Earthquake of 30 September 2009, Mw7.6, Padang, Sumatra, Indonesia

A Preliminary Reconnaissance Report

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Preface:
After the Padang earthquake of 30 September 2009, Mw7.6, the International Institute of Earthquake Engineering and Seismology (IIEES, Tehran, I.R. IRAN) has decided to dispatch a reconnaissance team to the prone area. Upon the government cooperation, IIEES has already an agreement of scientific cooperation with Badan Pengkajian dan Penerapan Teknologi (BPPT; Agency for Assessment and Application of Technology), Jakarta, Indonesia. IIEES reconnaissance team was formed by Dr Mehdi ZARE (engineering seismologist, Seismology Research Center of IIEES), Dr Ebrahim HAGHSHENAS (engineering seismologist, Geotechnical Earthquake Engineering Research Center of IIEES)and Dr Afshin KALANTARI (structural engineer, Structural Earthquake Engineering Research Center of IIEES). The bilateral reconnaissance team consisted of three IIEES reconnaissance team members and Dr Iwan G. Dr D. A. Tiwi and Mr Toni departed from Jakarta in the evening of 13 November 2003, towards Padang.

1. Introduction

The Padang, west Sumatra earthquake occurred on 30 September 2009 at 17:16:09 local time with magnitude of Mw7.6, depth 71 km, the location of -0.84 latitude and 99.65 longitude (according to Indonesian Geophysical Agency). The epicenter was at sea about 71 km southwest of Pariaman, West Sumatra. The earthquake caused 1100 deaths and felt in several cities, among others: Padang (with an intensity of VIII EMS98), Pariaman (VII), Padang-Panjang (VI-VII), Bukit tinggi (VI). Meanwhile, the USGS earthquake center located at coordinate -0.890 ° latitude and 99,961 ° E with a magnitude Mw 7.6 at a depth of 80 km.

2. Seismotectonic of the Prone Area

In most subduction zones, motion of the subducted plate is nearly perpendicular to the trench axis (Figure-1). In some cases, for example Sumatra, where the motion is

oblique to the axis, a strike-slip fault zone is seen, and is lying parallel to the volcanic chain. **Since 1975, 12 earthquake having magnitudes greater than 7.0 occurred in western Indonesia.**

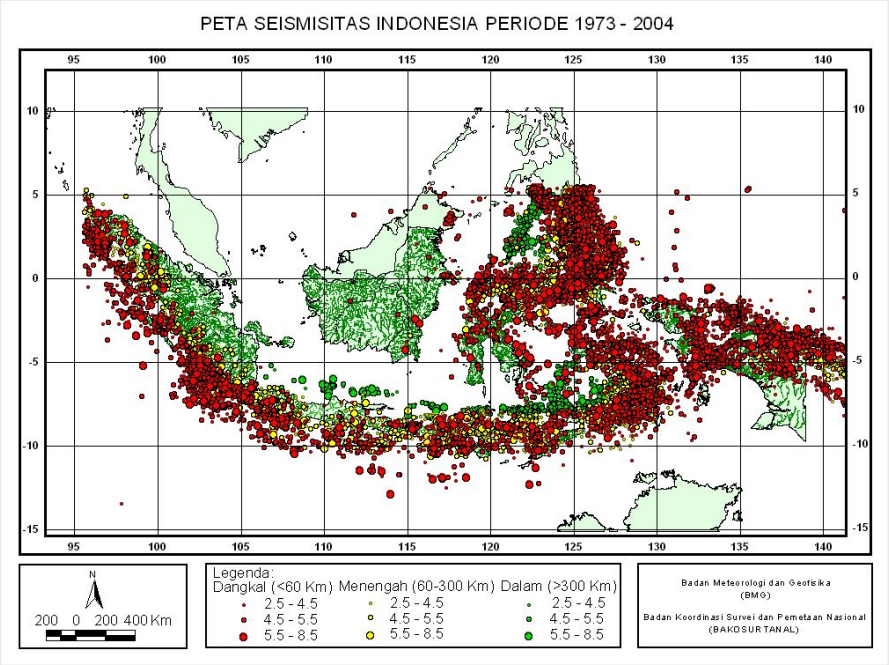

Figure-1: Seismicity of Indonesia

Padang earthquake which occurred on 30 September 2009, has produced the maximum acceleration of earthquake waves at Padang region between 200 gals in Padang and 120 gal in Padang Panjang. The maximum intensity is estimated to be occurred in Padang, to be VIII in EMS98 macroseismic scale, due to greater damages to engineered structures and a possible site effect. The maximum intensity was estimated to be VII in Padang Pariama, VI in Bukit Tinggi and Tandikat landslide area (Figure-2)

Figure-2: Macroseismic Intensity assessment for the prone area of the Padang earthquake of 20 September 2009.

3. Geotechnical Aspects

Geotechnical Aspects
3.1: Site effects
Site effect might had an essential role in amplifying the ground shaking in the epicentral area, specially in the city of Padang. This idea come from the most sever damages observed to the engineered constructed building in this city, while the epicentral distances for this city is greater than the central part of the Pariaman, for example. A preliminary Vs30 map prepared by Petresen (2007) based on assining a shear wave velocity to geological units. The soils in Padang city consist mainly from Quaternary alluvium (includes some swamps, bay and estuary mud) and have a very low shear wave velocity in upper 30 meters (180- 360 m/s). Regarding this range of velocity we can expected the ground motion amplification for the frequencies ranges from 1.5 to 4 Hz.

3.2. landslide :
ReliefWeb reported that over 1000 landslides were triggered by this earthquake. Based on the reports 400-600 death of the total of more than 1200 death caused by earthquake were killed by landslides. 3 villages were completely demolished by landslide and many others were damaged (Figure-3). Many roads were damaged or blocked by landslides and result in difficulties in rescue efforts.
The most destructive landslides happened during this earthquake are concentrated in the Tandikat regency. A cluster of villages including Pulu Koto (or Pulu Air), Cumunak, Lubuk Laweh and Timor Koto, were totally demolished or severly damaged in this area.

Figure-3 : Two giant landslides happened on Tandikat regency along the Lembah Tiga valley. Upper part of the photo: Cumanak landslide wiped and buried the village of Cumanak and killed near 200-300 peoples gathered for a wedding ceremony. Lower part of the photo: a landslide adjacent to the Lubuk Laweh landslide cut a road.

Observations of Structural Damage

A Mw 7.6 earthquake hit the western Sumatra and Padang city on September 30th 2009. A reconnaissance team was dispatched to the area by IIEES. There was no ground motion record available to estimate the earthquake PGA or the response spectra. The damage observation covers building and houses, water supply network and transportation system. A quick survey of hospitals was also performed during the reconnaissance trip.

Houses and Buildings

The buildings in the region can be categorized mainly as masonry and RC buildings. The damage level for the houses were estimated as following by local officials (Table-1).

Table-1: Damage to houses in the affected region and Padang city

Level of damage	Padang city	Total
High	33597	114797
Medium	35816	67198
Light	37615	67738

Low quality material and incorrect construction methods were identified as the main reasons of damage as shown in the following pictures. Soft storey effect was observed in several RC buildings in the Padang city. Considerable damage to historical buildings was observed (Figure-4).

Compressive failure of RC column

Soft storey response in RC building

Lack of correct practice in masonry buildings

Gantiang mosque, city's oldest mosque with hravy damage

Figure-4: Different examples of damages to buildings

Water supply system

The city water supply system takes use of three Water Treatment Plants (WTPs) the Gunung Paugilum WTP was observed. The WTP serves to 27000 households. Structural damage in the Generator room and damage to 600 mm stopped the WTP service for 14 days, interrupting some parts of the city water network. The network includes 1800 km of Steel, ACP, Galvanized steel pipe, Ductile pipe and PVC and covers 65000 households. The network is old and suffers from several leak points which number was estimated as many as 2500 points after earthquake. 68% of the damage points belong to the connection point of households to the network. The PVC connections are the next in ranking with 22% according to the local officials in Water Supply Company.

Transportation

The team had an observation of several road and railroad bridges in Padang city and Padang Pariraman region. There were no considerable damage in the bridges. Some minor cracks was observed in the Minankabau International Airport in Padang. The Padang city bus terminal totally collapsed.

Airport bridge in Padang city

Railroad bridge on the way from Pariaman to Padang

The Padang city bus terminal totally collapsed

Figure-5: damages to transportation facilities

A quick damage survey of hospitals in Padang city after 30th Sept. 2009 earthquake

In order to assess the seismic performance of the hospitals including the structure and equipments during and after earthquake, a quick survey of the hospitals was performed in the Padang city. For this purpose a checklist was provided to help the observers (Figure-6).

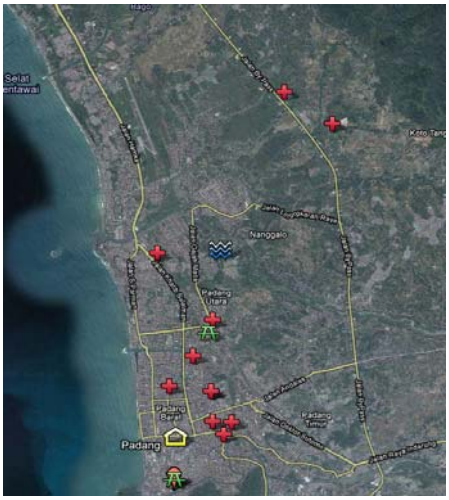

Figure-6: Surveyed buildings on the google satellite picture

5 out of 9 surveyed hospitals (Figure-7) were out of service and afew number of beds were provided under the tent. Damage to equipments such as MRI or X-ray equipments also were observed in the hospitals without structural damage which made the facility be partially out of service .

	Name of the hospital	No. of the beds	
1	Ibu sina-Padang	63	Operational
2	Local public hospital-building 1	70 beds	Operational
3	Dr. Reksodiwiryo	~ 300 beds	Partially operational
4	M Jamil hospital	600~700 beds	Partially operational
5	Siti rahman hospital	200 beds	Partially operational
6	RS BMC Padang	150 beds	Non-operational
7	Selasih Padang hospital	50~100 beds	Non-operational
8	RS yos sudorso	146 beds	Non-operational
9	RS Silaguri	55 beds	Non-operational

General information of the surveyed hospitals

Equipment damage Citirahman Hospital

Structural damage, Selaguri hospital

Collapse of the building, M Jamil Hospital

Figure-7: Damages to hospitals

Conclusion

Earthquake disaster has occurred in West Sumatra on 30 September 2009 at 17:16:09 local time with the Magnitude of Mw7.6, depth 71 km. This earthquake had caused the destruction of infrastructure, especially in Padang, Padang Pariaman and collateral disasters due to landslides and fires due to electricity circuit shortcut with total casualties of 1100 people killed. Casualties that occurred in urban and rural regions caused by the buildings collapses and landslides. The casualties induced by debris slides that caused about 400 people died. Loss of life caused by fire was not reported. Landslides occurred primarily because that consolidated volcanic rock (pumis) of the located on a clayey soil layer, supported by a moderate to somewhat steep slop. Buildings are damaged and collapsed in Padang mainly shop buildings, hotels, educational buildings and government buildings.

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STANDAR PERENCANAAN KETAHANAN GEMPA UNTUK STRUKTUR BANGUNAN GEDUNG SNI – 1726 – 2002.