Comparisons between deterministic and probabilistic liquefaction assessment approaches

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Project overview

Liquefaction assessments are commonly undertaken by geotechnical engineers using a deterministic approach. This approach does not appropriately take into account the significant uncertainties associated with a liquefaction assessment and can potentially compound the conservatism that is introduced when selecting input parameters. Therefore, the deterministic assessment approach can be conservative and the expected performance poorly understood. This research project looks at an alternative approach for liquefaction assessments - a probabilistic assessment. Other researchers have hypothetically experimented with the idea, but have never operationalised a probabilistic approach.

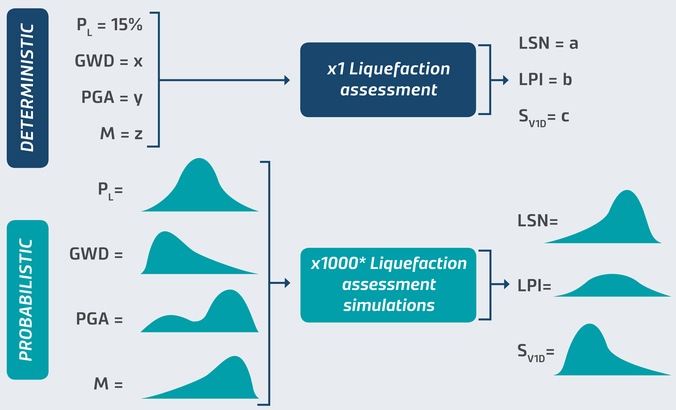
Probabilistic assessment tool

This research project has developed the first end-to-end probabilistic liquefaction tool that can be applied over an extensive geographical area. The following parameters can now be inputted into the tool as a normal distribution rather than a single value (as per the deterministic assessment approach):

- Magnitude (M)
- Peak ground acceleration (PGA)
- Groundwater depth (GWD)
- Cyclic strength (i.e. probability of triggering P_L)

NOTE: At this stage, the input parameters are modelled independently to each other and the same P_L value is applied for the entire CPT trace.

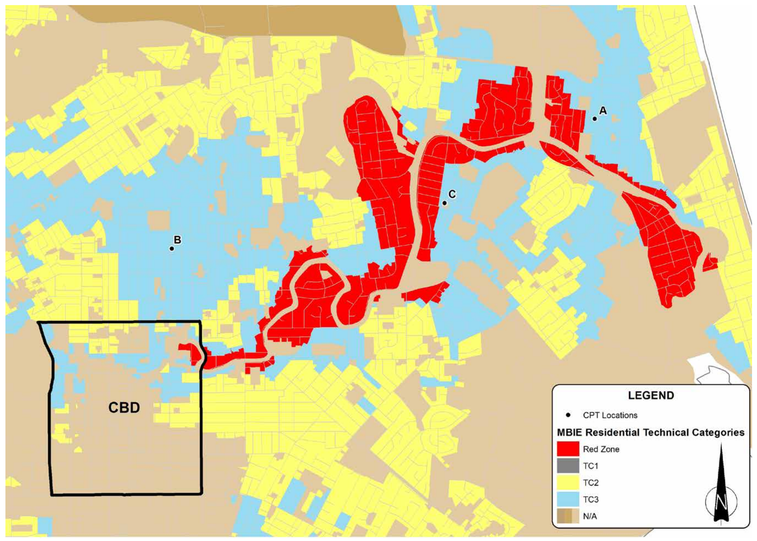
Deterministic v. probabilistic methodology



** NOTE: User can specify the number of simulations using Monte Carlo method.*

Output of LSN distribution using probabilistic assessment

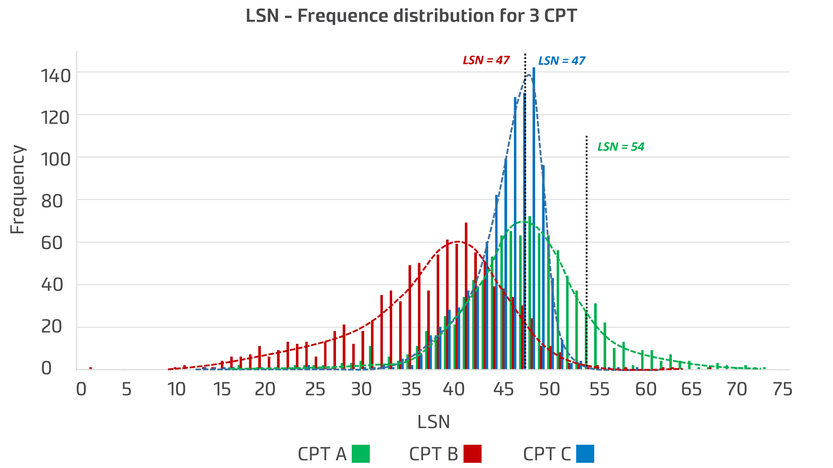
Three CPT in TC3 have been selected to undertake an initial probabilistic assessment. CPT A, B and C can be identified on the map.



A liquefaction assessment was undertaken for the three CPT using the deterministic approach and the probabilistic approach using the following example input parameters and associated normal distributions:

Input Parameter	Deterministic assessment	Probabilistic assessment	
		Mean	Standard deviation
Magnitude	7.0	7.0	0.5
PGA	0.5g	0.5g	0.1g
GWD	0.8m (i.e. upper bound)	1.0m	0.2m
C_0 (P_L)	2.8 (i.e. P_L = 15%)	2.6	0.2

For the probabilistic assessment, the liquefaction triggering computation was performed for 1000 simulations of the input parameters from their random distributions using the Monte Carlo method. The distribution of liquefaction parameter, LSN, is shown in the histograms and compared to the deterministic LSN value.



The differences between the deterministic LSN value and the probabilistic LSN distribution for the three CPT are noteworthy. For CPT A, the deterministic LSN value represents the 87th percentile of the probabilistic distribution, for CPT B, the deterministic LSN value represents the 93th percentile of the probabilistic distribution whereas for CPT C, the deterministic LSN value represents the 70th percentile of the probabilistic distribution. The results also show that while the input parameters have a normal distribution, the LSN output parameter, does not (and the distribution shape varies from site-to-site). CPT A has a slight left skew and CPT B and C have small right skews in the LSN distributions. The next step is to understand which input parameters have the most influence on the output distribution and whether this is influenced by soil type and density.

Future works

- Assess the probabilistic output distribution of other liquefaction vulnerability parameters (e.g. S_{V1D}, LPI...etc.)
- Enable "I_c cut-off" and "fines content (FC) correlation" to be input into the tool as a distribution rather than a fixed value
- Refine the tool so that the type of distribution can be specified (i.e. not just normal distribution)
- Introduce a dependency between the input parameter distributions (initially Magnitude and PGA and at a later date, I_c cut-off and FC)
- Develop a visual output to display probabilistic liquefaction assessments geographically and a methodology for use in engineering practice

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