EFFECT OF SOIL TYPE ON LATERAL DISPLACEMENT OF REINFORCED CONCRETE BUILDING

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ABSTRACT

As has happened in various cases of earthquakes, the impact caused by each earthquake event varies, because the earthquake shaking that occurs on the ground is not only influenced by the distance and strength of the earthquake, but also by local soil conditions which are related to the amplification phenomenon. earthquake waves are influenced by the type and thickness of the soil/sediment layer above the bedrock. Reinforced concrete storey buildings are designed to withstand both vertical and horizontal loads. The taller the building, the greater the lateral load that will be received by the building structure. In the design of earthquake-resistant structures, the inelastic behavior of the structure is highly expected for the occurrence of earthquake energy dispersion during both moderate and strong earthquakes. In earthquake-prone countries such as Indonesia, it is required to comply with applicable national standards and the structure can still function and be safe from earthquakes affected by the earthquake. The purpose of this study was to determine how much influence the type of soil has on the lateral displacement of a 10-story reinforced concrete building using shear walls in accordance with earthquake building regulations (SNI 1726, 2019) and loading (SNI 1727, 2020). The results obtained that soft soil types have the largest displacement value with a value of 91,831 mm and hard rock soil types have the smallest displacement value with a value of 44,114 mm.

Keywords : *Earthquake; Displacement; Dual system; Reinforced concrete; Shear wall*

INTRODUCTION

As has happened in various cases of earthquakes, the impact caused by each earthquake event varies, because the earthquake shaking that occurs on the ground is not only influenced by the distance and strength of the earthquake, but also by local soil conditions which are related to the amplification phenomenon. earthquake waves are influenced by the type and thickness of the soil/sediment layer above the bedrock (Irsyam et al., 2007). When an earthquake occurs, the first thing that feels the vibration is the ground around the epicenter. The vibrations caused by the earthquake were then spread in all directions to the location of the earthquake recorder on the ground. As long as the vibration spreads from the epicenter to the ground surface, the soil factor as a vibration conductor has a very important role (Irsyam et al., 2010).

Buildings in earthquake-prone areas must be planned to be able to withstand earthquakes by using a special moment-bearing frame system. Reinforced concrete storey buildings are designed to withstand both vertical and horizontal loads. The taller the building, the greater the lateral load that will be received by the building structure. (Zebua & K, 2022). In the design of earthquake-resistant structures, the inelastic behavior of the structure is expected for the dispersion of earthquake energy during both moderate and strong

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earthquakes. The design of earthquake-resistant buildings is required to plan columns and beams according to SNI rules (Fakhrurrazi et al, 2018). In reducing the existing earthquake load, it is necessary to use shear walls (Schodek, 1991; Nawy, 2009). In reducing lateral loads, shear wall installation is more effective if its location is at the core location and the outer side of the building. The concept of boundary elements in the use of shear walls is very appropriate in reducing deformation in a building (Cheng et al., 2020;). In earthquake-prone countries such as Indonesia, it is required to comply with applicable national standards and the structure can still function and be safe from earthquakes affected by the earthquake (Zebua et al., 2020).

The essence of the purpose of this study is to find out how much influence the soil type has on the lateral displacement of a 10-story reinforced concrete building using shear walls in accordance with earthquake building regulations (SNI 1726, 2019) and loading (SNI 1727, 2020).

METHODS

1. Concept Research Process

The research step starts from data collection and ends with the conclusions that have been presented in the flow chart Figure 1.

2. Research Types and Concepts

This study analyzes a 10-story reinforced concrete building that is planned according to the latest reinforced concrete regulations (SNI 2847,2019) to determine the effect of soil type on the lateral displacement of the building.

3. Building Load

The load used in this study uses live load, dead load and seismic load (linear static). Earthquake load data uses data from the 2021 earthquake map available on the Puskim website.

4. Combination Loading

The load used in this study uses live load, dead load and seismic load (linear static). Earthquake load data uses data from the 2021 earthquake map available on the Puskim website.

1. U = 1.4 D
2. U = 1.2 D + 1.6 L
3. U = 1.2 D ± 1.0 E + 0.5 L
4. U = 0.9 D ± 1.0 E

RESULTS AND DISCUSSION

1. Building Data and Structure

The building modeling in this analysis is made of 5 buildings according to the soil type parameters, with a height of 10 floors, a distance between portals of 4 meters and a height between floors of 3.5 meters. The total height of the building is 35 meters. The dimensions of the beam used are 25cm x 40 cm, the column size is 65 x 65cm, the plate size is 120cm, the shear wall size is 35 cm and the R value is 8.

The research location uses the Nias area using data on soft soil, medium soil, hard soil, rock soil, hard rock soil and the function of the building as a residence.

2. Drift Analysis

According to the results of the displacement, calculations are carried out based on the target displacement in a 10-story building with the regulation of SNI 1726 (2019) calculated according to the formula given below.

$$\delta_S = \frac{C_d \, x \, \delta_{se}}{I} \qquad (1)$$

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Where :
δ_{se} = displacement on the xth floor
C_d = magnification factor per (5.5)
I = priority factor (1.5)
Δ =Displacement

$\Delta_1 = \delta_{S2} - \delta_{S1}$
$\Delta_a = 0.020h_x$

In the rules of SNI 1726 (2019), it is necessary to control the displacement limits due to static lateral earthquake loads, below in tables 1 to 5, the displacement between floors is explained by the maximum allowable limit of the rules of SNI 1726 (2019), as below. The maximum limit of the displacement between floors in this study is 70 mm.

From all tables 1 - 5, it is known that all buildings of soft soil type, medium soil type, hard soil type, rock soil type and hard rock soil type that are planned have met the standard displacement limit between floors which has been calculated according to the requirements of SNI 1726 (2019) regulations.

Results of Building Lateral Differences
The value of the lateral displacement is taken on each floor. The results of the summary of lateral displacement of soft soil type, medium soil type, hard soil type, rock soil type and hard rock soil type are presented in **Table 6.**

From the **Figure 5**, it can be seen that buildings with soft soil types have the largest displacement, and buildings located on hard rock soil have small displacement values.

CONCLUSION

The results of the analysis carried out that the largest displacement value is found in the type of soft soil, it can be seen that the graph reaches 91,831 mm**.** The smallest displacement value is found in hard rock types with a displacement value reaching 44,114**.** The displacement value of hard rock and rock soil types does not show a significant difference. The hard rock soil type has a max value of 44,114 and the rocky soil type is 44,204.

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Appendix

Table 1. Drift limit control due to static seismic load equivalent soft soil type

Floor	H (m)	δ_e	δ	Δ	$\Delta_{a\ (0.02Hx)}$	Desc.
Roof	3.5	91.831	162.08	17.41	70	Yes
10	3.5	81.965	144.67	18.61	70	Yes
9	3.5	71.42	126.06	19.40	70	Yes
8	3.5	60.43	106.66	19.86	70	Yes
7	3.5	49.181	86.80	19.77	70	Yes
6	3.5	37.981	67.04	18.97	70	Yes
5	3.5	27.233	48.07	17.31	70	Yes
4	3.5	17.423	30.75	14.66	70	Yes
3	3.5	9.121	16.10	10.89	70	Yes
2	3.5	2.949	5.21	5.21	70	Yes
Base	0	0	0	0	0	Yes

Table 2. Drift limit control due to static seismic load equivalent to medium soil type

Floor	H (m)	δ_e	δ	Δ	$\Delta_{a\ (0.02Hx)}$	Desc.
Roof	3.5	78.057	286.21	30.75	70	Yes
10	3.5	69.67	255.46	32.86	70	Yes
9	3.5	60.707	222.59	34.25	70	Yes
8	3.5	51.366	188.34	35.06	70	Yes
7	3.5	41.804	153.28	34.91	70	Yes
6	3.5	32.284	118.37	33.50	70	Yes
5	3.5	23.148	84.88	30.57	70	Yes
4	3.5	14.81	54.30	25.88	70	Yes
3	3.5	7.753	28.43	19.24	70	Yes
2	3.5	2.507	9.19	9.19	70	Yes
Base	0	0	0	0	0	Yes

Table 3. Drift limit control due to static seismic load equivalent to hard soil type

Floor	H (m)	δ_e	δ	Δ	$\Delta_{a\ (0.02Hx)}$	Desc.
Roof	3.5	64.282	235.70	25.32	70	Yes
10	3.5	57.376	210.38	27.07	70	Yes
9	3.5	49.994	183.31	28.21	70	Yes
8	3.5	42.301	155.10	28.87	70	Yes
7	3.5	34.427	126.23	28.75	70	Yes
6	3.5	26.587	97.49	27.59	70	Yes
5	3.5	19.063	69.90	25.18	70	Yes
4	3.5	12.196	44.72	21.31	70	Yes
3	3.5	6.385	23.41	15.84	70	Yes
2	3.5	2.065	7.57	7.57	70	Yes
Base	0	0	0	0	0	Yes

Table 4. Drift limit control due to static seismic load equivalent to rock type

Floor	H (m)	δ_e	δ	Δ	$\Delta_{a\ (0.02Hx)}$	Desc.
Roof	3.5	44.204	162.08	17.413	70	Yes
10	3.5	39.455	144.67	18.612	70	Yes
9	3.5	34.379	126.06	19.397	70	Yes

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8	3.5	29.089	106.66	19.855	70	Yes
7	3.5	23.674	86.80	19.767	70	Yes
6	3.5	18.283	67.04	18.971	70	Yes
5	3.5	13.109	48.07	17.314	70	Yes
4	3.5	8.387	30.75	14.656	70	Yes
3	3.5	4.39	16.10	10.890	70	Yes
2	3.5	1.42	5.21	5.207	70	Yes
Base	0	0	0	0	0	Yes

Table 5. Drift limit control due to static seismic load equivalent to hard rock soil type

Floor	**H (m)**	**δ_e**	**δ**	**Δ**	**$\Delta_{a\ (0.02Hx)}$**	**Desc.**
Roof	3.5	44.114	161.71	17.413	70	Yes
10	3.5	39.355	144.30	18.612	70	Yes
9	3.5	34.279	125.69	22.697	70	Yes
8	3.5	28.089	102.99	16.555	70	Yes
7	3.5	23.574	86.44	19.767	70	Yes
6	3.5	18.183	66.67	18.971	70	Yes
5	3.5	13.009	47.70	17.314	70	Yes
4	3.5	8.287	30.39	14.656	70	Yes
3	3.5	4.29	15.73	10.890	70	Yes
2	3.5	1.32	4.84	4.840	70	Yes
Base	0	0	0	0	0	Yes

Table 6. Building Lateral Displacement

Floor	**H (m)**	**Soft soil type (Δ)**	**Medium soil type (Δ)**	**Hard soil tyoe (Δ)**	**Rock soil type (Δ)**	**Hard rock soil type (Δ)**
Roof	3.5	91.831	78.057	64.282	44.204	44.114
10	3.5	81.965	69.67	57.376	39.455	39.355
9	3.5	71.42	60.707	49.994	34.379	34.279
8	3.5	60.43	51.366	42.301	29.089	28.089
7	3.5	49.181	41.804	34.427	23.674	23.574
6	3.5	37.981	32.284	26.587	18.283	18.183
5	3.5	27.233	23.148	19.063	13.109	13.009
4	3.5	17.423	14.81	12.196	8.387	8.287
3	3.5	9.121	7.753	6.385	4.39	4.29
2	3.5	2.949	2.507	2.065	1.42	1.32
Base	0	0	0	0	0	0

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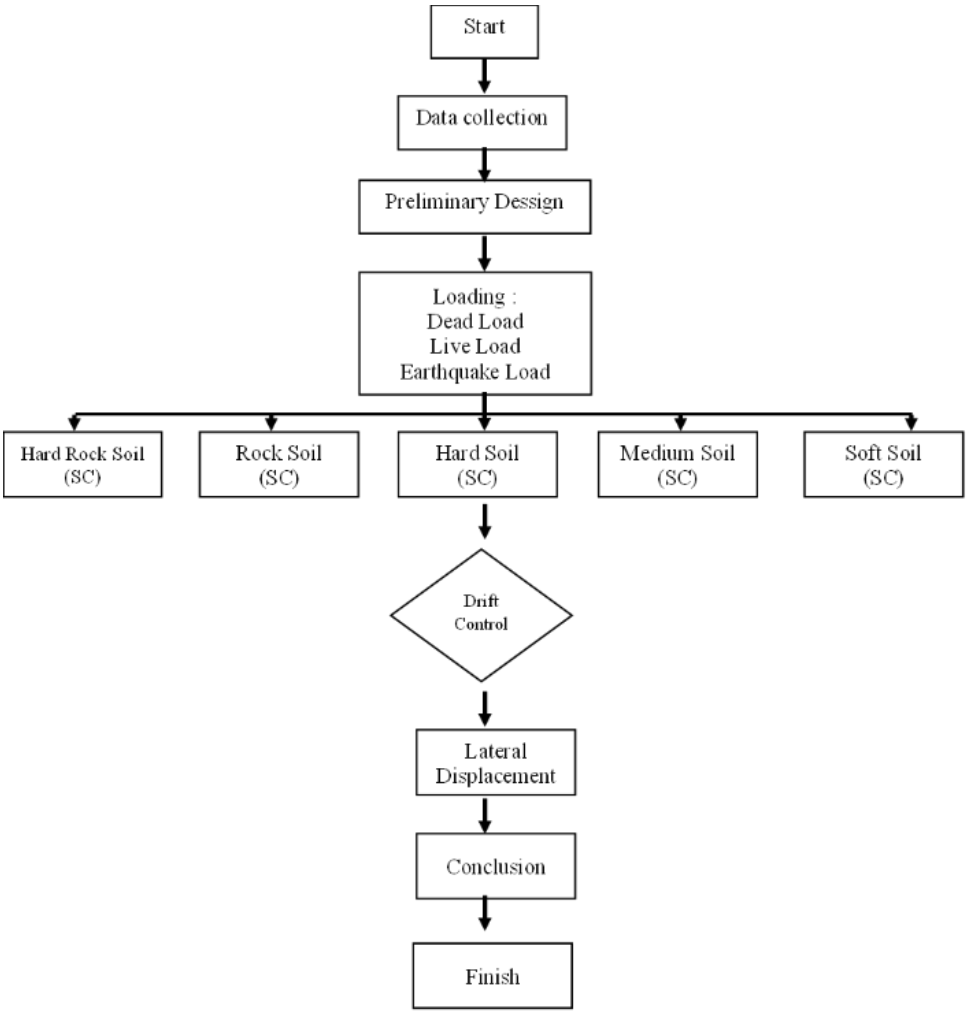

Figure 1. Research Flowchart

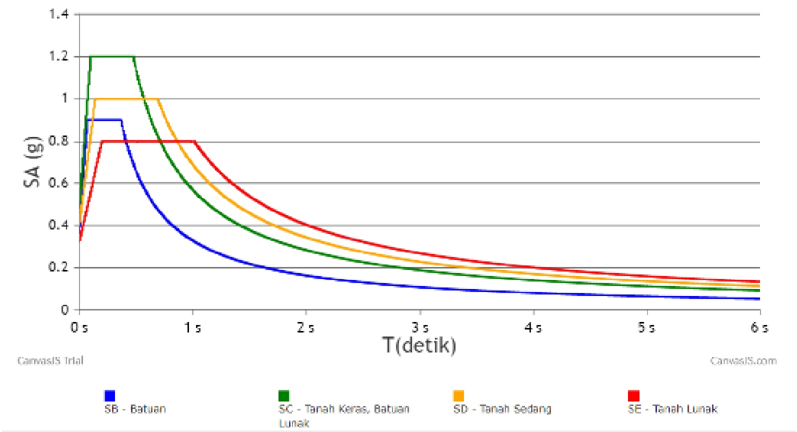

Figure 2. Spectrum of design response

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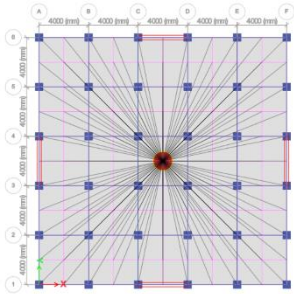

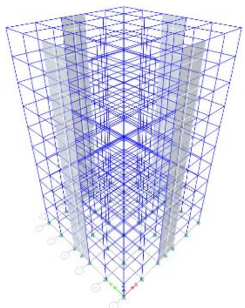

(a) Model view of the building structure (b) 3D Model of Building Structure

Figure 3. Plan View

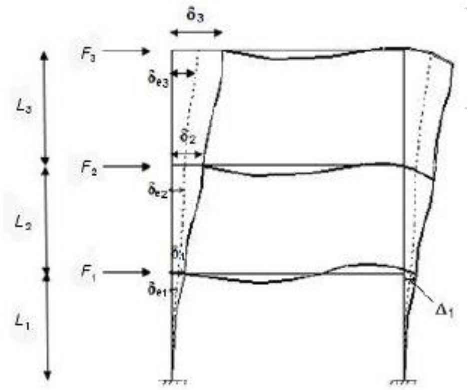

Figure 4. Determination of the displacement between floors

Source: SNI 1726-2019

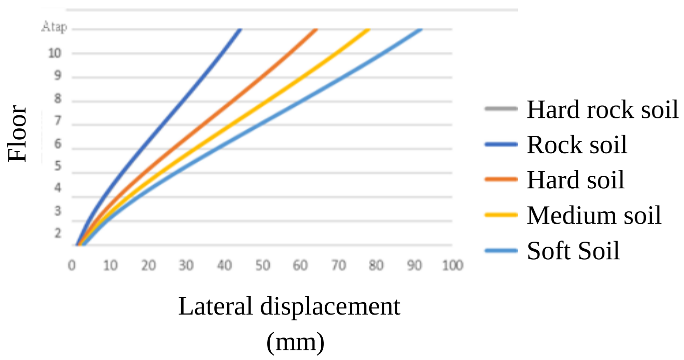

Figure 5. Lateral Displacement with Building Floor

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