



A Summary of MCEER
Reconnaissance Efforts

MCEER RESPONSE

OVERVIEW OF THE WEST SUMATRA EARTHQUAKE OF SEPTEMBER 30, 2009

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The September 30, 2009 West Sumatra earthquake occurred at 17:16:09 local time (10:16:09 GMT) with a moment magnitude of (M_w) 7.6, epicenter of 0.789°S , 99.961°E , and depth of 80 km (USGS and BMKG - Indonesian Meteorology, Climatology, and Geophysical Agency). The earthquake was located in the subduction zone of Indo-Australian and Eurasia plate. The reported peak ground acceleration (PGA) at the Andalas University, Padang, was approximately 0.3g.

The earthquake caused more than 1,100 fatalities and 3,000 injuries, damage to more than 100,000 structures, with losses estimated at IDR 21.6 trillion (USD 2.3 billion), quoted from an official report by BNPB (Indonesian National Disaster Management Agency). Most of the losses were caused by damage to infrastructure, especially in housing with losses of approximately IDR 15 trillion (USD 1.6 billion). Most damage was observed in the vicinity of Padang and Pariaman cities. Padang is the capital of the West Sumatra Province, located on the west coastline of Sumatra Island, about 45 km from the epicenter, and has the largest population in the region. Pariaman is a city located about 60 km northwest of Padang, also on the coastline, and approximately 55 km from the epicenter.

GEOTECHNICAL OBSERVATIONS

In general, the geotechnical conditions of Padang consist of sandy-silt, clayey-silt, sand, gravelly-sand and mud. Site-classification analy-

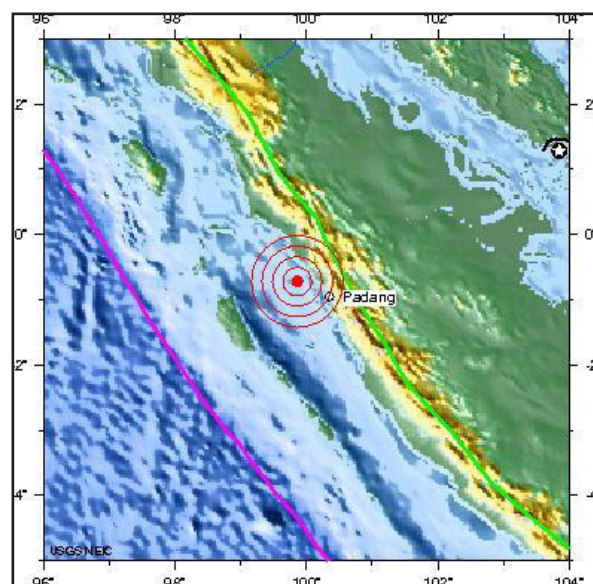


Figure 1. Epicenter of West Sumatra earthquake, September 30, 2009 (Source: USGS)

sis shows variations from soft to hard site classes. Local ground conditions within the city of Padang contributed to the variation in building damage for similar building types and constructions.

LIQUEFACTION

Liquefaction was observed in areas close to the shoreline, where saturated loose to medium dense sand and silty-sand conditions exist (see Figure 2).

The liquefaction and deformation induced foundation settlements were identified to have caused floor damage and some additional structural damage to buildings (Figure 3).



Figure 2. Example of liquefaction



Figure 3. Foundation and ground deformations that caused damage to a building



Figure 4. Landslide at Gunung Nan Tigo (Source: Indonesian Department of Education)

LANDSLIDES

Landslides and slope stability failures were also observed during the earthquake. The earthquake has caused landslides and collateral debris-flows in the hills surrounding Lake Maninjau. The most damaging landslide occurred at Gunung Nan Tigo in Padang Pariaman District, which completely demolished some villages and caused many fatalities (Figure 4).

DAMAGE TO STRUCTURES

The majority of buildings in Padang are one- and two-story non-engineered structures which include housing, commercial/residential buildings, school buildings, and religious facilities. These structures are typically confined masonry structures, with RC frames acting as a confinement for the brick masonry walls. However, non-engineered structures in the Pariaman area are mostly unreinforced masonry structures. In comparison, traditional non-engineered structures in the area are typically timber structures.

A minor percentage of buildings are 2 to 6-story engineered structures, consisting of government offices, hotels, malls, hospitals, and other public facilities. These structures are typically reinforced concrete frames with masonry infilled walls.

BUILDING DAMAGE

In Padang, the earthquake caused structural damage to many engineered buildings, while most non-engineered buildings experienced only light structural or nonstructural damage. In Pariaman,

damage mostly occurred to unreinforced masonry (URM) residential housing.

Most buildings that were damaged by the earthquake had poor detailing, such as sparse confinement with small diameter transverse reinforcement, no detailing on connections, non-seismic hooks, and use of plain rebars. Poor layouts with structural irregularities and large openings on the ground floor of the building also contributed to that unsatisfactory response, causing soft-story and/or weak story collapse mechanism, structural pounding, and torsion.

Typical structural damage to non-engineered structures was mainly caused by failure of walls and confining elements. The main problems were poor materials, such as low strength concrete, mortar, and brick materials, and inadequate structural elements and detailing as in the case of engineered structures.



Figure 5. Total collapse mechanism of a government office building in Padang



Figure 6. Soft story mechanism of a government office building in Padang



Figure 8. Damage to non-engineered structures in Padang



Figure 7. Poor detailing on RC structural members



Figure 9. Failure of weak confining frame with poor detail (inadequate development/embedment length, sparse stirrups)

DAMAGE TO INFRASTRUCTURE

Infrastructure damage such as embankments of roads and bridges was also identified. The failure was due to the marginal slope stability safety factor of embankments and cut. Damage to bridges was identified with ground settlement within the fill of the approach, as well as displacements of abutments and side walls. Ground settlement or deformation could also be associated with lateral spread during strong shaking of the abutment slopes. In some areas, landslides forced road closures. However, no traffic disruptions due to bridge damage were observed.

CLOSING REMARKS

The devastating earthquakes in West Sumatra have caused more than 1,100 fatalities as well as damage to buildings and infrastructure with the estimated losses of more than two billion USD. The earthquake served as a lesson that all structures in seismic prone areas should perform satisfactorily under earthquake loadings. Considering that vulnerable structures are commonly found, efforts should be intensified to ensure that all structures perform satisfactorily under earthquake loading, thus minimizing the potential losses and casualties.



Figure 10. Slope stability failures of a road at Lubuk Selasih KM 18+00



Figure 11. Damage to a road located along the shoreline in Padang due to lateral spread or slope stability of the road embankment



Figure 12. Damage to a bridge due to ground settlement within the fill of the approach and displacements of the abutment side walls

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