Two-Day Workshop on Advanced Computational Geotechnics Finite Element Analysis

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A two-day workshop on 'Advanced Computational Geotechnics and Finite Element Analysis was held on 3 and 4 September 2007 at Armada Hotel, Petaling Jaya. The course was conducted by Professor Harry Tan Siew Ann from the National University of Singapore and was attended by 96 participants (Figure 1). The workshop aimed to provide exposure on the use of advanced Finite Element Method analysis in dealing with complex geotechnical analysis and optimising cost effectiveness of solutions. Licences of FEM software packages Plaxis 2D V8 and Plaxis 3D Foundation (P3DF) were sponsored by Consoft Asia during the workshop for participants to have a hands-on experience.

The workshop started with an overview of soil stiffness and Mohr-Coulomb soil model. Professor Tan then illustrated how Finite Element Modelling (FEM) can be used to derive bearing capacity factors Nc, Nq and Ng for a footing (rough and rigid / flexible) as compared to the values proposed by Vesić (1975). However, the computed values are similar to the theoretical values only for an angle of friction less than 30°.

Figure 1: Prof. Harry Tan conducting the workshop

Professor Tan then covered the modelling of undrained behaviour, in particular, the three common methods of stress analysis. Method A is modelling undrained behaviour in terms of effective stresses with drained strength parameters, Method B model

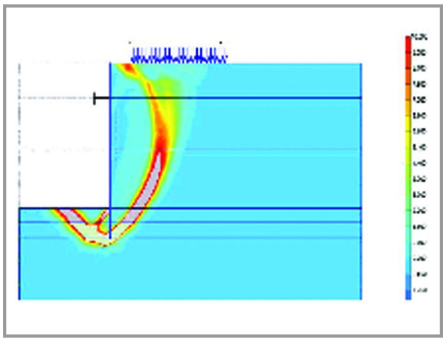

Figure 2: Failure Mechanism of an Excavation

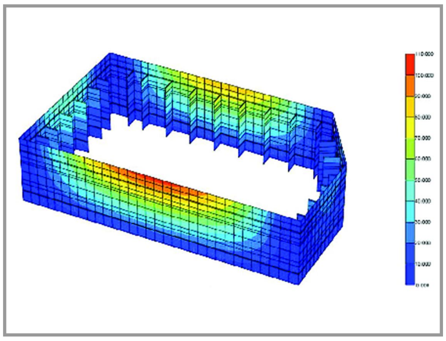

Figure 3: Wall displacements of counterfort diaphragm wall after excavation to final level

in terms of effective stresses with undrained strength parameters while Method C model in terms of total stresses. Of the three methods, only Method A and B are recommended as Method C is a total stress analysis with no information on excess pore pressure response. While Method A is recommended, Method B can also be used when effective strength parameters are not available.

He also illustrated the influence of soil dilatancy between the Mohr-Coulomb (M-C) and Hardening-Soil (H-S) constitutive model where the choice of dilatancy angle can greatly affect the soil behaviour. In addition, Professor Tan explained in detail the H-S model and its differences compared to the M-C model. Some of the advantages of the H-S model are its stress-dependent stiffness behaviour, its ability to model better non-linear behaviour and the effects of density and shear hardening. This model is well suited for excavation problems. However, the H-S model cannot model characteristic peak strength, softening and creep behaviour.

Participants were given a hands-on opportunity to learn how to simulate triaxial shear tests using axis-symmetric 2-D FEM. From the simulation, participants were shown how the typical volumetric-axial strain curve for undrained and drained triaxial shear tests were produced in 2D FEM that were comparable to laboratory test results. Subsequently, Professor Tan introduced the use of the Soil Test module available in the FEM software package which automatically simulate triaxial and oedometer tests. This can be used to quickly validate the soil parameters before using them in FEM.

On the second day, Professor Tan showed the use of 2D and 3D FEM in deep excavation problems (Figure 2). In 2D FEM, he showed how to model a cantilever retaining wall and illustrated how the results from FEM correspond closely to the measured results from a case study of instrumented retaining wall.

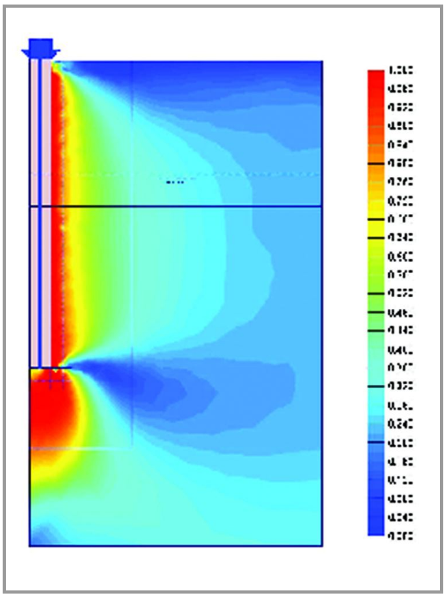

Figure 4: Relative shear distribution for single pile in H-S model

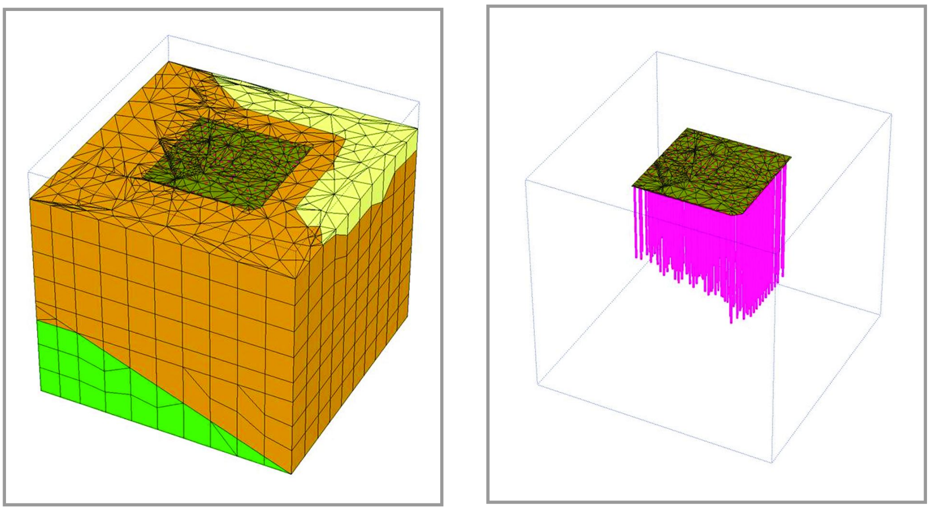

Figure 5: KL Tower piled raft foundation model in 3D FEM

In 3D FEM, case studies were used to illustrate the use of 3D FEM in deep excavation projects. One of the projects involved the modelling of an innovative counterfort diaphragm wall without internal strutting for an 8m deep excavation (Figure 3). He illustrated how the diaphragm wall and counterfort were modelled and the use of Jet Grouted Pile at the base of the excavation to prevent basal heave failure. The 3D soil profile based on the boreholes carried out across the site was also modelled.

Participants were also treated to a second hands-on exercise to model a 10.7m deep excavation for the basement of the New OG building in Singapore. The model has varying soil profile using the H-S model and excavation with intermediate struts. The excavation was unique by the use of sheet pile wall on one side and grout mixed pile wall on the other.

The workshop continued with the modelling of a single pile to simulate pile load test behaviour using both the M-C and H-S models (Figure 4). In particular, Professor Tan illustrated the influence of interface elements between pile body and soil, where the shaft resistance of the pile was smaller when interface elements were used. He also showed the study of load-settlement profile for a single pile compared with a pile group and pile raft where the pile raft and pile group mobilised less shaft resistance.

The participants were introduced to two pile modelling tools in the 3D FEM software: Solid Pile and Embedded Pile where Embedded Pile is composed of beam elements whereas solid pile is composed of volume elements. Professor Tan illustrated the comparison of the results between the two pile models in terms of axial compression, tension and lateral pile load test behaviours.

Professor Tan also showed the comparison of the settlement behaviour of Pile Raft and Pile Group in 3D FEM with other analysis methods such as Poulos-Davis-Randolph, FLAC-3D, GASP and GARP5. The comparison showed that the 3D FEM software's pile raft results generally correspond reasonably well with other analysis methods.

The workshop concluded with Professor Tan presenting several case studies to illustrate projects in which the 3D FEM software has been used successfully to model Piled-Raft Foundations. Examples include the modelling of a highrise tower block piled-raft foundation in Kuala Lumpur with varying soil profile of residual soil over limestone and slump zone (Figure 5); and the simulation of piled-raft foundation at St Thomas Walk, Singapore, to model the complex non-uniform soil profile and predict the total and differential settlements of the piled-raft foundation.

On behalf of IEM's Geotechnical Engineering Technical Division, Engr. Liew Shaw Shong presented a token of appreciation to Professor Tan for his informative workshop and Eddy Tan of Consoft Asia for providing the Plaxis software packages in this workshop. ■

REFERENCES

Vesi, A. S. (1975), Foundation Engineering Handbook, 1st ed. Winterkorn and Fang, Van Nostrand Reinhold, 751 pp.