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 shown 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. In principle, 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 Foundation and FLAC 3D). However, the complexity and high computational costs involved preclude the routine use of such techniques in pile design and restrict their use to special cases.

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

- **Computational costs**

3D FEM or FDM calculations are extremely computationally demanding, particularly if non-linear soil behaviour is considered.

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.

- **Effort in input data storage and preparation**

A larger amount of time is required in the input stages of design for the preparation of a 3D mesh and to input the data with 3D FEM or FDM codes. Moreover, the database files of the input/output data require a large amount of memory disc space (e.g. Comodromos 2004 reports that 200 MB of disc space is necessary for a single run of the 9-pile group analysis with FLAC 3D).

The amount of input data required by Repute is minimal and is normally carried out in a couple of minutes. The BEM mesh is automatically calculated by Repute in a matter of seconds.

- **Complexity**

3D FEM or FDM codes are relatively complex to use, and errors can occur in the data development and modelling, particularly when non-linear soil behaviour is considered. In addition, 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 for special cases by highly experienced engineers (and when the finances and the time are available). In any case, as discussed by Poulos (2016), simpler mehods of analysis (such as Repute) are essential for checking the correctness of results.

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).