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The Effect of Earthquake and Volcanic Eruption to the Nuclear Installation: A Retrospective on 2006 Yogyakarta Earthquake and Merapi Eruption

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ABSTRACT

Earthquake hitting Yogyakarta, Indonesia on May 27th, 2006 that was followed by volcanic eruption of Mount Merapi had been pronounced as one of the most severe natural disasters ever occurred in the national history alongside the Tsunami happened in Aceh, Indonesia on 2004. The earthquake was caused by the activity of Opak faults which is located only ± 7 km away from Kartini nuclear reactor in the Yogyakarta province, Indonesia. This study aims to emphasize on the importance of disaster management mitigation to reduce the potential risk in future possibilities of natural disaster reoccurrence. It was concluded that retrofitting on the nuclear installation setup to withstand earthquake and volcanic eruption along with increasing people awareness and preparedness by arranging trainings on emergency response periodically are of great necessities to reduce the risk in time of disaster. Other than that, this work also described about the community service activities done by Indonesian National Nuclear Agency to help with the community revival post disasters.

Keywords: Disaster Mitigation, Earthquake, Volcanic Eruption, Nuclear Installation, Yogyakarta

1. INTRODUCTION

Fifteen years ago, on May 27, 2006, an earthquake measuring 5.9 on the Richter scale occurred in Yogyakarta and its surroundings. It was the second largest natural disaster to occur after the 2004 Aceh tsunami, which killed 170,000 people. At the time the earthquake occurred, the people of Yogyakarta were facing the fear of the threat of an eruption of Mount Merapi as well.

Based on the data from the Indonesian Destructive Earthquake Catalog and a map of earthquake-prone areas compiled by the Center for Volcanology and Geological Hazard Mitigation, the Yogyakarta area is one of the areas prone to destructive earthquakes. The complete data is presented in **Table 1**. [2]

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Table 1. Catalogue of the earthquake causing damage at Yogyakarta

No.	Earthquake Name	Date	Location	Altitude (Km)	MAG	MMI Scale	Damage
1.	Yogyakarta	10/6/1867	-	-	-	VIII-IX	The magnitude of the earthquake was felt in Surakarta, 372 houses collapsed, 5 people died
2.	Yogyakarta	23/7/1943	8.6^0 LS-109.9^0BT	-	-	VIII-IX	The magnitude of the earthquake was felt from Garut to Surakarta, 213 people died, 2,096 people were injured, 2,800 houses were destroyed
3.	Yogyakarta	13/1/1981	7.2^0LS-109.3^0 BT	-	-	VI	The magnitude of the earthquake was prominently felt in Yogyakarta.
4.	Yogyakarta	27/5/2006 05:54;01 WIB	17.2 km	8.007^0 LS-110.286^0 BT	62 Mw	VII	More than 5,700 people died, thousands were injured in Yogyakarta and Central Java, landslides and soil cracks occurred, liquifaction and thousands of buildings and houses collapsed.

According to Harian Kompas, Sunday (28/5/2006), there were 3,098 deaths and 2,971 were injured from Bantul Regency on Saturday, 27 May 2006 until 00.15 WIB. The earthquake also destroyed 3,824 buildings, infrastructure and cut telecommunication networks in Yogyakarta and Bantul. The victims affected were not only in Bantul area, but also in Yogyakarta, Sleman, Kulon Progo, Gunung Kidul, Klaten, and even Boyolali. Most of the victims death was caused by collapsing buildings. Meanwhile, many injured victims occurred because of the extraordinary panic.[1]

Therefore, this paper aims to make us aware of the importance of disaster management and mitigation efforts that must be carried out continuously to minimize the risk of earthquakes and the eruption of Mount Merapi in the Yogyakarta area which may be repeated in the future.

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2. METHOD

This work was written based on the literature review compiled from the Disaster Management and Mitigation report related to Yogyakarta earthquake that occurred on May 27th, 2007, and the eruption of Merapi volcano. Government-related report and published articles regarding the event were used as the main source for the data used for the current elaboration.

Some of the reports used as a base for this research were including Joint report with BAPPENAS, D.I.Yogyakarta Provincial and Regional Governments, Central Java Provincial and Regional Governments and International Partners and the Report on the Activities of the 2006 Yogjakarta Disaster Victim Care Post, PSTA-BATAN Yogyakarta, 2006.

3. RESULTS AND DISCUSSION

3.1. Event Description of Earthquake in Yogyakarta

The earthquake that occurred on May 27, 2005, was called the Yogyakarta Earthquake, because the worst disaster occurred in this area. According to the United State Geological Survey (USGS) Station, the epicenter is located on land and is thought to have occurred due to the activity of a horizontal fault system in the Yogyakarta area which is trending southwest – northeast. Meanwhile, based on the calculation of the TTD DESDM, the location of the earthquake center is located on land at coordinates 7.89° South Latitude – 110.37° East Longitude or is located at a position of ± 1.5 km northeast of Bantul City, Special Region of Yogyakarta Province.

Based on the analysis of the focal mechanism issued by the USGS, the type of fault that caused the earthquake was the sinistral strike slip fault and the geological map issued by the Geological Survey Center (formerly the Geological Research and Development Center) of the ESDM Geological Agency, it can be concluded The cause of the earthquake was due to active fault activity in the southern part of Yogyakarta in a southwest-northeast direction with a position of N 231o E, Dip 87° and slip 3°, as shown on the map in **Figure 1**.

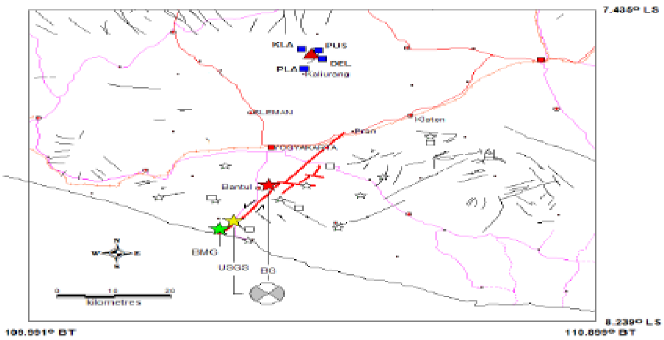

Figure 1. Calculation of the epicenter of the Yogyakarta earthquake according to BMKG, USGS and BG. [2]

Sulaeman, C *et al.* have characterized the source of the 2006 Yogyakarta earthquake based on GPS data and obtained data on the displacement pattern and the direction of the maximum shear strain anomaly in the area indicating the presence of a southwest-northeast trending fault with a horizontal type of left-sided fault known as the Fault. Opaque. The Opak Fault activity was the cause of the earthquake on May 27, 2006. The position of the source of

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the earthquake at that time was estimated to be located at 10 km east of Bantul. The value of the seismic moment (Mo) of the earthquake is 8.1385 x 1025 dyne cm and the moment magnitude (Mw) is 6.5. The normal strain value oriented in the west - east is greater than the normal strain value oriented in the south - north direction. The simple kriging method combined with gaussian sequential simulation gives quite good results compared to without being combined with gaussian sequential simulation [3]. The Seismogram of the Yogyakarta earthquake from BPPTK is can be seen in Figure 2.

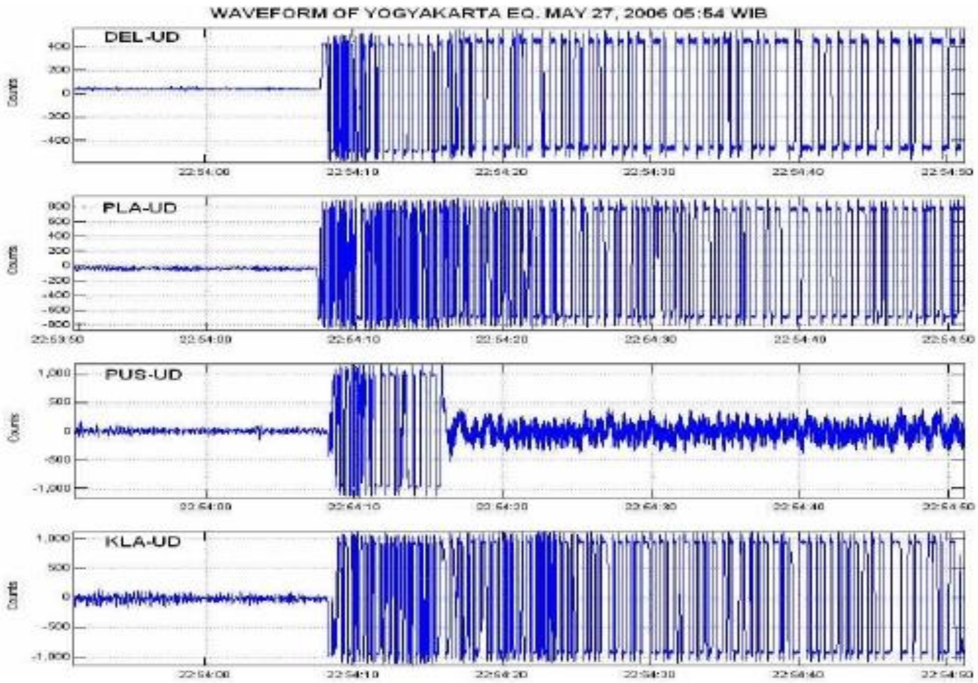

Figure 2. Seismogram of the Yogyakarta earthquake from BPPTK

3.2. Volcanic Eruption Following Yogyakarta Earthquake

Fourteen days before the earthquake occurred, the Center for Volcanology and Geological Hazard Management of the Ministry of Energy and Mineral Resources raised Merapi's alert status to level 4, which means that a major eruption is imminent. Since the earthquake, minor eruptions have generated storms of hot clouds and volcanic material, as the lava dome at its summit has grown. Merapi volcano eruption and the release of hot clouds and lava incandescent is can be seen in Figure 3.

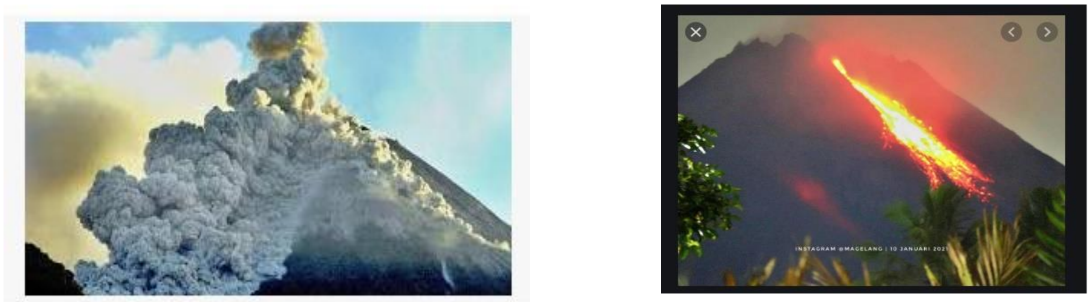

Figure 3. Merapi volcano eruption and the release of hot clouds and lava incandescent

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On June 8, the incandescent lava flow reached 4 km towards Krasak and Boyong Rivers and reached a maximum distance of 4.5 km from the headwaters of the Gendol River. Merapi's activity remains at level 4 due to the risk of incandescent lava flows, and tens of thousands of people have been evacuated. Although the occurrence of low-depth earthquakes near volcanoes is normal, the available data cannot yet explain whether there is a direct link between these earthquakes and the continuous eruption of Mount Merapi [4]. The eruption of Mount Merapi that occurs continuously and located near to the earthquake site has increased the difficulties of delivering humanitarian and relief aid.

3.3. Damage Assessment

The geographical damage distribution map is can be seen in Figure 4.

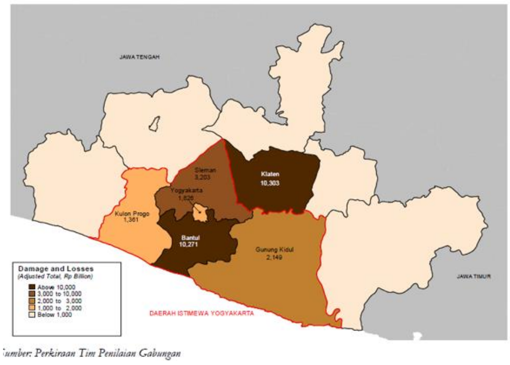

Figure 4. Geographical Damage Distribution Map

Based on Figure 4, the impact that was highly concentrated in the districts of Bantul, Yogyakarta Province and Klaten in Central Java. Bantul and Klaten together suffered more than 70% of all damage and losses. Among the other main areas that suffered damage included Yogyakarta City and three other rural districts in Yogyakarta province as shown on the map in Figure 4. Klaten district experienced the most damage, particularly housing, while in Bantul the damage and losses were severe in the productive and housing sectors [4].

The damage and losses caused by this natural disaster were worsen by several things, including it occurred in the most densely populated area in the world, the shallowness of the epicenter contributed to widespread structural damage, most of the buildings had not yet used earthquake-resistant construction [4].

3.4. Impact on Nuclear Installation Area

The Kartini Reactor is a nuclear installation located in the area of Yogyakarta earthquake occurence, which is ± 7 km to the west of the Kali Opak fault. At the time of the incident, coincidentally on Saturday, which was a holiday, the reactor was in a shutdown condition, the position of the employees was in their respective homes, so the impact was relatively very small, only a crack in the wall in the administration building.

In accordance with the statement of the Governor of the Special Region of Yogyakarta, Sri Sultan Hamengku Buwono X, that there is no need to worry about the existence of the Yogyakarta Kartini nuclear reactor. This is because the nuclear reactor is not located in the earthquake red line. The Sultan's statement responded to concerns following the damage to the Fukushima Daiichi Nuclear Power Plant (PLTN) in Japan, due to the earthquake and tsunami. [5]

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3.5. Disaster Management

1. Nuclear Installation Area

Mitigating the impact of this natural disaster is focused on the Kartini reactor and other laboratories in the area. Some of the actions taken after an earthquake, among others:

a. Closure of access to the reactor and all laboratories for employees.

b. Radiological survey by Radiation Protection Officer to assess radiation safety aspects.

c. After being declared safe by the Radiation Protection Officer, the technician on duty is allowed to enter to repair the equipment and scattered items.

d. An assessment of the feasibility of the building/building shall be carried out by the Public Works Department.

2. Employees and the surrounding community

On the first working day after the incident, the BATAN Jogja Disaster Management Task Force was formed. The types and stages of the activities carried out were adjusted to the conditions in the field at that time which were all emergency because; difficulties in finding logistics/groceries, difficulties in traveling because most of the roads are blocked by the ruins of buildings and refugee tents, as well as public panic due to the continued occurrence of aftershocks. The details of the activities carried out by the Jogja BATAN Command Post include:

a. Inventory of Employee Data Affected by Disasters

The data is obtained on the basis of reports from the concerned superiors/other employees as well as visits by volunteers from the Command Post which includes data on damage to the house/residence, the safety of the person concerned/his family, the urgent need for assistance and temporary shelter after a disaster occurs.

b. Providing Assistance to Disaster Victims

The distribution of this assistance was carried out by the volunteers of the BATAN Jogja Post to disaster victims consisting of employees, families of employees and retirees as well as the public who live in the vicinity. This is intended so that the assistance provided can ease the burden on BATAN residents who are victims of disasters, and also can help the surrounding communities, because in general at that time they still lived in groups in one tent.

3.6. Disaster Mitigation

Mitigation or efforts to reduce disasters caused by earthquakes require knowledge of the source of earthquake disasters, including identification of areas experiencing the impact of earthquake shocks, in the form of soil cracks, land subsidence, ground shifting, and liquefaction. Another effort is to learn from buildings that can withstand the impact of an earthquake of 6.2 Mw, increase preparedness and vigilance for the threat of an earthquake that may repeat itself in the future. [7]

After the 27 May 2006 earthquake, the Kartini Reactor building has been retrofitted/strengthened the building structure as well as equipped with an earthquake detector (Geosig), so that in the event of an earthquake it is possible to determine the peak ground acceleration (PGA) and ground movement patterns. PGA is a measure of earthquake acceleration on the ground and an important parameter in seismic modeling and analysis at a particular location. In the final study report of LAPI ITB entitled Analysis of the Structure of the Kartini BATAN Yogyakarta Nuclear Reactor Building Due to Seismic in 2005, it was stated that the PGA limit set for the Kartini Reactor location was 0.225 g or 2.2065 m/s^2 where at that acceleration the building structure could experience significant damage. structurally severe.[8]

From the data recorded on Geosig, the PGA of the earthquake that occurred at the Kartini Reactor was far below the specified threshold of 0.225 gravity. The earthquake that caused the largest PGA after the 27 May 2006 earthquake was an earthquake on 21 August 2010 with a PGA of 0.0577 gravity.[9]

4. CONCLUSION

The 2006 Yogyakarta Earthquake disaster has taught us a lot, especially with regard to disaster management and improvement of earthquake disaster mitigation efforts in the Yogyakarta area and especially in the nuclear installation area. Mitigation efforts are carried out physically and non-physically. Physical mitigation efforts include carrying out physical development that is able to reduce the impact of the earthquake or Merapi eruption. Non-physical mitigation efforts include awareness and capacity building to deal with disaster threats in the form of emergency drills. With these mitigation efforts, it is hoped that the risk of an earthquake, Merapi's eruption in the future can be minimized.

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