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ANALYSIS OF A PEAK GROUND ACCELERATION VALUE AND EARTHQUAKE INTENSITY USING DONOVAN METHOD IN BANTEN PROVINCE

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ABSTRACT

Analysis of a peak ground acceleration value and earthquake intensity in Banten Province has been carried out using historical earthquake data from 2008 to 2018. This research aims to describe a prone area of the earthquake. The specification of data was a magnitude > 5 SR and the depth 0-70 km. The Donovan method was used to analyze peak ground acceleration value and the earthquake's intensity. According to the data obtained, 31 earthquake points with a maximum earthquake strength occurred on October 16, 2019, with a depth of 10 km and a magnitude of 6.48 SR. This earthquake was located in Ujung Kulon with coordinates -6.81 LS and 105.113 BT. Based on data analysis result was obtained a peak ground acceleration value and the intensity of earthquake maximum in The Pandeglang Regency with a peak ground acceleration value was 211.56 cm/s^2, and intensity of scale VIII and a large risk level of three. While a peak ground acceleration minimum is located in the South Tangerang City was 62.82 cm/s^2 with a scale of intensity VII and a moderate risk level.

Keywords: earthquake, peak ground acceleration, intensity, Donovan method, Banten province

INTRODUCTION

The Indonesian country is an archipelago state on the located encounter of three of the plate are Eurasian plate, Indo Australian plate, and Pacific plate [1]. This condition often induces to happen the earthquake in tectonic and volcanic. Another earthquake trigger is the formation of a subduction zone. A subduction zone is a state where one tectonic plate falls under another tectonic plate. This subduction route extends along the west coast of Sumatra Island, along the south of Java Island, south of Bali, Lombok, Flores, Maluku, and Papua.

Java Island is located between Eurasia and Indo-Australian plates. The movement of this plate is about 6.5 cm/ year around Java and Bali. In the south of the island of Java, the subduction path of the Indo Australian plate is relative to the north against the Eurasian plate, while the Pacific plate moves westward relative to the Eurasian plate and the Indo Australian plate. Earthquakes often occur in an area where tectonic plates meet, which results in a higher earthquake stage in the region. Earthquakes may trigger damage to the construction of buildings. Damage to the construction of buildings is not only caused by the quality of the building being built but also the condition of the land on which the building stands, which can be seen from the level of reinforcement, land retaliation against shocks, and maximum ground acceleration.

Based on the information from the Directorate of volcanology and geological disaster mitigation, the ministry of energy and mineral resources recorded 28 earthquake-prone areas in Indonesia. One of them is the Banten Province [2]. About 45% of the Banten Province is prone to the earthquake. In the West and South are the prone area, the tectonic earthquake cause this area is passed the Indo Australian plate and Eurasian plate [3]. Furthermore, in the Banten Province are the Sunda microplates. There are the zoning zone of microplates and the seismogenic structure that can trigger and cause the earthquake around the Sunda strait [4].

Based on the observations made, the researcher of the earthquake that occurred in Banten Province from 2008 until 2018 with magnitude is > 5 SR. This amount is taken because it has caused damage to structures such as cracks in the wall. The depth is used 0 km until 70 km where were 31 the earthquake points. The following data is shown in FIGURE 1:

FIGURE 1. The distribution of earthquake points in Banten Province in 2008-2018

TABLE 1 shows the time of the location of the depth and magnitude of the earthquake at each point:

TABLE 1. Data of Earthquake in Banten Province from 2008 until 2018 [5].

No	Time	Location	Depth (Km)	Magnitude (SR)
1	2008-11-15 13:00:46	A1	10	5.22
2	2009-03-27 20:53:28	A2	27.7	5.15
3	2009-10-24 03:09:53	A3	14.7	5.06
4	2009-10-16 09:52:50	A4	10	6.48
5	2010-02-20 04:57:33	A5	10	5.03
6	2010-08-11 19:10:23	A6	50.1	5.47
7	2011-01-12 12:44:45	A7	13.1	5.33
8	2011-03-20 01:20:13	A8	10	5.32
9	2011-04-05 04:34:43	A9	49.8	5.1
10	2011-07-17 10:59:09	A10	57.8	5.18
11	2011-08-21 16:54:19	A11	25.8	5.08
12	2012-04-14 19:31:46	A12	20.8	5.36
13	2012-04-14 19:26:41	A13	69.8	5.75
14	2012-06-04 11:18:14	A14	69.6	5.71
15	2013-02-02 01:19:32	A15	10	5.33
16	2013-04-08 18:53:44	A16	48.4	5.17
17	2014-01-09 16:16:48	A17	10	5.36
18	2014-01-05 11:32:10	A18	40.6	5
19	2014-07-09 00:01:32	A19	39.2	5.08
20	2015-11-04 06:14:35	A20	40.1	5.04
21	2016-08-12 07:17:15	A21	50.3	5.07
22	2017-02-08 08:34:17	A22	69.7	5.04
23	2017-07-08 22:48:37	A23	57.3	5.07
24	2017-12-16 00:22:30	A24	37.1	5.44
25	2018-01-26 10:12:50	A25	29.8	5.02
26	2018-01-26 04:48:25	A26	30	5.15
27	2018-01-23 06:34:54	A27	46.2	6.09
28	2018-02-16 13:28:10	A28	48.9	5.03
29	2018-02-16 05:13:02	A29	10	5.09
30	2018-03-19 11:36:27	A30	40.4	5.18
31	2018-10-29 21:11:19	A31	64.7	5.28

Based on TABLE 1, we can see that the maximum earthquake occurred on October 16, 2009, with a depth of 10 km and a magnitude of 6.48 SR. The earthquake is located around Sunda strait is in the west end of Ujung Kulon with coordinates -6.81 LS and 105.113 BT.

In 2018, in the Lebak District occurred an earthquake with a magnitude 6.1 SR. Consequently, there is 1 died, and the 1231 house damaged consists of 1125 light damaged and 106 heavily damaged. The damaged located 16 sub-district on the south coast Banten. Some of the school buildings were damaged too.

In an effort to minimize damage caused by earthquakes, it is necessary to mitigate earthquake disasters by conducting further studies of the spatial area of Banten. One step that can be done is to analyze the value of the peak ground acceleration and intensity of the earthquake that occurred in the Banten Province.

The maximum land shed approach needs to be taken in order to determine the form of building coaching and improve the spatial structure of the areas exposed to earthquakes. The estimation of the maximum land squatter value can be determined in 2 (two) ways, namely by using an acelograph and by using an empirical approach. Some of the methods used through an empirical approach include Gutteberg Richter, Donovan, Esteva, Fukushima Tanaka, Murphy O'brein, Mc Guirre and Kanai.

When an earthquake occurs, a ground acceleration value will be generated somewhere [6]. The value of ground acceleration needed in calculating the design of the building is the peak ground acceleration value. The motion of a peak ground acceleration (PGA) is the biggest value from the ground acceleration in a place caused the earthquake [7]. Although earthquakes with large forces do not occur often, they are still dangerous to human life. This acceleration value indicates the level of risk of damage that will arise to the building. This is needed in adjusting the strength of buildings to be built in the area. Therefore, it is necessary to analyze the value of the peak ground acceleration and intensity of the earthquake that occurred in Banten Province.

METHOD

The Donovan method is one of the methods used to calculate the value of a peak ground acceleration in an area. This method has been widely used by previous investigators in determining the maximum land fraction value in various regions of Indonesia. In 2018 Dwi Romadiana, Syafriani, and Andiyansyah conducted an investigation in analyzing the maximum ground acceleration value in the West Sumatra region using the Donovan method [8]. Apart from that, Cloudya Gabriella Kapojos, Gerald Tamuntuan, and Guntur Pasau have also used the Donovan method in their investigations to analyze the maximum land shed in the North Peninsula area of Sulawesi Island. Based on this, the reviewer also applied the Donovan method to the study area in Banten Province. Before calculating a peak ground acceleration value, epicenter, hypocenter, and surface magnitude values must be determined in advance. The following steps are taken to get the peak ground acceleration [9]:

1. Determine the location of the epicenter using the following equation:

   $$E_p = 111 * \sqrt{(lo - li)^2 + (bo - bi)^2}$$

   E_p in a kilometer, lo, li, bo, bi in degree.
2. Determine the distance of the hypocenter using the equation:

   $$\Delta = \sqrt{E_p{}^2 + h^2}$$

   Δ is hypocenter distance (km) and h is a depth (km).
3. Determine the surface magnitude

   $$M_s = 1{,}78 * Magnitudo - 5.17$$

M_s is the surface magnitude (SR)

4. Determine the peak ground acceleration value [10]:

$$\alpha = \frac{1080\exp(0.5M_s)}{(\Delta+25)^{1.32}}$$

α is the peak ground acceleration value (gal or cm/s^2).

For analyzing the earthquake intensity we can use TABLE 2:

TABLE 2: The level of risk of earthquake damage [11].

No	The level of risk	Acceleration (cm/s^2)	Intensity (MMI)
1	Very little risk	<25	<VI
2	Little risk	25-50	VI-VII
3	The first of moderate risk	50-75	VII-VIII
4	The second of moderate risk	75-100	VII-VIII
5	The third of moderate risk	100-125	VII-VIII
6	The first of big risk	125-150	VIII-IX
7	The second of big risk	150-200	VIII-IX
8	The third of big risk	200-300	VIII-IX
9	The first of very big risk	300-600	IX-X
10	The second of very risk	>600	>X

RESULT AND DISCUSSION

Data analysis has been carried out using the Donovan method to obtain the maximum acceleration value and the level of risk caused by the earthquake for each district and city in Banten Province. Banten Province consists of 4 (four) districts and 4 (four) cities, namely Pandeglang Regency, Lebak Regency, Serang Regency, Tangerang Regency, Serang City, Cilegon City, Tangerang City, and South Tangerang City.

A. A Peak Ground Acceleration

When an earthquake occurs, it will produce an acceleration of the ground. The ground acceleration is different depending on the location of the earthquake point.

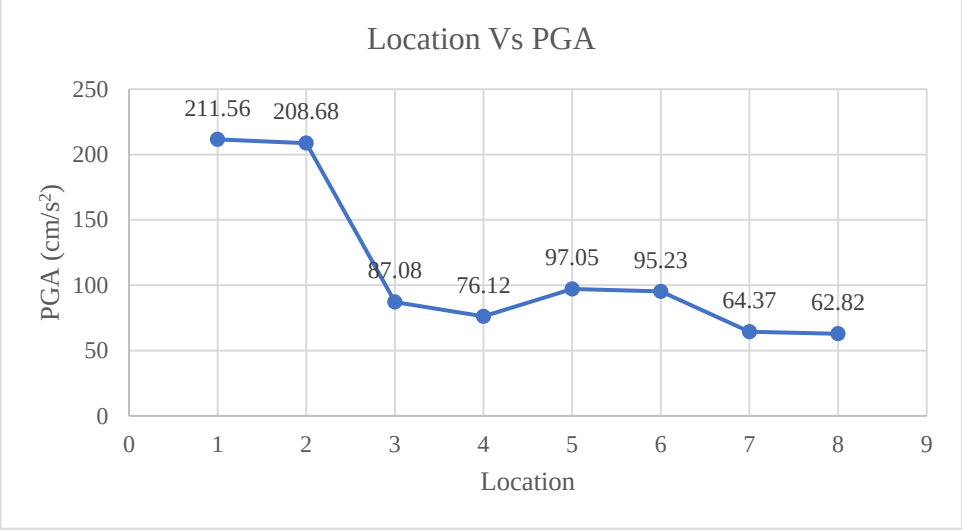

FIGURE 2. The chart of distribution PGA's value with the locatin in Banten Province

First, Pandeglang Regency has a maximum peak ground acceleration value of 211.56 cm/s^2. This happened at point A4 that had a magnitude of 6.4 SR and a depth 10 km. While the minimum of peak ground acceleration value is 18.91 cm/s^2 that which happened at point A22. Second, Lebak Regency has the greatest of a peak ground acceleration value is 208.68 cm/s^2 that caused at A4 point and the smallest of peak ground acceleration value is 19.07 cm/s^2 that occurred by A22 point. Third, Serang Regency has the highest peak ground acceleration value is caused A4 point with 87.08 cm/s^2. While the smallest of a peak ground acceleration value is 1.40 cm/s^2 that caused at A22 point. Fourth, Tangerang Regency obtained the greatest peak ground acceleration value of 76.12 cm/s^2 and the smallest of a peak ground acceleration value is 1.42 cm/s^2 . The maximum value is used by A4 point and the minimum value is caused by A22 point.

Next in the cities in Banten Province, the first in the city of Cilegon, which has the largest of a peak ground acceleration value is 97.05 cm/s^2. That occurred at A4 point. Whereas the smallest of a peak ground acceleration value is 1.38 cm/s^2 . That was caused by A22 points. Secondly, the city of Serang has a maximum of peak ground acceleration value is 95.23 cm/s^2 and the smallest of peak ground acceleration value is 1.40 cm/s^2. Each value was occurred by A4 point for maximum value and at A22 for minimum value. The third in the city of Tangerang has the largest of a peak ground acceleration value is 64.37 cm/s^2 that is caused by A4 point. Whereas the smallest of a peak ground acceleration value is 1.42 cm/s^2 that occurred by A22 point. Fourth, South Tangerang City has a maximum of a peak ground acceleration value is 62.82 cm/s^2 and the smallest of a peak ground acceleration value is 1.43 cm/s^2. There are caused by A4 for maximum value and A22 for minimum value.

Based on the results of data analysis in each regency and city in Banten Province due to the earthquake, the highest maximum ground acceleration value is due to the earthquake that occurred at point A4 with an earthquake magnitude of 6.4 SR and a depth of 10 km. Pandeglang Regency was very impacted by the earthquake. But the smallest of a peak ground acceleration happened at A22 point with the magnitude 5.04 SR and the depth 69.7 km. This was caused the distance position a point and the strength of the earthquake to be determined area.

B. Intensity of Earthquake

The intensity of the earthquake will be connected with a peak ground acceleration value. This value describes the level of risk when the earthquake happened. The scale usually is used MMI (Modified Mercally Intensity).

The Pandeglang Regency has a peak ground acceleration value of 211.56 cm/s^2 with a level of risk including a large risk of three. The effect obtained by the strength of this earthquake is a lot of cracks in the walls of buildings, some collapsed, broken glass. Apart from that, some of the wall plaster came off. Most of the roof is shifting down or falling and the structure of the building has mild to moderate damage.

Then, Lebak Regency has the greatest of a peak ground acceleration value is 208.68 cm/s^2 with a large risk level of three. The impact that occurred was almost the same as that occurred in Pandeglang district that was structural damage such as cracks in walls, collapsed buildings, broken glass, and loose wall plaster.

Next, Serang Regency has the highest peak ground acceleration value is 87.08 cm/s^2 with a moderate risk level of two. The acceleration of this land can still be felt by many people but does not cause damage. The hanging objects are vibrate and so are the glass window.

Then Tangerang Regency obtained the greatest peak ground acceleration value is 76.12 cm/s^2 with a moderate risk level of two. The impact felt is almost the same as Serang Regency, where the earthquake occurred it could be felt but did not cause damage and light objects that were hung swayed.

Then, the city of Cilegon, which has the largest peak ground acceleration value of 97.05 cm/s^2 with a moderate risk level of two. The effects that occur in non-structural parts of the building suffer a little damage, such as hair cracks on the wall; the roof shifts downward and partially falls.

Next, the city of Serang has a maximum of peak ground acceleration; the value is 95.23 cm/s^2 with a moderate risk level of two. The impact felt was almost the same as that of Cilegon City, where the building suffered minor damage, cracks occurred, and the roof shifted down, and some of the roofs fell. Then in the city of Tangerang has the largest peak ground acceleration value is 64.37 cm/s^{2,} with a moderate level of risk. The impact that occurred was that the earthquake was felt but did not cause damage. The hanging objects sway, and the window was vibrated.

The last, South Tangerang City has a maximum of peak ground acceleration; the value is 62.82 cm/s^2 with a moderate level of risk. The effect is felt almost the same as in Kota Tangerang, where the ground acceleration can be felt by many people but does not cause damage. The object that was hanging shook, and the window glass was too.

So, we can deduce the level of risk about a large risk of three until a very small risk level. This was caused by the distance of the earthquake's point to the location that is found. If the earthquake's point had shorter to a place, so in the place would have a big risk to damage of the earthquake. While if the location further from the point of the earthquake, so the damage was easy.

CONCLUSION

The Donovan method is a method that can be used to determine the peak ground acceleration value. Based on the results of the data analysis above, it can be concluded that Pandeglang Regency is an area that has the greatest peak ground acceleration value, which has a value of up to 211.56 cm /s^2. This peak ground shedding was caused by an earthquake measuring 6.4 on the Richter scale and a depth of 10 km. The earthquake impact is included in stage VII with a high-risk stage of three.

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