46.154	OK
Lt. 1 Mazz	1.636	1.154	1.636	1.154	3500	8.998	6.347	53.846	OK

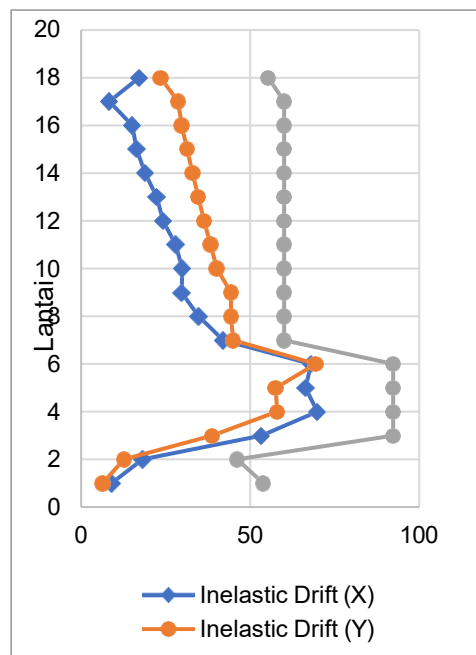


Figure 2. Inelastic Drift Respon Spectrum

The table 5 and figure 2. show that the inter-storey drift values for the RA Suite Simatupang Hotel Building, obtained through response spectrum analysis, are within the permitted drift limits. Therefore, the structure of the RA Suite Simatupang Hotel Building is considered safe based on the results of the response spectrum analysis.

Table 6: Interstory Drift (X) Times History

Story	H (mm)	interstory drift Tingkat X			Drift Limit (mm)	Check
		Iwate Off	New zealand 2016	Tohoku		
LMR	3600	13.01	26.05	3.98	55.38	OK
Atap	3900	6.79	9.16	15.37	60.00	OK
Lt.16	3900	11.98	16.71	20.42	60.00	OK
Lt 15	3900	7.79	18.22	25.00	60.00	OK
Lt.14	3900	9.61	21.28	29.95	60.00	OK
Lt 13	3900	12.23	25.37	34.12	60.00	OK
LT.12	3900	14.39	27.81	37.42	60.00	OK
Lt. 11	3900	17.51	32.27	40.57	60.00	OK

Story	H (mm)	interstory drift Tingkat X			Drift Limit (mm)	Check
		Iwate Off	New zealand 2016	Tohoku		
Lt. 10	3900	20.03	34.78	42.22	60.00	OK
Lt. 9	3900	21.83	34.53	41.40	60.00	OK
Lt. 8	3900	26.08	39.45	34.88	60.00	OK
Lt.7	3900	31.36	46.57	35.57	60.00	OK
Lt. 6	6000	54.70	73.85	55.44	92.31	OK
Lt. 5	6000	58.30	67.92	49.35	92.31	OK
Lt. 4	6000	61.24	70.32	60.58	92.31	OK
Lt. 3	6000	49.83	50.69	46.27	92.31	OK
Lt. 2	3000	16.89	17.11	17.10	46.15	OK
Lt. 1 Mazz	3500	8.66	8.51	8.02	53.85	OK

Table 7: Interstory Drift Y Times History

Story	H (mm)	Interstory drift Y			Drift Limit (mm)	Check
		Iwate Off	New zealand 2016	Tohoku		
LMR	3600	28.00	19.28	21.91	55.38	OK
Atap	3900	35.94	24.33	27.30	60.00	OK
Lt.16	3900	37.85	25.70	28.31	60.00	OK
Lt 15	3900	39.86	27.41	28.47	60.00	OK
Lt.14	3900	41.73	29.50	28.55	60.00	OK
Lt 13	3900	42.80	31.80	29.60	60.00	OK
LT.12	3900	40.91	34.22	30.77	60.00	OK
Lt. 11	3900	31.70	36.77	31.65	60.00	OK
Lt. 10	3900	26.87	39.23	32.76	60.00	OK
Lt. 9	3900	30.50	44.04	37.42	60.00	OK
Lt. 8	3900	33.72	45.05	39.38	60.00	OK
Lt.7	3900	35.04	45.68	40.45	60.00	OK
Lt. 6	6000	52.46	68.34	59.61	92.31	OK
Lt. 5	6000	51.35	64.80	56.95	92.31	OK
Lt. 4	6000	43.80	51.36	42.65	92.31	OK
Lt. 3	6000	33.40	38.10	31.78	92.31	OK
Lt. 2	3000	10.91	11.12	10.05	46.15	OK
Lt. 1 Mazz	3500	5.28	5.64	5.18	53.85	OK

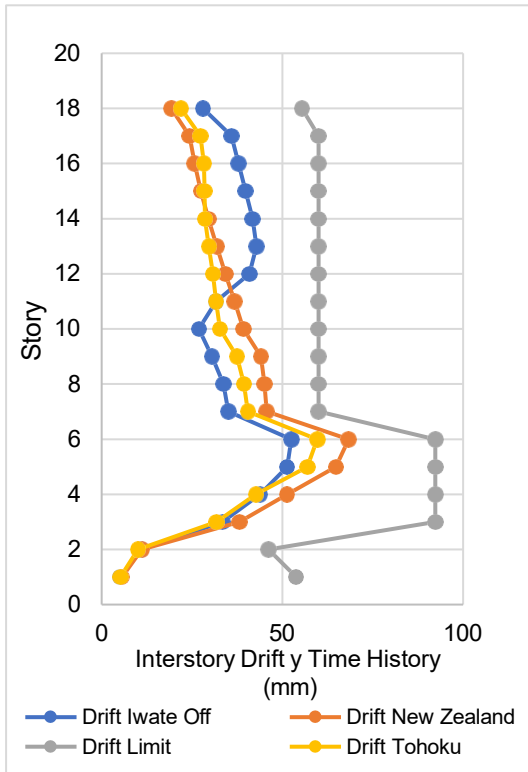


Figure 3. inelastic Drift Y Times History

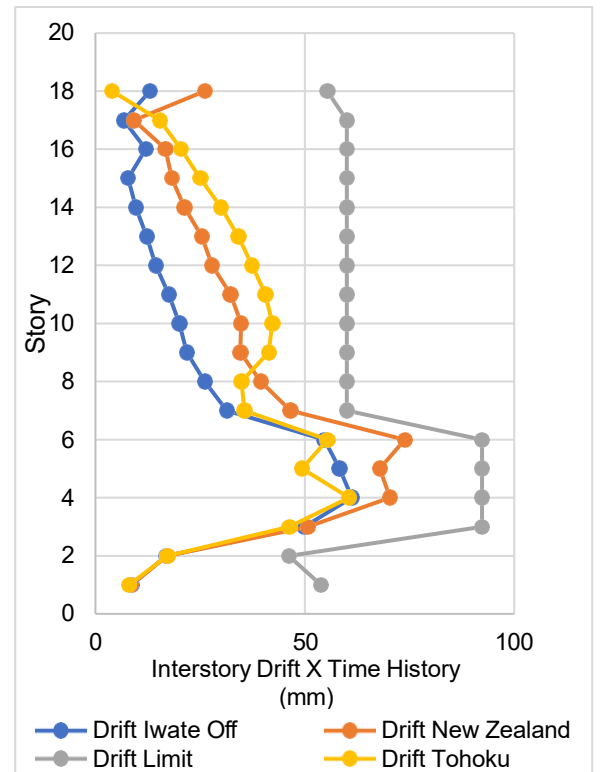


Figure 4. Inelastic Drift X Times History

Table 6 and 7. Figure 3 and 4 shows that the inter-storey drift values for the RA Suite Simatupang Hotel Building, obtained through time history analysis, have met and not exceeded the specified drift limits. Thus, the structure of the RA Suite Simatupang Hotel Building is considered safe based on the results of the time history earthquake analysis.

### 3.7 Structural Performance Level

The structural performance level was assessed based on the ratio of displacement to total height, adhering to ATC-40 guidelines. For the Hotel RA Suite Simatupang, the maximum total displacement and maximum inelastic displacement in both X and Y directions consistently remained below 0.01 and 0.005, respectively. This indicates that the building's performance level is categorized as *Immediate Occupancy* (IO) for all analyzed earthquake scenarios (Response Spectrum, Iwate Off, Beni Off, Megatruss).

Table 8: Structural Performance Level Summary (X-direction).

Model	Quake	Dt	D1	Building height (mm)	Total Maximum Deviation	Maximum Inelastic Deviation	Performance Level
		(mm)	(mm)		Dt/H	(Dt-D1)/H	
1	Respon Spectrum	100.851	1.636	77000	0.001310	0.001289	IO
2	Respon Spectrum	107.804	2.537		0.001400	0.001367	IO
3	Time Histori Shallow Crustal	75.672	1.574		0.000983	0.000962	IO
4	Time Histori Beni Off	103.367	1.547		0.001342	0.001322	IO
5	Time Histori Megatruss	114.139	1.617		0.001482	0.001461	IO

Table 9: Structural Performance Level Summary (Y-direction).

Model	Quake	Dt	D1	Building height	Total Maximum Deviation	Maximum Inelastic Deviation	Performance Level
		(mm)	(mm)		(mm)	Dt/H	
1	Respon Spektrum	117.923	1.154	77000	0.00153W1	0.001516	IO
2	Respon Spektrum	133.748	2.542		0.001737	0.001704	IO
3	Time Histori Shallow Crustal	113.114	0.96		0.001469	0.001457	IO
4	Time Histori Beni Off	116.795	1.025		0.001517	0.001504	IO
5	Time Histori Megatruss	106.48	0.866		0.001383	0.001372	IO

Tables 6 and 7 show that the maximum total deviation values calculated are less than 0.01, and all maximum inelastic deviation values are less than 0.005. Thus, Tables 6 and 7 indicate that the RA Suite Simatupang Hotel Building falls under the Immediate Occupancy (IO) structural performance level for all earthquake models. The Immediate Occupancy (IO) performance level indicates that the structure is fully capable of withstanding base shear forces.

#### 4. CONCLUSIONS

Based on the performance analysis of Hotel RA Suite Simatupang building under dynamic earthquake loads, the following conclusions are drawn:

1. The maximum horizontal displacement of Hotel RA Suite Simatupang under response spectrum earthquake loads is 100.851 mm (X-direction) and 122.201 mm (Y-direction). The corresponding maximum drifts are 69.867 mm (X-direction) and 69.443 mm (Y-direction). When analyzed without shear wall stiffeners, the maximum horizontal displacement increases to 107.804 mm (X-direction) and 133.748 mm (Y-direction), with maximum drifts of 80.058 mm (X-direction) and 111.006 mm (Y-direction).
2. For Time History earthquake loads, the maximum horizontal displacement for the Iwate earthquake is 78.038 mm in the X-direction and 113.114 mm in the Y-direction, with maximum drifts of 61.24 mm (X) and 52.46 mm (Y). For the New Zealand 2016 earthquake, the maximum horizontal displacement is 108.104 mm in the X-direction and 116.795 mm in the Y-direction, with maximum drifts of 73.85 mm (X) and 68.34 mm (Y). For the Tohoku earthquake, the maximum horizontal displacement is 108.667 mm in the X-direction and 105.959 mm in the Y-direction, with maximum drifts of 60.58 mm (X) and 59.61 mm (Y).
3. The structural performance level of Hotel RA Suite Simatupang, based on ATC-40, is consistently at the "Immediate Occupancy" (IO) level after being subjected to both response spectrum and time history earthquake loads.

## REFERENCES

- Badan Standardisasi Nasional. (2019). SNI-1726-2019-Persyaratan-Beton-Struktural-Untuk-Bangunan-Gedung gempa (SNI-1726-2019-Structural-Concrete-Requirements-for-Earthquake-Buildings). (in Indonesian)
- Dewi, D. I. R. (2020). EVALUASI KINERJA STRUKTUR GEDUNG DENGAN METODE PUSHOVER ANALYSIS SESUAI PEDOMAN ATC-40 (Studi Kasus: SMP 3 Muhammadiyah Yogyakarta) [EVALUATION OF BUILDING STRUCTURE PERFORMANCE WITH PUSHOVER ANALYSIS METHOD ACCORDING TO ATC-40 GUIDELINES (Case Study: SMP 3 Muhammadiyah Yogyakarta)]. *Inersia: Jurnal Teknik Sipil*, 12(1), 1–11. <https://doi.org/10.33369/ijts.12.1.1-11> (in Indonesian)
- Effendi, F., Wesli, W., Chandra, Y., & Akbar, S. J. (2018). Studi Penempatan Dinding Geser Terhadap Waktu Getar Alami Fundamental Struktur Gedung [Study of Shear Wall Placement on the Natural Fundamental Vibration Period of Building Structures]. *Teras Jurnal*, 7(2), 274. <https://doi.org/10.29103/tj.v7i2.133> (in Indonesian)
- Fadilah, H. M., & Walujodjati, E. (2020). Perbandingan Pembebanan Gempa Bangunan Bertingkat Menggunakan Analisis Static Equivalent dan Analisis Dynamic Time History di Kab. Garut [Comparison of Earthquake Loading for Multi-Storey Buildings Using Static Equivalent Analysis and Dynamic Time History Analysis in Garut Regency]. *Jurnal STT Garut*. <http://jurnal.sttgarut.ac.id/> (in Indonesian)
- Fardis, M. N., & Papailia, A. (2021). Seismic design and assessment of structures: From theory to practice. *Earthquake Engineering & Structural Dynamics*, 50(8), 2115–2138. <https://doi.org/10.1002/eqe.3456>
- Lestari, T. I. (2016). PERBANDINGAN SIMPANGAN PADA STRUKTUR BETON BERTULANG DENGAN SISTEM RANGKA PEMIKUL MOMEN KHUSUS (SRPMK) BERTINGKAT 3 DAN 6 AKIBAT GEMPA BERULANG (Studi Literatur) [COMPARISON OF DRIFT IN REINFORCED CONCRETE STRUCTURES WITH SPECIAL MOMENT RESISTING FRAME (SMRF) SYSTEMS FOR 3 AND 6 STORIES DUE TO REPEATED EARTHQUAKES (Literature Review)]. (in Indonesian)
- Mulyo, A., & Utami, D. (2019). ANALISIS KINERJA STRUKTUR GEDUNG BERTINGKAT DENGAN METODE RESPON SPECTRUM DITINJAU PADA DRIFT DAN DISPLACEMENT MENGGUNAKAN SOFTWARE ETABS (Performance Analysis of Building Structural with Spectrum Response Method Reviewed on Management and Control Using ETABS Software). *J.Infras*, 4(1). (in Indonesian)
- SNI 1726-2019. (2019). Tata cara perencanaan ketahanan gempa untuk struktur bangunan gedung dan nongedung [Procedure for earthquake resistance design of building and non-building structures]. Badan Standardisasi Nasional, 8. (in Indonesian)
- SNI 1727-2020. (2020). Penetapan Standar Nasional Indonesia 1727:2020 Beban Desain Minimum dan Kriteria Terkait Untuk Bangunan Gedung dan Struktur [Determination of Indonesian National Standard 1727:2020 Minimum Design Loads and Associated Criteria for Buildings and Structures]. Badan Standardisasi Nasional, 8, 1–336. (in Indonesian)
- United States Geological Survey. (2023). What is an earthquake? <https://www.usgs.gov/faqs/what-earthquake>