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Opinion paper from M J Pender

BO#1 View from Practice: Adequacy of Current Design Models

How are site effects addressed in engineering practice?

In New Zealand a revision of the loading standard is in preparation, Standards New Zealand (2002). This continues the practice of the current loading standard in absorbing site response effects into the design spectra. Different spectra are specified for four site classes (strong rock and rock are regarded as one site condition). So once the designer has settled on the site condition there is no further consideration of site effects. These design spectra have been arrived at empirically by considering collected data from New Zealand strong motion records, appropriate attenuation relationships, supplemented by information from places with a similar seismic environment to New Zealand. The loading standard does allow the designer to decide to undertake specific assessment of site effects. In these cases the limited G - γ and D - γ data for local materials is used, probably supplemented by information from elsewhere. However, site specific response analyses are not common in NZ practice.

BO#2 Adaptations Needed for use in Performance-Based Framework?

Can uncertainty be reduced through more lab testing?

The source of the variability we are concerned with is in the field. More laboratory testing does help to get a better idea of the variability, but the laboratory testing required for site response analysis is expensive and I wonder if one could ever afford to do enough. I have recently done some intense CPT probing of Auckland residual clay to depths of about 10 metres. From this it emerges that the distance scale of the variability is less than 10 m and very much less than the spacing of typical investigation CPT soundings. My conclusion is that zones of intense CPT sounding work supplemented with correlations to estimate the in situ shear wave velocity might be more useful in coming to a good indication of the range of variability of the soil. Having a fix on the variability of the shear wave velocity one would then need enough laboratory testing of the materials at the site to get the shape of the G - γ and D - γ relationships. There is an assumption in this suggestion. Simply that the variability of the shear wave velocity is likely to be more significant than variability in the shape of the shear modulus and hysteretic damping curves. However, the shear wave velocity in the specimen used for laboratory testing will be less than the in situ value (see the comments for BO#3 and BO#6 below), so we need to incorporate a correction for this and here another assumption is needed. This time that the sampling disturbance has a greater effect on the shear wave velocity of the laboratory sample than on the "larger" strain cyclic behaviour. Thus one arrives at a field G - γ relation by hauling the small strain end of the laboratory curve up to a value corresponding to the in situ shear wave velocity and then assuming that the two curves converge at a shear strain of several tenths of a per cent. (What happens to the D - γ curve?)

If, as stated above, the uncertainty is in the field then one should measure all the information needed in the field, that is not only the shear wave velocity but also the G - γ and D - γ relationship – this can be done but is expensive.

Through a new model form?

At the risk of stating the obvious, it is necessary to emphasise that any new model (or existing one for that matter) needs to be very simple, else the required effort to determine model parameters will not be practical. In the case of existing complex models there is often a practice of using "generic" values for some of the parameters.

BO#3 Understanding and Addressing Soil Disturbance Issues

What tests could be performed to address soil disturbance issues?

I think a very good indicator of sample disturbance is the comparison between the in situ shear wave velocity for the soil and the value measured in a laboratory specimen consolidated to the in situ state of effective stress. Measurement in the field is routinely done using the seismic CPT. In the laboratory bender element tests give the velocity. There have been questions about interpretation of the travel times from bender element testing but I think this is now resolved using cross-correlation processing of the signals, also comparatively inexpensive apparatus has been developed, Mohsin et al (2004).

BO#4 Issues for "Special Soils" such as gravels, silt, peat, and improved ground

Are adequate models available for these special soils?

The properties of gravel must be one to the most neglected topics in the geotechnical field. The reasons are obvious but the challenge is important.

BO#6 Issues for Merging Existing Worldwide Data Sets

Are different testing techniques and methods used in other countries

In NZ we do not have any resonant column devices. The only equipment for determination of G - γ and D - γ curves is a torsional free vibration device (solid cylindrical specimen), Taylor and Parton (1973). For pumiceous sand we have compared the small strain shear moduli obtained with this device with those from bender element measurements, Fig. 1. I offer these results in support of my suggestion that bender element measurement is an appropriate method for determining shear wave velocities of laboratory specimens. Comparison of these with field values is then a gauge of sample disturbance. For Auckland residual clays we have measured in situ shear wave velocities in the range 150 to 250 m/sec. We find that laboratory bender element shear wave velocities on these residual clays are in the range 100 to 150 m/sec. In the context of correlations between properties, another that we have used is between undrained shear strength and small strain shear modulus. For the Auckland residual clays we were initially very surprised at finding that the small strain shear modulus was only a few hundred times the undrained shear strength and not a few thousand. The paper by Weiler (1988) was helpful here as it indicated that as the overconsolidation ratio increases the G_{max}/s_u ratio decreases. Furthermore for all overconsolidation ratios the value of this ratio is lower for larger values of the plasticity index. Auckland residual clays are not overconsolidated in the classical manner, but in many ways behave as heavily overconsolidated soils so our ratio of a few hundred is not unreasonable.

References:

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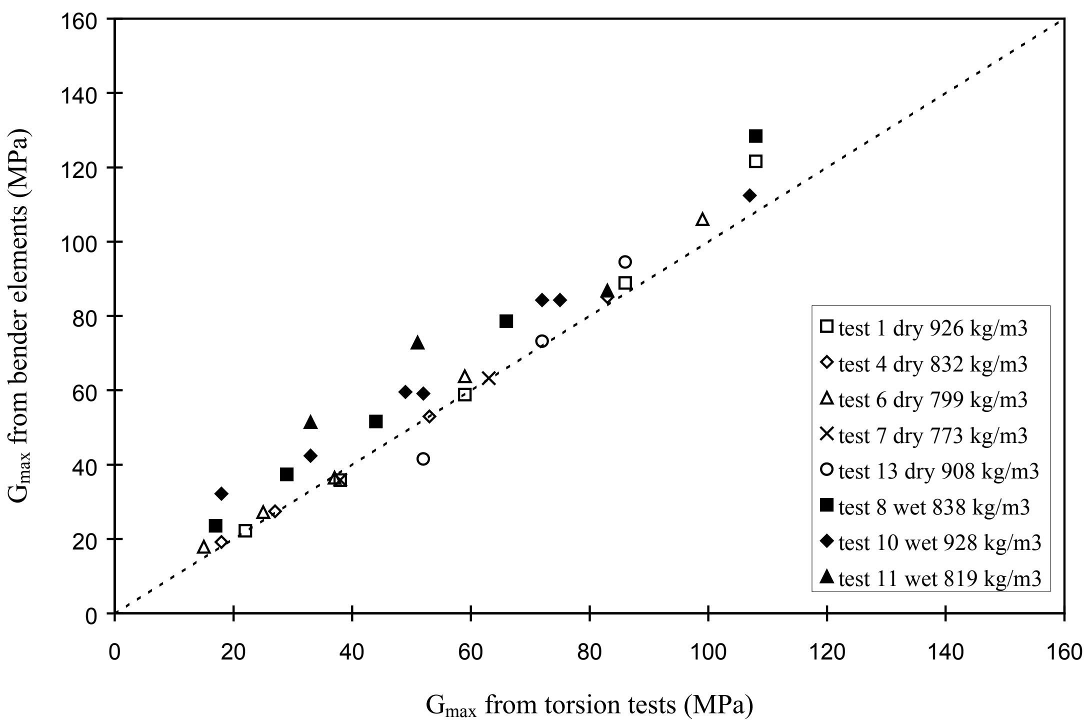

Fig. 1 Comparison between small strain shear moduli for laboratory specimens of pumiceous sand derived from bender element and free vibration torsion tests.