Impacts of 2014 Chiangrai Earthquake from Geotechnical Perspectives

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In the evening of the 5th May 2014, the largest earthquake ever recorded which has epicenter within Thailand strikes Chiangrai province. The magnitude was later reported to be 6.3 M_L with 7 km depth. More than 10,000 houses were damaged and 2 people died. Even though the earthquake magnitude is just in moderate level but for the country that considered being seismic quiet region, this is a serious one. This paper presents the factual data relating with the damage relating with geotechnical aspects.

Keywords : earthquake, liquefaction, emergency response

1. Introduction

Thailand is located in the moderate seismic hazard area. According to UBC classification, the strongest seismic hazard zone is zone 2B as shown in Fig 1. Fig 2 shows the earthquake events occurred around Thailand since 1912-2007 (Ornthammarath and Warnitchai et.al, 2010). It can be seen that most of the large earthquake occurred in the area of plate boundary in the Andaman Ocean, through Myanmar and up to China. Moderate and small earthquake events were recorded in the northern and western part of the country. Table 1 shows the statistical data of the first ten magnitude event that recorded by the instrument in Thailand. Before the 5th of May the 5.9 magnitude was the largest which occurred in 1986 and concluded to be the Reservoir Triggered Seismicity event (TMD).

2. Geology

The 6.3 M_L occurred in the 5th of May 2014 at 6:08 pm in Chiang Rai province, northern country of Thailand. The hypocenter depth was 7 km. The epicenter location initially reported by Thai Meteorological Department to be at Parn district which locates 30 km away from Chiang Rai city.

The epicenter is considered to be located at the low to moderate population area. The acceleration attenuation curve is plotted by using the peak ground acceleration from various seismic stations and shown in Fig 3. The plotted attenuation curve fitted well with the relationship proposed by Sadigh et al. (1997). According to the plot and fitted relationship, the peak acceleration of 0.1g was possible at the 30km radius distance from epicenter. This matches well with the actual condition where most of the damage is found within 30 km radius from epicenter.

The epicenter located in the PhaYao fault zone, which is one of the 14 active faults in Thailand (Fig 4). Fenton et al. (2003) estimated the maximum magnitude that this fault could produce to be 6.6. Many aftershocks have been observed (Fig 5). Eight events occurred with the magnitude more than 5.0. The hypocenter depths of all the aftershocks were shallow and generated between two fault lines as shown in Fig 6.

The ground ruptures have been observed. Their direction is either parallel or perpendicular to the Pha Yao fault lines (Fig 7). Most of the ruptures located over the

Quaternary deposit area. The thickness of the deposit may be more than 200 m, according to the resistivity survey as shown in Fig 8 (DGR, 2009).

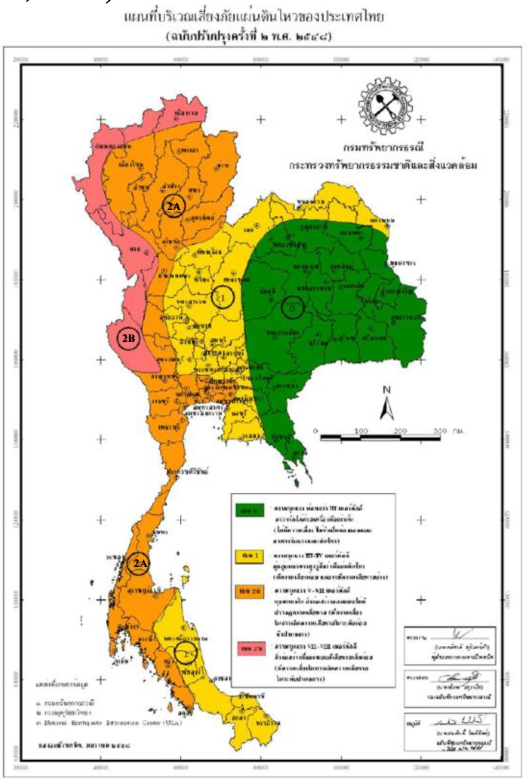

Figure 1 : Seismic hazard zone of Thailand (DMR, 2005)

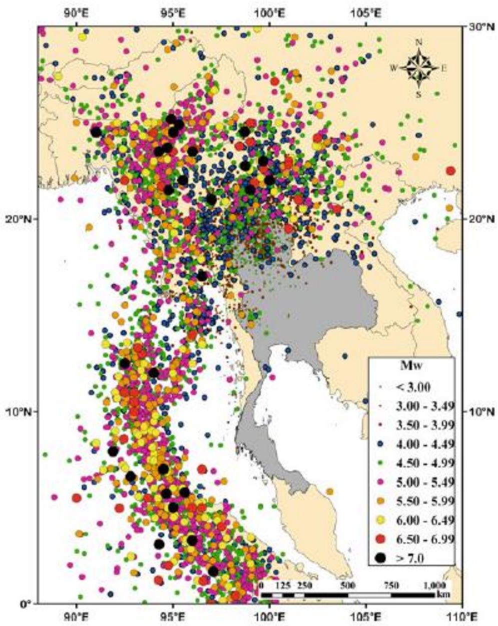

Figure 2 : Thailand and its surrounding seismicity from 1912 to 2007 (Ornthammarath and Warnitchai et.al, 2010)

Table 1 : First ten earthquake magnitude recorded by the instrument in Thailand

No.	Date	Magni-tude	Earthquake epicenter
1	05/05/2014	6.3	Pran, Chiangrai
2	22/04/1983	5.9	Srisawat, Kanchanaburi
3	17/02/1975	5.6	Thasongyang, Tak
4	06/05/2014	5.6	Pran, Chiangrai
5	06/05/2014	5.6	Maesuay, Chiangrai
6	22/12/1996	5.5	Boundary Thailand and Laos
7	15/04/1983	5.5	Srisawat, Kanchanaburi
8	22/04/1983	5.2	Srisawat, Kanchanaburi
9	21/12/1995	5.2	Prao, Chaingmai
10	05/05/2014	5.2	Muang, Chiangrai

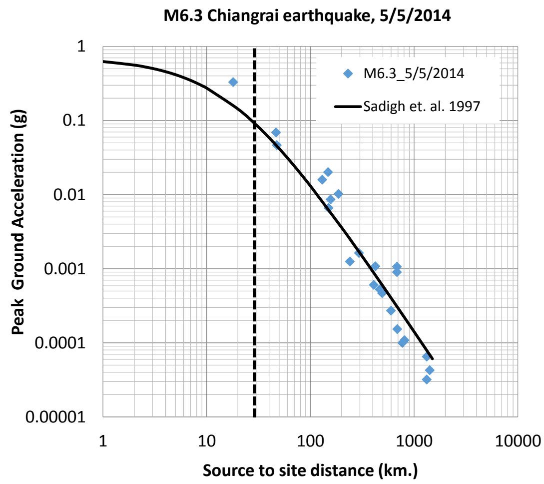

Figure 3: Recorded acceleration at 6.3 Magnitude, Chiangrai Earthquake

3. Overall damage

Immediately after the earthquake, the need for building safety assessment was highly required. Most people have to stay outside of their house since they were not sure if the damaged house were safe. Regarding the investigation by Department of Public Works, it is found that more than 10,000 houses were report damaged. More than 500 volunteer engineers from all over the country came to help on the safety evaluation of each house. It took three weeks to finish all the evaluation and found that 475 houses were highly damaged, 2180 were partially damaged and could be repair and 7714 has a minor damage. In addition, 138 temples and 56 schools were found to be highly damaged.

Most of the buildings were not designed to resist the earthquake force since the structure that below 15 m were not enforced by law to design for earthquake resistance. Wooden house is less damaged comparing to the reinforced concrete (RC) structure (Fig 9) since it's light and more flexible.

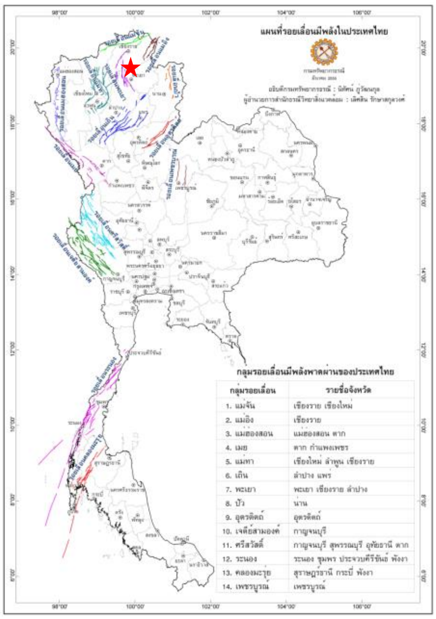

Figure 4 : Epicenter location of 6.3 Magnitude, Chiangrai earthquake (DMR, 2005)

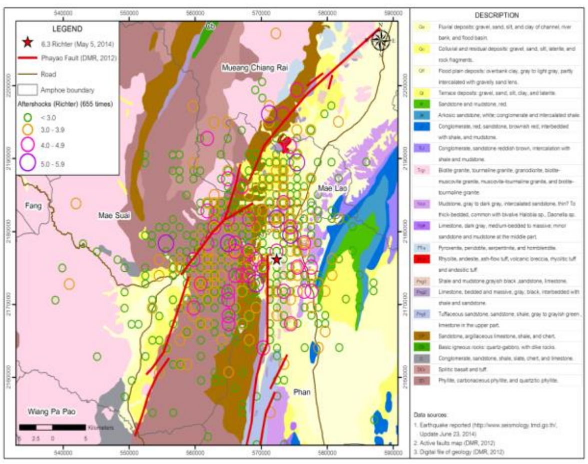

Figure 5 : Aftershocks location recorded from 5 May to 23 June 2014

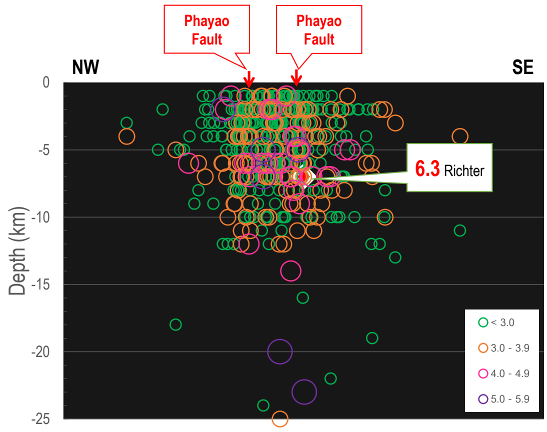

Figure 6 : The hypocenter depths of all the aftershocks (5 May to 23 June 2014)

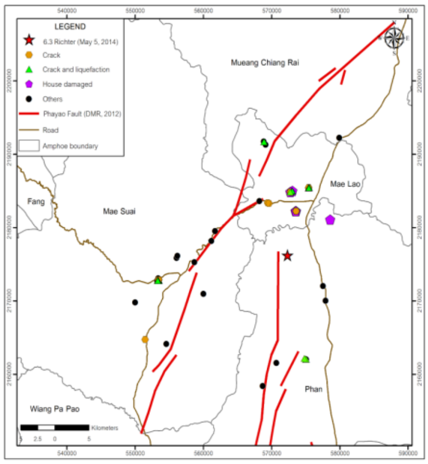

Figure 7 : Ground ruptures location

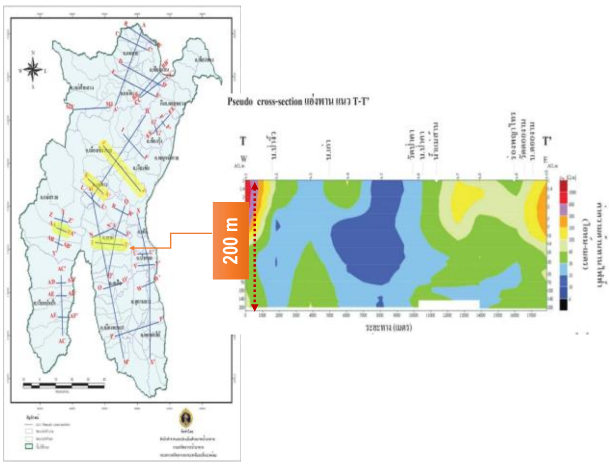

Figure 8 : Thickness of soil deposit from resistivity survey (DGR, 2009)

Most of the buildings were not designed to resist the earthquake force since the structure that below 15 m were not enforced by law to design for earthquake resistance. Wooden house is less damaged comparing to the reinforced concrete (RC) structure (Fig 9) since it's light and more flexible.

Figure 9 : The damaged of reinforced concrete structure (Picture taken by Dr. Pennung Warnitchai)

4. Liquefaction

Liquefaction was found within the radius of 20 km from epicenter and located in the quaternary deposit (Fig 10 and 11). It means that the peak acceleration should be over than 0.15g to cause liquefaction, according to the attenuation model discussed earlier. The subsoil investigation found the loose saturated sand in the shallow depth. Furthermore, the gradation of the soil particle found to be a uniform grade and fitted within the range of liquefiable material (Fig 12). The liquefaction potential analysis using Seed' method (Seed et al., 1971) also found that the soil will be liquefied if the peak acceleration is more than 0.15g (Fig 13).

Some foundation settlement was found due to liquefied soil underneath the shallow foundation. However, none of the cases were serious damage (Fig 14).

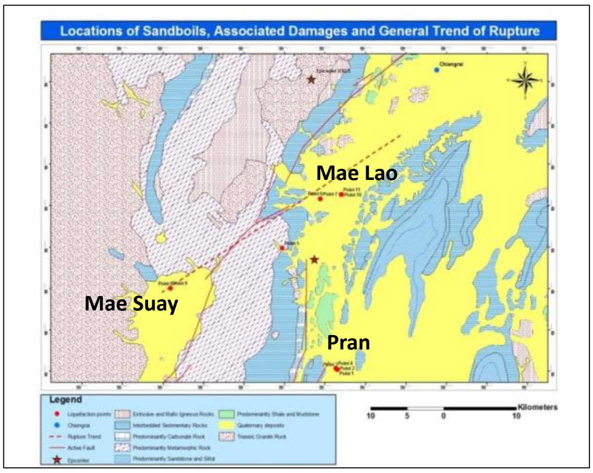

Figure 10 : Location of observed liquefied soil

Figure 11 : The liquefied soil evidence

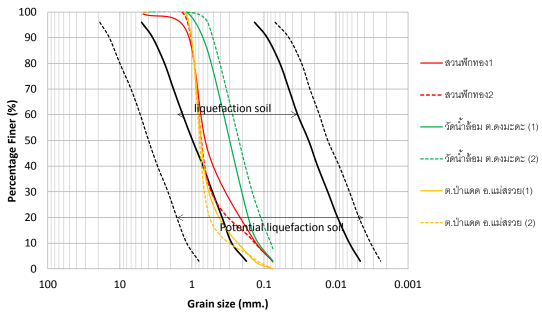

Figure 12 : Gradation of liquefied soil plotted in liquefiable range

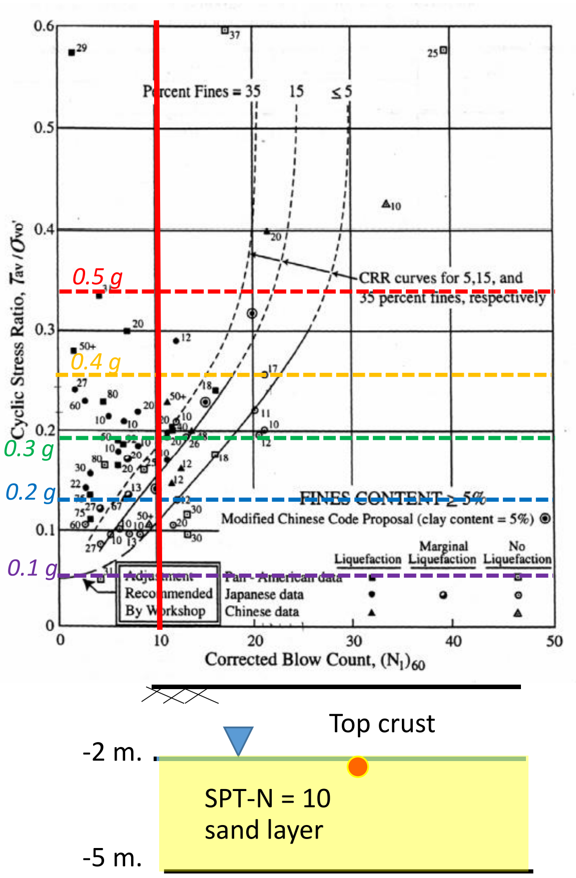

Figure 13 : The liquefaction potential analysis using Seed's method

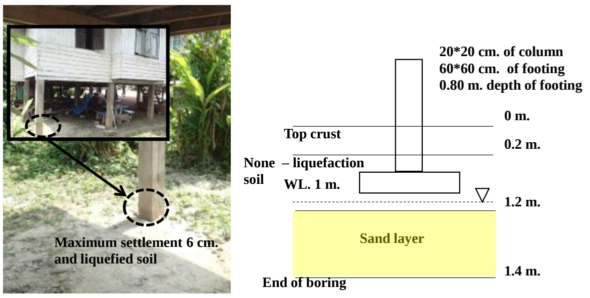

Figure 14 : Foundation settlement due to liquefied soil

5. Lateral spreading and landslide

Lateral spreading were observed near the river or stream channel (Fig 15) and also the new filled soil area (Fig 16). Landslide was not observed, even though the mountainous area located within 20 km from epicenter (Fig 17). Only some rock fall was seen.

Figure 15 : Lateral spreading observed near the river or stream channel

Figure 16 : Lateral spreading observed at new filled soil area

6. Dam behavior

Fig 18 shows the location of dams over the seismic hazard zone of Thailand. One large dam (50 m high) and several small dams are located within 20 km from the epicenter (Fig 19). All of them performed well since it has been designed to resist the seismic force using pseudo static method. The previous work of Soralump and Kumma (2010) found that most of the small and medium sizes dams own by Royal Irrigation Department are quite safe to seismic force (Fig 20). Small longitudinal and transverse cracks were found but none of them leak (Fig 21). One large dam called Mea Suew get serious concerns from the public. It's a composite dam, consist of RCC spillway section at the center and side by earth dam. So far, no serious damage was observed.

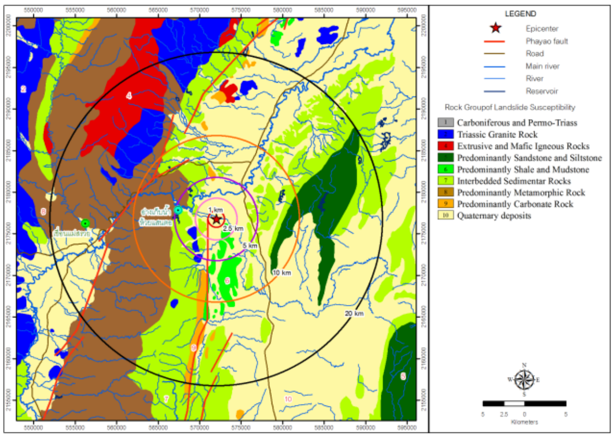

Figure 17 : Landslide potential area

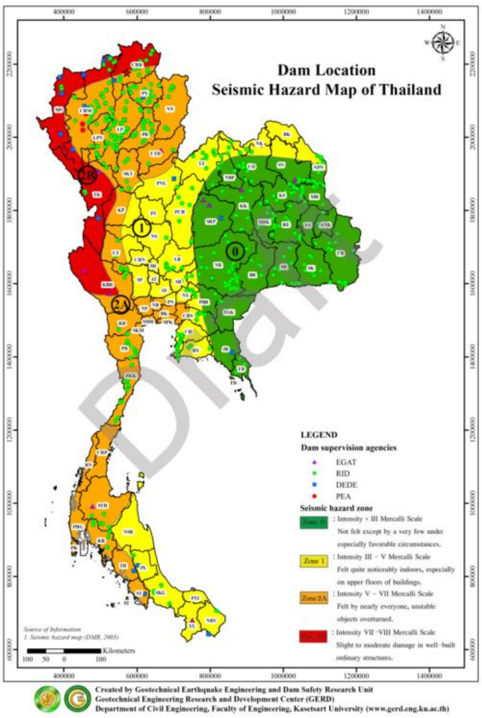

Figure 18 : Dam locations plotted over the seismic hazard zone of Thailand

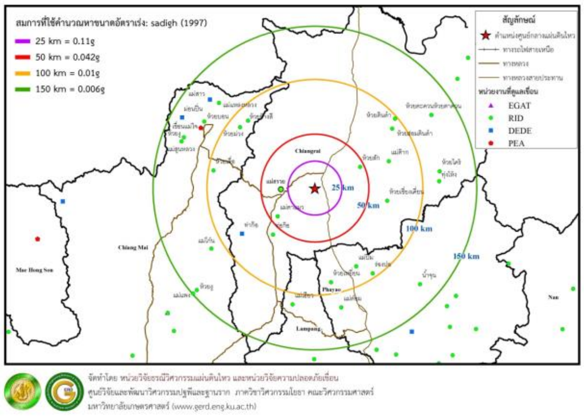

Figure 19 : Dam location within 20 km radius

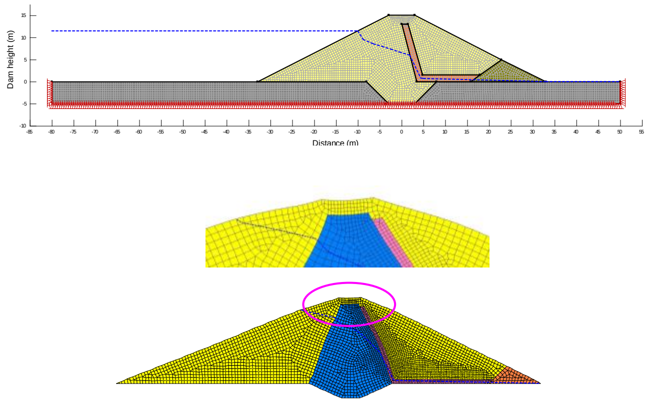

Figure 20 : Seismic deformation analysis of medium and small dam (Soralump and Kumma, 2010)

Figure 21 : Small longitudinal and transverse cracks

7. Conclusion

7.1 Most of the damage occurred to the structure that has not been designed to resist the earthquake force. Enforcement of small building for adequate seismic design may need to be reconsidered.

7.2 Ground rupture, liquefaction and lateral spreading were observed but caused minor damage. However, these phenomena bring serious attention to the preventive design to prevent the serious damage in the future especially from liquefaction.

7.3 Dams performed quite well since the design standard is already concern about the seismic force.

8. Acknowledgements

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9. References

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