Earthquake Damage – Intensity Relationship Based on Sumatran 30 September Earthquake

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SUMMARY:

Hundred Thousands buildings in West Sumatra Province have been damaged due to 30 September 2009 earthquake. The earthquake has epicenter 100 km offshore of Padang City, the Capital City of the province. Survey has been conducted to assess the damage of the building in few days after the earthquake. In this survey, the damage of buildings are categorised into 3 level that are heavily, moderate and slightly damages. This paper explores the level damage of building and then the intensity of the shaking in the affected area. Then based on the coordinate of every building location, the buildings are scattered in a map together with the intensity level. The relationship between the damage level and intensity for West Sumatra then is developed. This special damage-intensity relation is very important to be used for predicting the damage level due to a specified earthquake. The damage level is needed by The Government to develop an emergency and reconstruction budget plan for earthquake disaster in future.

Keywords: Earthquake, damage assessment, earthquake intensity

1. INTRODUCTION

On 30 September 2009 an earthquake with 7.6 on the Richter scale was shock in West Sumatra. The time of occurring earthquake is at 17:16:10 local time. The epicentre was at a depth of 80 km in about 50 km to the west-northwest of Padang, the capital city of the Province. The earthquake resulted in relatively severe ground shaking in and around Padang. The Modified Mercali intensities is about VII or VIII. More than one million people were affected by the earthquake through total or partial loss of their homes or building. In this paper, it is shown the relation between the intensity of the earthquake and the damage of the houses in Padang. Padang is in the dense populated city in West Sumatran and one of the most seismically active regions of the world.

In Indonesia, there is an earthquake design code that firstly was published in 1970 [Public Work Department 1970]. In the practical works, the code was applied for engineered building only. There is no statement to force people to consider the earthquake safe for their houses. According to the code, buildings higher than 40 m must be designed using dynamic analysis and the others can be designed for equivalent static forces. The corresponding peak ground acceleration (PGA) is about 0.025g, 0.05g and 0.10g with three earthquake zones. Meanwhile, the Padang 30S'09 earthquake has the PGA of about 0.3g to 0.4g. [USGS, 2009].



Figure 1. Padang 30S'09 design response spectra. [BMKG/USGS, 2009]

The earthquake design code was updated in 1987 [Public Work Department 1987] with the Region then was divided into six earthquake zones. Padang was located in the highest zone. The peak ground acceleration in that code was not significantly increased. The highest PGA coefficient is 0.13g. Further, in 2002 there was a significant increase in the seismic design loads [SNI 2002]. The important engineered buildings at that time were designed with PGA of 0.3g. This story indicates that many building were design and built with very low seismic load before they were suffering the West Sumatra 30S'09 earthquake.

After the large earthquakes in the West Sumatra region, a new version of the Indonesian earthquake code is released in 2010. A further increase in the maximum PGA is declared fantastically until more than 1.0g. Based on the recorded of September 2009 earthquake, spectral accelerations for design is published as in Figure 1. Here, the design spectra in the 1987 and 2002 codes are plotted along with. The response spectra for the 30S'09 ground motion initially recorded in Padang [BMKG/USGS 2009].

However, until now there is no a formal Indonesian design code for ordinary housing. But there are many construction details for the use of non-engineered buildings which published by personal authors or organizations. Many authors presented drawings of recommended design details for single-storey buildings which included details for what was referred to locally as simple houses. The very famous of those is proposed by Teddy Boen who has been studying for simple housing for more than 40 years around the world. The well known of his work of creation is shown in the Figure 2.

2. DAMAGE SURVEY

Soon after the earthquake an emergency team lead by the University of Andalas conducted the damage survey of building in the West Sumatra Province. As one public university in West Sumatra, Andalas University initiated a process of damage survey and data collection on the ground in order to obtain an accuracy and validation data. The budged survey is supported by Government which has purpose to avoid duplication of data that already exposed by the media. It was reported by a National new paper that the West Sumatra provincial Government has been collected invalid data, since the discovery of mismatch total population in the district of Padang Pariaman with a population of data owned by the Padang Pariaman regency.



Figure 2. Building the earthquake safe masonry house [Boen, 2005]

Padang city consists of 13 districts involving 104 villages. There are 116,476 houses scattered in the city of Padang. The survey recorded at around 37,587 houses were heavily damaged, 38,485 and 40,406 suffered moderately and slightly damage respectively. The data is very important information for Government to do the next steps in implementation of rehabilitation and reconstruction of buildings after the earthquake in West Sumatra and Padang in general.



Figure 3. A heavily damage houses

In order to obtain accurate data then the assessment survey team directly went to the field. The data collection had been carried out by the team supported by students and engineers as volunteers from the 6^{th} until October 31^{st} , 2009. The volunteers fell directly into the field to retrieve quantitative data if the number of buildings were damaged by the earthquake. Data retrieval houses equipped with photographs of damaged houses. Every house then pasted with stickers as a mark of verification has been recorded and avoided to be re-recorded.

Determination of the extent of building damage was done by visual observation. Based on the visual observation, the affected buildings can be classified according to three level of damage. There are also three initial given for the building: RB for a heavily damaged building/house, RS for a house with a level of moderate and RR for the slightly damaged house. For the example, the condition of a house that referred to be suffering from heavily damage is shown in Figure 3.

3. RESULTS

This paper shows the plot results of survey of the damage homes in Padang. The results are displayed in the term of map which is divided by districts in the city. Figure 4 a, b and c show damage to the houses with the category of heavily, moderate and slightly for the city. In every figure, the number that indicated the damaged houses is displayed. The size of the bubble also presents of the ratio damage in each district. It seems that there is quite diverse spread of damage to the house. However this spreading data may be figuring the seismic ground condition that has been reported by Sengara et al (2009) as shown in Figure 5.



a. Heavily damage

b. Moderately damage

c. Slightly damage

Figure 4. Damage houses in Padang

Furthermore, by dividing the area based on the level of earthquake intensity, it can be displayed a graph of the distribution of damage to houses related to the peak ground acceleration. In the figure 6 can be seen that there may a relationship between the PGA with the distribution of the damage. In the figures also plotted the percentage of damaged houses in the city of Pariaman where located only a teens kilometres from the epicentre. The straight line curve is built in figure 6 to fit the relation between the damage level and the earthquake intensity in West Sumatra.

4. CONCLUSIONS

The West Sumatra Province has been badly damaged by 30 September 2009 earthquake. The earthquake has epicenter 100 km offshore of Padang City, the Capital City of the province. To learn the affect of the earthquake to the damaged houses in West Sumatra, the survey has been conducted in few days after the earthquake. The damage of buildings are categorised in 3 level that are heavily, moderate and slightly damages. Based on the survey and the peak ground acceleration, the relationship between the damage house and earthquake intensity for West Sumatra is then developed. It shows that the damage of houses associates with the intensity of earthquake. This special damage-intensity

relation is very important to be used for predicting the damage level due to a specified earthquake in the future. The Government can use the relation for developing an emergency and reconstruction budget plan for earthquake disaster.



Figure 5. Seismic microzination map for Padang [Sengara et al, 2009]



Figure 6. Damage house and the peak earthquake acceleration

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