Adequacy of Current SSI Design and Material Models - An Opinion Paper

By

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How are Site Effects Addressed in Engineering Practice?

We address site effects a variety of ways – from use of soil-site attenuation relationships, published maps and charts, to application of "sophisticated" computer programs involving a variety of site response and constitutive models. The number of "sophisticated" analyses is steadily increasing, though it is still a relatively small percentage of the analyses conducted.

When are Generic versus Site-Specific Soil Properties Used?

Basic soil properties (unit weight, shear strength) are established on a site-specific basis on many of the projects that involves numerical modeling. However, they frequently established indirectly, based upon correlation with other measurements (e.g., SPT blow counts). Shear wave velocity is measured on an increasing number of projects, though the number of projects on which shear wave velocity is measured is still less than 50% of the total for which response analyses are conducted. Non-standard soil properties such as modulus reduction and damping curves and the parameters of the PWP generation models) are almost never established on a site-specific basis: generic curves are typically used for these parameters.

What Models are Currently Being Used?

We defer to the survey Steve Kramer conducted on currently used (site response) models for this workshop. However, Steve's survey does not include site response models which account for Soil Structure Interaction (SSI).

We are aware of several SSI and quasi SSI programs (using equivalent plain strain width) in use in practice (Tara, Dysac, Lynos, SuperFlush, Adina, Dynaflow, Diana, FLAC, PLAXIS).

What are the Limitations of the Current (SSI) Models?

Many of them are not intened for commercial application and require heavy involvement by the developer (e.g., Tara, Dysac, Lynos, Dynaflow). With respect to the commercially available and supported programs, FLAC and PLAXIS are the most common. FLAC is more versatile (FISH language) and has, in GeoSyntec opinion, better dynamic module. PLAXIS is easier to use. We (GeoSyntec) have no experience with SuperFlush, Adina, and Diana.

Wide application of these (and other) programs is limited because:

- Not easy to use for dynamic site response analysis, especially for effective stress analysis;
- No developer-provided/supported dynamic stress-strain model (other than Mohr-Coulomb); and
- No developer-provided/supported seismic Pore Water Pressure (PWP) generation models.

However, lack of wide application of the models is not necessarily a bad thing, as many of the applications we have seen in practice are inappropriate and misleading. These deficiencies are generally related to lack of proper calibration and validation of the model. These programs have many special features and options, and calibration and validation of the model is required for almost every problem. Simply because a particular computer program was used previously to predict the response of an earth dam does not mean that the particular configuration of options and features being used by the engineer for another application is appropriate, robust, and stable, even if it is for an embankment of a similar configuration. Each particular application of a model (i.e., each combination of options and features and model geometry) must be calibrated and validated against a "known" or "accepted" solution. When a new feature or different combination of features is used, model calibration and validation becomes even more important.

Recommendations:

Most importantly, standard guidance is required for calibration and validating SSI models applied in practice. "Standard" or "accepted" model configurations that may not require calibration, "known" solutions that "typical" applications can be calibrated and validated against, and for procedures identifying, calibrating and validating "new" or "non-standard" applications of a model (e.g., a new geometry, application, feature, or combination of model features). Such guidelines are necessary to mitigate the potential

for misuse of these powerful models in practice. Misuse of these models both endangers public safety and hinders their acceptance and application in practice.

Besides establishing guidance on model calibration and validation, further application of these programs for dynamic effective-stress applications (with SSI) can be speed up by:

- Standardizing (agreeing upon two to three) constitutive models for stress-strain and seismic PWP generation (coupled or decoupled; loading-reloading must be a part of the package); and

- Developing a consistent set of soil parameters for selected model(s).

The consistent set of soil parameters should be developed in such a manner that the practicing professionals can, based upon basic soil classification data (grain size distribution, plasticity) and applicable stress levels, select model parameters (e.g., as the Vucetic and Dobry modulus reduction and damping curves can be selected based upon PI).