Is the Lembang Fault a Potential Threat to Bandung?

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ABSTRACT

The objective of this study is two folds: (1) to determine whether the Lembang Fault, 10 km north of Bandung is a potential threat to Bandung city or not; and (2) to simulate the social and economic loss of Bandung and surroundings if an earthquake occurs along the fault due a slippage of 3 mm/year along the fault by means of a catastrophe modeling technique.

A cat model is basically an infrastructure for risk quantification. The model used has been developed by Maipark Insurance company itself. The losses will be determined by computing the three modules, these are: (1) the hazard module; (2) the inventory module; and (3) the vulnerability module.

The earthquake hazard data is based on the GPS Study (Abidin et al., 2009); the vulnerability module is based on the European Macro Seismic Scale of 1998 (EMS-98); whereas the inventory module is based on the number of dwelling houses and the number of people living in the vicinity of Bandung combined by the results of the high rise building surveys.

The simulation results of this study is based on the contour of the ground acceleration map, distribution of building values, population, risk and loss distribution which will affect Bandung area.

KEY WORDS: Earthquakes Risk, Catastrophe Modeling, Lembang Fault, Loss

INTRODUCTION

Lembang Fault is located at the northern side of Bandung. It is about 10 km from the center of Bandung. The fault is unfolded from east to west for about 22 km away. This fault passes Maribaya on the East and Cisarua on the West.

Lembang fault is expressed as fault scrap. The escarpment wall is facing north. The height measurement of this fault scrap approximately reaches 450 m, while in the western part (Cisarua) is lower, approximately 40 m. The fault scrap is disappeared in the North side of Padalarang. The high of this fault scrap reflects the magnitude of fault displacement.

Lembang fault was first formed about 100.000 years ago in the eastern part. The formation of faults in this section coincides with the formation of the caldera in the process of cataclismic eruption. While the western part is younger, approximately formed 27.000 years ago. Age of the fault is derived from the age of pyroclastic deposits that was broken by the fault in the area (Nossin et al. 1996).

Lembang fault can be observed well enough at Gunung Batu. Gunung Batu itself is andestik igneous. The age dating result with K-Ar method shows that andesitic igneous in Gunung Batu was formed at 0,51 Ma or about 510.000 years ago (Sunardi and Koesoemadinata, 1997).

The research with GPS that has been done lately (Meilano, 2009) shows that Lembang fault is an active fault, which strengthen the previous research result in which the Chideung earthquake at September 19, 1999 is directly associated to the activity of this fault (Marjiyono et al. 2008).

The approximate values of ground acceleration that results from active fault earthquake have ever been simulated by Handayani et. al. (2009) by using the attenuation equation Boore (Douglas, 1997).

According to GPS research, the slip rate of Lembang fault is 3 mm/year (Meilano, 2009). Simply put through an empirical magnitude moment relationship with average displacement from Wells and Coppersmith (1994) shows that moment magnitude 6.3 that is going to be used as upper limit at maximum scenario in the simulated impact of Lembang fault earthquake in the residential area in West Bandung regency, Bandung regency, Cimahi city, and Bandung city.

METHODS

Attenuation Equation

There is much attenuation that has been published. This empirical formulas is derived from analysis of earthquake event or an accelerograph recording. Given the least seismic data and the absence of accelerograph networks in the research area, the specific attenuation equation for the area still can not be determined, so attenuation equation from Boore (1997) is used in this research. It is assumed that the result of equation that derived from the research in western coast of Northern America represents the condition of this research area, namely in the subduction zone and there are segments of shear fault (Handayani et. al. 2009).

The equation used is as follow:

$$\log Y = b_1 + b_2(M-6) + b_3(M-6)^2 + b_4 r + b_5 \log r + b_v(\log V_{s30} - \log V_a) \quad (1)$$

where:

$$r = \sqrt{d^2 + h^2} \quad (2)$$

d is epicentrum distance, M is moment magnitude, V_{s30} is S wave velocity at 30 meters depth and Y is PGA (Peak Ground Acceleration) in g unit.

Boore's recommendation for the Constanta is as follows:

$b_1 = -0.105$
$b_2 = 0.229$
$b_3 = 0$
$b_4 = 0$
$b_5 = -0.778$
$h = 5.57$
$b_v = -0.371$
$v_a = 1400$

Comparison between this attenuation equation with others could see below:

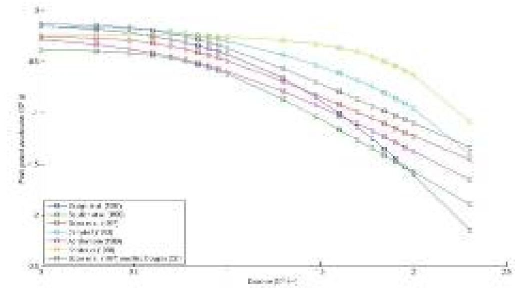


Fig1. Comparison between attenuation equations

V_{s30} Velocities Classification

For the velocity classification V_{s30} the values given by Wills et. Al (2000) is used.

Tabel 1. Velocity Classification by Wills et al. (2000)

Wills et al. (2000) Classification	DE	D	CD	C	BC	B
Boore et al. (1997) Vs30 (m/s)	180	270	360	560	760	1000

In general, Bandung geological formation is divided in to four groups. B category, hard rock, consists of breccia, consolidated volcano rocks, breccias, Sunda volcanic lava. Younger igneous rocks can be easily classified in category BC that consists of tuff, lava, and breccias from tha Malabar and Tangkuban Perahu Mountain. While the Miocene sediments can be classified into category CD that consists of tuff, breccias, sand stone lava, conglomerate, and lacustrine sedimentation that can be classified into category D (Handayani, 2009). The geological map that is used is Bandung geological map scales 1:100.000 (Silitonga, 2003).

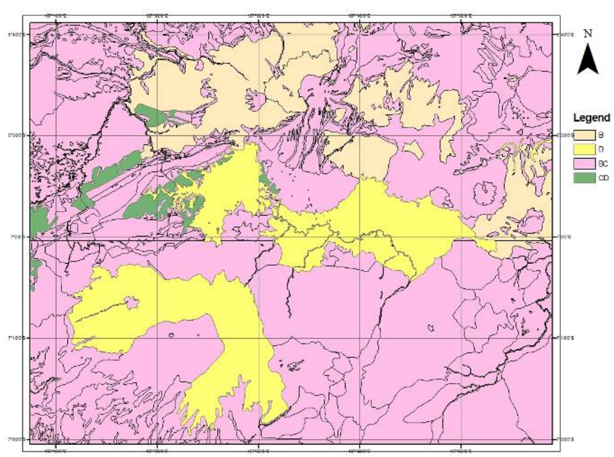


Fig2. Site classification map

Land Use Classification

For the purposes to build inventory dataset, we used SPOT V image with 2.5 x 2.5 m resolution. Classification of residential area is done by using software Ermapper with unsupervised classification.

Then this data is divided into grid 0.001 x 0.001 degree. Data on the number and floor buildings is obtained from BPS (2007) data in the same year of the SPOT image that is used as the basis for determining the distribution of buildings. The price of each kind of construction is taken from building price journal that is published by Departemen Pekerjaan Umum.

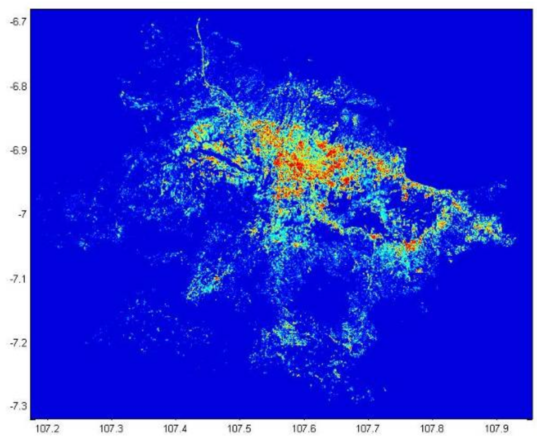


Fig3. Result of classification, distribution of Building Value in Study Area

Vulnerability Module

Ground acceleration values were converted to the scale of damage that has been commonly and widely used MMI (Modified Mercalli Intensity). This scale describes the effects that occurred in an area affected by the earthquake.

Wald et al. (1999) provide empirical relation between the PGA with MMI values, which is shown as follow:

$$I_{mm} = 3.66\ log(PGA) - 1.66 \quad (3)$$

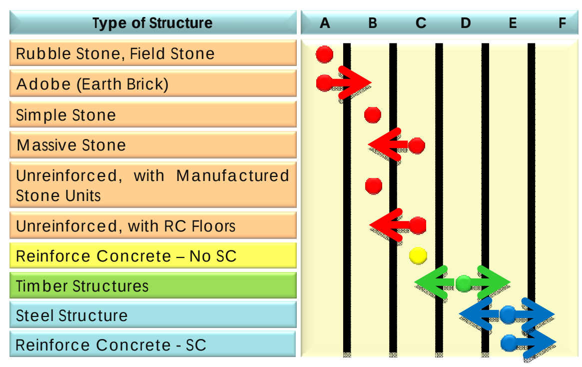
Where:

I_{mm} is intensity in MMI (Modified Mercalli Intensity) scale. Wald used California data to defined this equation. We use this equation to convert PGA (Peak Ground Acceleration) to MMI (Modified Mercalli Intensity) scale.

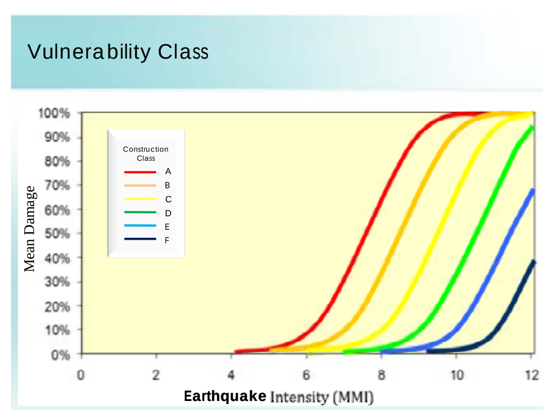
Identifying buildings in detail is very hard to be done among all data that has been collected. To overcome it, analysis on damage effect for each type of building is taken from BPS data (2007), and also reference of price for each type of buildings, that is reinforce concrete, steel frame, wood frame, and masonry/others.

Steel frame is building structure that uses steel as its frame. Wood frame is building structure that uses wood as its frame. Reinforced concrete frame is a concrete structure that uses steel as its bone. Masonry is building that does not use structure or concrete structure but does not use steel as its bone.

Each type of buildings that has been mentioned above will experience different impact for each MMI. One of the curves of relation between MMI with mean damage ratio is the curve that resulted from EMS (1998) research, which is shown as follows:



(a)



(b)

Fig4. (a) table of construction class based on structure (b) relationship curve between mean damage ratio and MMI

Loss Module Scenarios

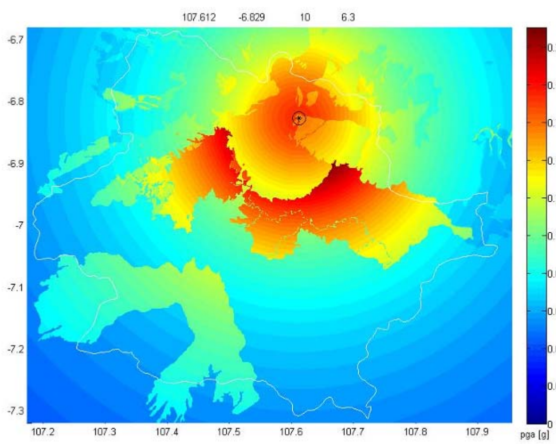
The simulation is done with 3 scenario; minimum, medium, and maximum. For minimum scenario M 4.3 is used, M 5.3 is used for medium scenario, and M 6.3 is used for maximum scenario.

The epicenter position randomly scattered around Lembang fault. Each scenario is done for 100 events. Loss value optimalization is done by using Monte Carlo simulation.

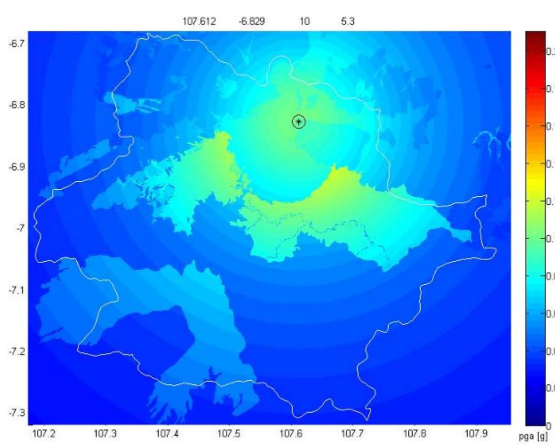
RESULT

The three simulation scenarios show area that might be affected surface earthquake because of the activity of Lembang fault is very broad.

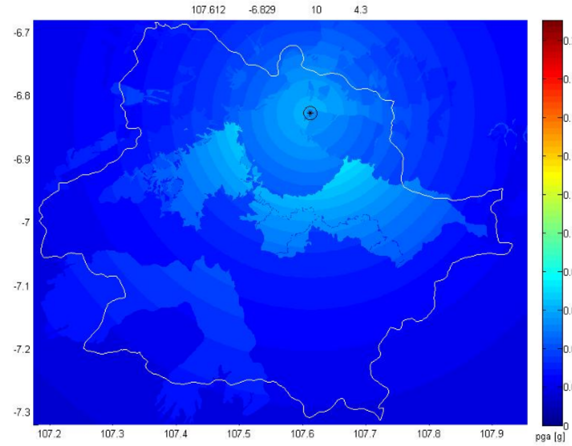
The simulation result shows that besides the northern area of Bandung that closest to this fault, the southern area is also experienced a great damage because the area is located above lake sedimentation that is very vulnerable to earthquake shocks.



(a)



(b)



(c)

Fig5. PGA for single event for a) maximum scenario b) medium scenario c) minimum scenario

Simulations show that the most affected area beside arround Lembang fault area is the south of Bandung city. It is because lacustrine sediment in southern area.

Loss module that is resulted from minimum scenario show economic losses amounted around IDR 138 billion. Medium scenario produced losses estimation around IDR 982 billion, and the maximum scenario produced losses estimation nearly IDR 4 trillion.

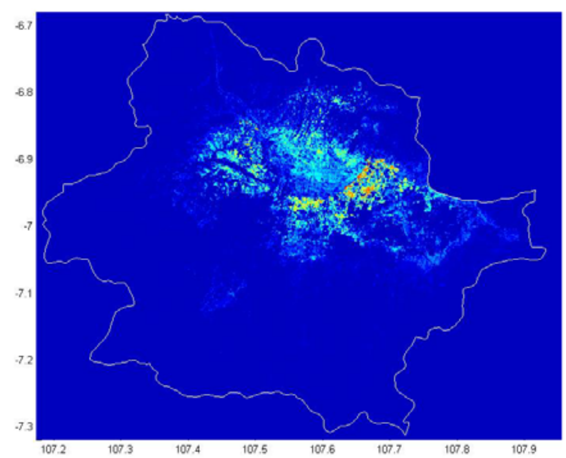


Fig6. Loss distribution of maximum scenario

CONCLUCION

This study shows that considering loss estimation values that could be resulted from Lembang fault earthquake activity, the threat of damage that might be occurred in Bandung area is worth to be concerned. The earthquake that is caused by this fault will affect a great damage both in the northern and southern side of Bandung. The northern side will experience a great damage because it is located near to the fault, while the southern side will affect the damage because it is located over lake sedimentation or classified as D site class.

Simulation with only medium scenario shows a great loss estimation values, about IDR 928 billion. This value will make a significant affect to government and also private sector budget, only for the physical building reconstruction, before we include the cost for public facilitation and social reconstruction, and also the cost of business and economic loss, that is not investigated in this research study.

It is highly recommended to all stakeholders; especially the government to take serious consideration to potential disasters caused by the activity of Lembang fault, considering the huge amount of losses that could be resulted.

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