This video provides an overview of changes and additions to the old 2010 Module 1 on liquefaction hazards.

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Transcript

Welcome to this Build It Right presentation - Identification, assessment and mitigation of liquefaction hazards.

This is an overview of new information in Module 3 of the Earthquake Geotechnical Engineering education series prepared by a partnership between the Ministry of Business Innovation and Employment and the New Zealand Geotechnical Society.

This new module is relevant for experienced geo-professionals who are familiar with the old 2010 Module and I will give you a brief overview of the changes and additions.

Module 3 is part of the series on New Zealand Earthquake Geotechnical Engineering Practice some of these have been published and others are still under development.
There are five main changes to Module 3 which I will summarise now and then describe each in more detail in this presentation.

First, a liquefaction assessment process flowchart has been added. This chart describes the key activities that need to be performed and their sequence, and provides links to the relevant sections of the module.

Second, the Seismic Hazard interpretation approach has changed. The third change is that the CPT-based triggering method of Boulanger and Idriss in 2014 has been recommended. This supersedes the Idriss and Boulanger method 2008.

This new method is more complex but theoretically more sound. It also incorporates some data from the Canterbury earthquake sequence.

Fourth, we have included additional commentary based on observations from Canterbury.

The fifth and final change is that much of the material related to the general description of geotechnical hazards and estimation of ground motion parameters has been moved to the new Module 1.

I will now expand on the first four of these changes. The first is around key steps and process.

This Assessment Flowchart, Figure 5.2, shows the Key Steps in the Liquefaction Evaluation Procedure and provides references to the rest of the module content.

Simplified liquefaction assessment requires earthquake load specification in terms of Peak Ground Acceleration (PGA) and Moment Magnitude (MW) which in turn requires an appropriate interpretation of the seismic hazard.

It is currently not possible to easily obtain the deaggregated seismic hazard in New Zealand without a site specific hazard assessment. Therefore for routine engineering projects, we have shifted from the NZS1170.5 hazard definition where a magnitude-weighted hazard was used, to the NZTA Bridge Manual hazard definition.

The Bridge Manual provides a more appropriate description of the hazard for liquefaction evaluation, in which PGA-Mw pairs are used to define the earthquake load in the liquefaction triggering analysis.

The Manual’s maps are duplicated in Module 3 and have PGA and ‘effective magnitude’ pairs defined through contour maps, for different return periods and site classes.

This recommendation is an interim measure. The seismic hazard interpretation is a subject of close scrutiny at the moment. We intend to update this aspect as soon as possible.

The BI 2014 method incorporates additional liquefaction case history data (some of it derived from the Canterbury Earthquake sequence) and a re-fitting of the analysis methodology to this updated data set.

The main changes in this method are:

- A new formulation for magnitude scaling factor (MSF).
- A revised relationship between \( I_{SC} \) and fines content.
- Details of the formulation for the equivalent clean sand adjustment for fines content. This is for CPT data, not for SPT data.
- Lastly, a probabilistic version of the CPT-based liquefaction triggering procedure is provided.

I'm now going to expand on these changes a little more. The updated Magnitude Scaling Factor considers not only the effect of increasing duration with earthquake magnitude but also accounts for differences in the soil response depending on soil density (represented by penetration resistance).

It implies that the MSF varies significantly in dense sands, while the variation of MSF with Mw is much smaller for loose sands.

With regard to fines content – where CPT data alone is available – then guidance is given on the soil behaviour type index \( I_{SC} \) to evaluate liquefaction susceptibility and the relationship is shown here.

Note that the correlation between FC and \( I_{SC} \) is relatively weak as shown in this figure, and for high risk/high consequence projects, CPT testing ideally should be complemented by drilling, sampling and lab testing.

A probabilistic version of the CPT-based liquefaction triggering procedure is also presented in BI 2014.

It is noted that the uncertainty in the liquefaction triggering analysis is smaller than the uncertainty in the seismic hazard evaluation, and may often be smaller than the uncertainty in the site characterisation.

The section on the evaluation of liquefaction-induced settlement, lateral spreading and cyclic horizontal ground displacements is substantially updated to reflect the learnings from Canterbury and recent research including the effects on structures. This subject will be covered in more detail in Module 4.

The performance levels table has been updated to include LPI, and LSN screening criteria as well as the factor of safety. This table also includes explanatory notes which are critically important to consider when reviewing this table.

It is noted ground-deformation predictions (for example settlement) and liquefaction-damage indices such as, LPI and LSN, are proxies for predicted performance and are typically applied for area based screening.

Some effort has gone into discussing how these indices should be interpreted.

Module 3 also includes more discussion on uncertainties in the liquefaction assessment processes - including uncertainties around PGA, Fines Content, Plasticity Index and Ground Water Level.

It is noted that the potential effects of these uncertainties should be considered through parametric or sensitivity studies.

With regard to post liquefaction residual strength upper bound, lower bound and best estimate values should be considered.

It is acknowledged these strength values are highly uncertain but are needed for bearing capacity, lateral loads on piles, and the Newmark displacement prediction methods and others.

Module 3 also includes expanded sections on gravelly and clayey soils, and a specific sub-section on volcanic soils.
There is also a brief discussion on the influence on the soil matrix of gravelly soils on its liquefaction susceptibility.

The Module retains and slightly expands its brief discussion on the mitigation of liquefaction and lateral spreading but note that this section will be largely superseded by Module 5 – Ground Improvement - when it is published.

This concludes this presentation on the key changes to Module 3: Identification assessment and mitigation of liquefaction hazards.

The MBIE Building.govt.nz web site includes this and other documents referred to in this presentation and the worked examples presented at the training courses.