Repute vs 3D FEM/FDM analyses

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The analysis of a pile group under general loading (V, H and M) is a truly 3D problem and thus requires a 3D model. As pointed out by Poulos (2000), "*2D plane-strain analyses of pile groups must be approached with extreme caution because the results may be misleading*".

One of the main features of Repute is its capability to provide a complete 3D boundary element (BEM) solution of the soil continuum while retaining a computationally efficient code. Although a complete 3D analysis of a pile group can be carried out by finite element (FEM) or finite difference (FDM) analyses using commercial codes (eg. Plaxis 3D or FLAC 3D), the complexity and high computational costs involved preclude the routine use of such techniques in pile group design and restrict their use to special cases/projects.

Main advantages of using Repute instead of 3D FEM or FDM analyses for pile group design include the following:

• Computational costs

3D FEM/FDM calculations are computationally demanding, particularly if non-linear soil behaviour is considered and multiple loadings cases are present. The high computing costs also reduce the time available to undertake some essential tasks such as the necessary checks, the calibration against measured results and the sensitivity studies to investigate the significance of variation in soil properties, stratigraphy and other factors (Haberfield 2017). This is a problem for many practical projects where time and financial restraints are imposed.

As an example, McCabe & Sheil (2014) report that, using Plaxis 3D, the calculation time for an axially loaded 49-pile group is 40 hours on a 1.6-GHz quad core Intel i7 processor. Using a similar computer, the same pile-group is analysed with Repute in only 160 seconds, i.e. over 1,000 times less than with Plaxis 3D. In addition, the amount of input data required by Repute is minimal and normally entered in a few minutes. Repute input and output data can therefore be checked and reviewed in a matter of minutes.

• Complexity

3D FEM/FDM codes are relatively complex to use correctly and place particularly high demands on the competency of users. In order to perform reliable calculations, suitably experienced specialists are therefore required to correctly define the model inputs and review the significant amount of output. As an example, major problems are related to the high mesh dependency (it has been shown that the results are strictly dependent on the geometry and refinement of the mesh) and to the uncertainty in assigning stiffness/strength properties to the pile-soil interface elements (e.g. Poulos 2001, Lee et al. 2010, Brinkgreve and Broere 2003). Thus, 3D FEM and FDM analyses should only be applied 1) for special cases, 2) by highly experienced engineers, and 3) when the finances and the time are available. As discussed by Poulos (2005), it is preferable, at least from a practical viewpoint, to employ analyses which may involve a greater degree of approximation (such as Repute), but may be simpler to use and more readily adapted to carrying out parametric studies, as well as solving real-world problems. In any case, simpler mehods of analysis are essential for checking the correctness of results from sophisticated and error-prone 3D FEM or FDM analyses.

Repute removes the above drawbacks and successfully predicts the pile response in a simpler and more direct manner. As stated by Poulos et al. (2001), "*It is not necessary to employ complex representations of non-linear soil behaviour in order to obtain reasonable predictions of lateral pile response. Even a simple elastic-plastic or hyperbolic response may often be adequate to capture the main non-linear effects*". The above statement is supported by a large amount of experimental observations on full-scale pile groups.

• External loads

3D FEM or FDM codes have been utilized with some success for analyses of pile groups under axial loading. Further research, testing and validation are needed to use this kind of analyses in routine pile-group design, particularly when lateral or torsional loading are applied.

Repute removes the above limitation as it can deal with pile groups under any loading conditions (vertical, horizontal, moment and torsional loading acting in any directions).