LIQUEFACTION VULNERABILITY ASSESSMENT IN LOW-SEISMIC REGIONS: A CHIANG RAI CASE STUDY

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1. INTRODUCTION

The increasing number of earthquakes in Thailand has raised concerns about seismic hazards such as ground shaking, seismic-induced landslide and liquefaction. The liquefaction evidence in rural areas of Mae Sai, Chiang Rai induced by the 2011 Tarley earthquakes led to an increase in risk awareness of liquefaction in denser populated areas of Chiang Rai

This research presents the probabilistic liquefaction hazard analysis of two sites in Muang Chiang Rai using empirical equations and finite element modelling called UBC3D-PLM. By installing two boreholes, the site-specific analyses vastly reduced the uncertainties of existing hazard assessments and updated soil database for northern Thailand.

2. METHODOLOGY

2.1 Site investigation

In this study, the Standard Penetration Test (SPT) and the downhole seismic test were conducted to obtain in-situ soil properties, including penetration blow counts, shear wave velocity and fines content. The field study included two SPT-borehole sites installed in Chiang Rai Rajabhat University (CRRU)

2.2 Probabilistic seismic hazard analysis (PSHA)

Peak horizontal acceleration (PHA) and earthquake magnitude, estimated from the probabilistic seismic hazard analysis, highly influences on liquefaction potential. For this study, the PHA are calculated at ground surface for the simplified equations, and bedrock for finite element analysis in PLAXIS software. The PSHA maps represents the likelihood of various of ground motion associated with the 10% and 2% probabilities of exceedance over 50 years.

The OpenQuake Engine software developed by Global Earthquake Model (GEM) foundation were utilized to construct seismic hazard models. The PHA are quantified using the conventional mean (classical PSHA) while the earthquake magnitudes are quantified using the disaggregation analysis (disaggregated PSHA).

2.3 Probabilistic liquefaction potential calculations

The liquefaction assessments for this study incorporate both empirical and numerical analyses. The empirical analysis follows the equations proposed by Boulanger et al. 2014. For the numerical analysis, the UBC3D-PLM constitutive model was simulated using the input model parameters proposed by Sukkarak et al. 2021. The author calibrated the UBC3D-PLM model using monotonic and cyclic test results of soil specimens collected in Mae Lao district. For reasons of simplification, the modeled soil layers consist of homogenous dense sand, loose sand and clay.

3. RESULTS

3.1 Geotechnical investigation and soil properties

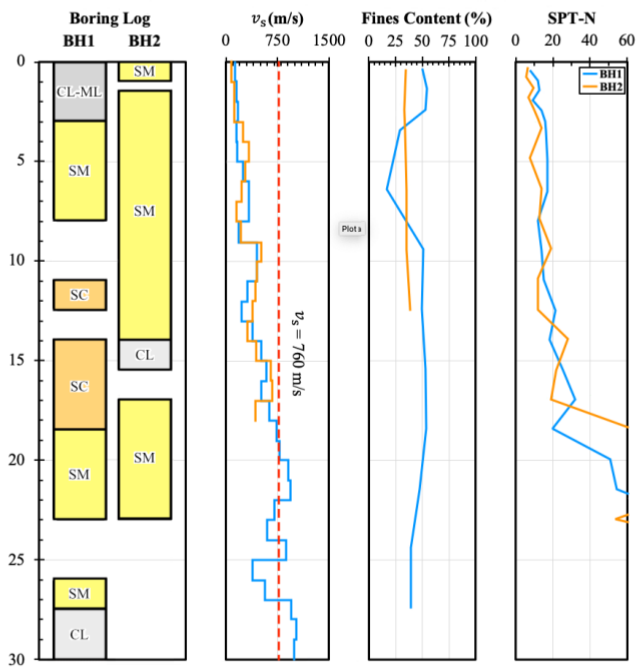

Figure 1. Soil properties of BH1 and BH2

3.2 Probabilistic seismic hazard analysis

The earthquake magnitude that contributes most significantly to the ground shaking of 10% and 2% probabilities of exceedance is 7.5M. In addition, the correlated peak horizontal accelerations are summarized in Table 1.

Table 1. Peak horizontal accelerations at surface/ bedrock

Site ID	$PGA_{surface}$		$PGA_{bedrock}$	
	10% POE	2% POE	10% POE	2% POE
BH1	0.215	0.452	0.208	0.434
BH2	0.215	0.457	0.208	0.434

3.3 Probabilistic liquefaction potential

For empirical method, factors of safety of each specimen were individually calculated using the simplified procedure based on SPT blow count data. The soil columns were assumed fully saturated.

For finite element method, the generation of excess pore pressure over time within a single borehole was illustrated in Figure 2.

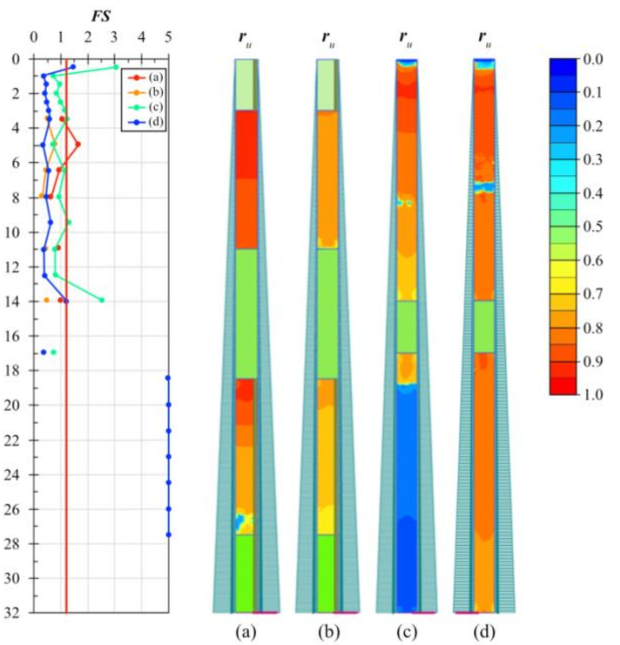

Figure 2. Liquefaction potential assessment using simplified and finite element methods a) BH1 at 10% probability (b) BH1 at 2% probability (c) BH2 at 10% probability and (d) BH2 at 2% probability

Liquefaction potentially occurs when a safety factor lower than 1 in the empirical analysis and a pore pressure ratio exceeding 0.95 in the numerical analysis. The depth at which soil is potentially liquefied is within a shallow, loose sand layer. The predicted liquefied depth from the empirical analysis closely aligns with the finite element modeling indicating a strong agreement in the locations of potentially liquefied soil layer.

The parameters used in the simplified procedures can be directly derived from the in-situ tests while variables in UBC3D-PLM model must be obtained from both field and laboratory tests. However, the numerical approach provides a more realistic results compared to the empirical approach since the model also simulates the interaction between soil particles and fluids.

4. CONCLUSIONS

(1) The liquefaction potentially occurs in the capital of Chiang Rai when subjected to the levels of ground shaking associated with 10% and 2% probabilities of exceedance over 50-year period.

(2) The depths of potentially liquefied soil are within the shallow, loose sand layer. The claim is supported by a high correlation between empirical and numerical results.

5. REFERENCE

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