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ANALYSIS OF PEAK EARTHQUAKE ACCELERATION (PGA) VALUE IN THE DUMAI DURI KANDIS ROAD AREA KM 68 + 975 USING PSEUDOSTATIC ANALYSIS

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Abstract

This study aims to analyze the acceleration value of peak earthquakes with pseudostatic in Riau Province using exploratory research. Earthquakes are one of the natural disasters that often occur in Indonesia. In addition to its high intensity, the impact caused often causes a lot of losses. As one of a high potentialy seismic activity province, Riau is vulnerable to earthquake disasters, the road sections are traversed by heavily loaded vehicles such as on Jalan Dumai Duri Kandis KM 68 + 975 which borders several areas at high risk of earthquakes, so an analysis of the acceleration value of peak earthquakes is needed. The results were found that the earthquake plan that can be used on the Dumai Duri Kandis KM 68 + 975 road section for analysis is PGA = 0.25-0.3g and PGA = 0.25g is taken, the average N-SPT value obtained is 10, based on the average N-SPT value obtained the site classification for its location in the form of soft soil, based on the site classification obtained, the amplification factor for the PGA Soft Land site class = 0.2, Ss = 0.5 is 1.7 while for the Soft Land site class PGA = 0.3, Ss = 0.75 is 1.2. After interpolating obtained FPGA value = 1.45 (for PGA = 0.25), the peak acceleration value of the earthquake on Dumai Kandis Road was 0.1088 g which was needed to analyze slope stability using soil parameter data sourced from laboratory to obtain more accurate safety factor.

Keywords: Earthquake, Soil Reinforcement, Exploratory Research

Introduction

Earthquakes are one of the disasters that often occur in Indonesia with a high level of intensity (Mase et al., 2020), resulting in a lot of loss and damage (Farisi, 2020; Muhaimin et al., 2016). This is influenced by Indonesia's location in the *ring of fire* (Pambudi, 2017), making it prone to earthquakes (Nasruddin et al., 2016).(Nasruddin et al., 2016) According to data from the Central Statistics Agency (2021), throughout 2021 earthquake disasters in Indonesia have occurred 8,726 times and claimed many lives (Hadi et al., 2019).(Hadi et al., 2019) One of the provinces in Indonesia that has the potential for earthquake disasters is Riau Province, this is because this province is directly adjacent to West Sumatra Province, which is known for its high seismic activity potential (Ismayani et al., 2021; Saputra et al., 2020), as a result of which several areas in this province that are directly adjacent or adjacent to West Sumatra Province also received overflow from the high disaster activity. Some of them are in Rokan Hulu Regency, Kampar Regency, and Kuantan Sangingi Regency (Saputra &; Makrup, 2021), where the value of accelerating ground movement will shrink along with the increasing distance from the earthquake source. This is comparable to the closer the distance, the greater the value of the earthquake acceleration that occurs in the three locations. This means that the closer distance causes the earthquake acceleration value at the study location to be of high value (Suryanita et al., 2016) as in the three districts (Saputra et al., 2021).

Jalan Dumai Duri Kandis KM 68 + 975 is a road section adjacent to the three locations above, the road section has soil conditions that are prone to earthquakes and landslides that cause piles on the road section (Bokko et al., 2019). This location is traversed by many vehicles with heavy loads (Sandhyavitri &; Saputra, 2019; Sentosa & Dewi, 2011) so that the potential danger needs to be anticipated because it concerns the safety of the public. Jalan Dumai Duri Kandis KM 68 + 975 also has a sloped road section, this situation adds to the potential risk of earthquake activity opportunities.

The disaster risk needs to be further identified to get a more in-depth analysis of the steps that must be taken in preventing and overcoming earthquakes, one of which must be known is the analysis of the acceleration value of the peak earthquake (Hasibuan &; Hasibuan, 2020; Pasau &; Tanauma, 2011) which can be used to assess the potential damage caused (Partono et al., 2019). With a sloped terrain, one of the anticipations that can be done is through strengthening the soil retaining wall with *bored pile* (Himawan et al., 2017), this is in order to prevent further impacts such as landslides (Subhan et al., 2020). However, this does not yet have a really strong basis, so in determining the right strategic steps, a more detailed study is needed to get a clearer picture of the level of risk that will occur so that it can be used as a reference and more mature consideration.

In assessing earthquake activity in an area, pseudostatic analysis is widely used (Pujianto et al., 2017; Rekzyanti et al., 2016; Yudianto et al., 2022). This analysis is one of the methods used in the calculation of earthquake strength which is a derivative of Newton's second law, this analysis assumes that the collapse field is in an active condition (Tjie-liong et al., 2013). The pseudostatic method is commonly used in strengthening slopes (Nurhidayah et al., 2022) by changing the force arising from earthquake loads from dynamic to static (Pramulandani, 2020), the method applies lateral force work through the center of mass towards the outside of the slope. This method is widely used because it is easier to understand and apply (Pujianto et al., 2017).

In this study, an assessment of the value of peak earthquake acceleration will be carried out with pseudostatic analysis by reviewing it using exploratory research methods. The results can be used as an illustration and basis for decision making to anticipate and improve the condition of the Dumai Duri Kandis KM 68 + 975 Road section due to the potential risk of earthquakes it has.

Research Methodology

This research is an exploratory research used to solve and study problems in the field (Janah et al., 2016; Mudjiyanto, 2018) in this case is an analysis of the stability of slopes and soil retaining walls on Jalan Dumai Duri Kandis KM 68 + 975 Riau Province. The data used for this study consisted of primary and secondary data.

Primary data is in the form of soil parameters and is taken using 2 methods, namely machine drill and SPT. The purpose of this drilling is to take *undisturbed* soil samples so that later the soil samples can be identified (Iqbal et al., 2017) while the N-SPT test aims to obtain physical parameters and soil strength. Secondary data were obtained from previous studies that had been conducted related to the investigation of soil characteristics in the area.

This study aims to provide an analysis related to the potential for landslides in these vulnerable areas with pseudostatic analysis as a basis for consideration in determining the prevention and mitigation of these potential hazards, especially in infrastructure aspects to support better mobility and comfort sustainability for each user (Shobari et al., 2019).

Research Results and Discussion

The result of this study is to analyze slope stability under earthquake conditions (Febriansya et al., 2021; Wardana, 2011). Analysis of the peak acceleration of the earthquake was carried out by pseudostatic method (Pramulandani &; Hamdhan, 2020). This is done to determine how much the value of the safety factor of slope protection with soil retaining walls (Kuningsih et al., 2011) and to determine the effect of earthquake loads that occur on the slope (Guntur &; Siregar, 2023). The parameters for calculating the earthquake load on Jalan Dumai Duri Kandis KM 68+975 are as follows:

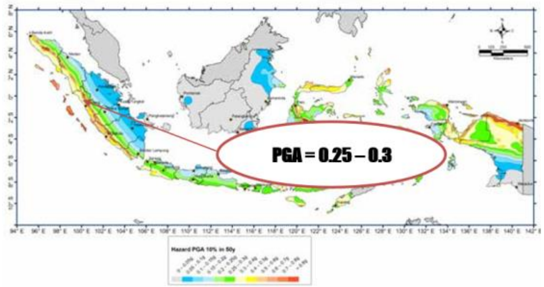

Figure 1. 2017 earthquake map 10% probability in 50 years

Based on SNI 8460:2017 Subarticle 7.5.1.1 seismicity planning design for slopes is determined with the possibility of exceeding the magnitude during the 50-year plan life is 10% (National Standardization Agency, 2017). Thus, for the Dumai Duri Kandis Road section, the earthquake plan used for analysis is PGA = 0.25-0.3g and taken PGA = 0.25g.

Earthquake load analysis on the 2D PLAXIS numerical program (Mansur et al., 2019; Mina et al., 2022; Yakin et al., 2022) was carried out by pseudostatic modeling through the necessary input, namely the value of peak acceleration on the surface (Waskito et al., 2016). The acceleration value is obtained by determining the site class, amplification factor, and average design tax return.

The way the *pseudostatic method works* is by providing an additional static load from the earthquake load. So that the earthquake force becomes the acceleration of the earthquake multiplied by the weight of the structure. This study used original earthquake data so that the effects of swaying in the opposite direction/alternating direction could be included. Because it is a little complex, therefore in this study *pseudostatic* analysis is used in earthquake load analysis.

Determination of Average N-SPT Value

$$\overline{N_{60}} = \frac{\sum di}{\sum \frac{di}{N}}$$

Where:

di represents the thickness of the later and N is the SPT value of each layer thickness

Table 1. Design for Determining Average Tax Return

No	di	N	di/N
1	7	4	1.75
2	3	9	0.33
3	7	15	0.47
4	13	34	0.38

$$\overline{N_{60}} = \frac{30}{2.932} = 10$$

Based on the calculation of the average N-SPT value, the N-SPT value of Jalan Dumai Kandis is 10.

Determination of Site Classification Based on Average N-SPT

Table 2. Site classification based on SNI 8460:2017

Site Classification	$\bar{v}_s$ (m/seconds)	$\bar{N}_{SPT}$ or $\bar{N}_{SPTch}$	$\bar{S}_u$
SA (hard rock)	> 1.500	N/A	N/A
SB (bedrock)	750 - 1.500	N/A	N/A
SC (hard soil, very dense, and soft rocks)	350 - 750	> 50	≥ 100
SD (medium soil)	175 - 350	15 - 50	50 - 100
SE (soft soil)	< 175	< 15	< 50
	Or any soil profile containing more than 3 m with the following characteristics: 1. Plasticity Index, PI > 20 2. Up to air, (w) ≥ 40 or any soil profile containing more than 3 m with the following characteristics %, and 3. Flowless shear strength, Su < 25 kPa		
SF (special soil, which requires site-specific geotechnical investigation and site-specific response analysis)	Any subsoil profile that has one or more of the characteristics such as: - Prone and potentially failed or collapsed due to earthquake loads such as easy liquefaction, very sensitive clay, weak cemented soil - Highly organic clay and/or peat (thickness, H > 3m) - High plasticity clay (thickness, H > 7.5 m with Plasticity Index, PI > 75 - Soft/half-firm clay layer with a thickness of H > 35 m with *Su* < 50 kPa		

Based on the calculation of the average N-SPT in point a, it can be seen that the site classification based on SNI 8460:2017 for the Dumai Kandis road is included in the Tanah Soft (SE) site classification because the value is < 15 or 10.

Amplification Factor

Based on the classification of the site obtained, which is categorized as Soft Soil (SE), the amplification factor is shown in Table 3.

Table 3. Amplification factor based on SNI 8460:2017

Site Class	PGA ≤ 0.1 $S_s \leq 0.25$	PGA = 0.2 $S_s = 0.5$	PGA = 0.3 $S_s = 0.75$	PGA = 0.4 $S_S = 1.0$	PGA ≥ 0.5 $S_S \geq 1.25$
Hard Rock (SA)	0.8	0.8	0.8	0.8	0.8

Site Class	PGA ≤ 0.1 $S_s \leq 0.25$	PGA = 0.2 $S_s = 0.5$	PGA = 0.3 $S_s = 0.75$	PGA = 0.4 $S_S = 1.0$	PGA ≥ 0.5 $S_S \geq 1.25$
Stones (SB)	1.0	1.0	1.0	1.0	1.0
Hard Soil (SC)	1.2	1.2	1.1	1.0	1.0
Medium Soil (SD)	1.6	1.4	1.2	1.1	1.0
Soft Soil (SE)	2.5	1.7	1.2	0.9	0.9
Special Soil (SF)	SS	SS	SS	SS	SS

Based on table 3 above, it can be seen the amplification factor (FPGA) value obtained based on SNI 8460:2017 by carrying out an interpolation procedure, so that the amplification factor shows the FPGA value = 1.45 (for PGA = 0.25).

Peak Acceleration

The peak ground acceleration value (PGA) is indispensable in designing earthquake-resistant structures (Saputro & Aris, 2018), the value of peak acceleration on the surface is taken by multiplying by the horizontal coefficient, which is formulated as follows: (Partono et al., 2019; Putri et al., 2017):

kh = (1,45 – A) A, so for PGA values = 0.25

a = PGA x FPGA x kh

a = 0.25 x 1.45 x 0.3 = 0.1088 g

So that the peak earthquake acceleration is 0.1088 g.

Conclusion

Based on the results and discussions that have been described, the following conclusions can be drawn:

1. Based on SNI 8460:2017 Subarticle 7.5.1.1, seismicity planning design for slopes is determined with the possibility of exceeding magnitude during the planned life of 50 years is 10%. Thus, for the Dumai Duri Kandis Road section, the earthquake plan that can be used for analysis is PGA = 0.25-0.3g and taken PGA = 0.25g.
2. The average N-SPT value obtained is 10.
3. Based on the average N-SPT value, a site classification for Dumai Kandis Road is obtained in the form of soft soil.
4. Based on the classification of sites obtained, the amplification factor for the PGA Soft Land site class = 0.2, Ss = 0.5 is 1.7 while for the PGA Soft Land site class = 0.3, Ss = 0.75 is 1.2. So after interpolating obtained FPGA value = 1.45 (for PGA = 0.25).
5. The value of the peak acceleration of the earthquake on Dumai Kandis Road is 0.1088 g.

So it is necessary to analyze slope stability using soil parameter data sourced from laboratory test results to obtain more accurate safety factor results.

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