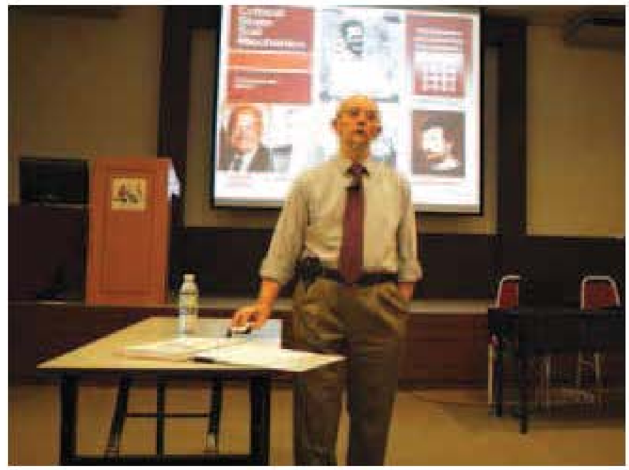
2½-Day Short Course on "Understanding The Behaviour of Clays – Deformation, Strength and Critical States"

by Ir. Yee Thien Seng

GEOTECHNICAL ENGINEERING TECHNICAL DIVISION

IEM Geotechnical Engineering Technical Division organised a 2½-day short course on Understanding The Behaviour of Clays – Deformation, Strength and Critical States on 8-10 October, 2013, at Tan Sri Professor Chin Fung Kee Auditorium, Wisma IEM, Petaling Jaya. 52 participants attended the course conducted by Professor Jim Graham, formerly of the University of Manitoba, Canada.

The subject is fundamentals of modern soil mechanics where soil deformational responses to load changes are rationally modelled employing the elasto-plastic framework to permit a wide variety of soil behaviours to be reproduced acceptably. The framework links the volume (actually voids ratio) changes in a soil element to effective stress changes and the resulting shear strength it can mobilise, instead of being treated as entirely separate entities in conventional soil mechanics practices. This is especially useful to engineers involved in soil testing as well as those undertaking the design of geotechnical works. As it was conducted in a systematic but largely qualitative manner, the course would help participants move up to the full blown mathematical treatment of the subject should they wish to do so.



Professor Jim Graham conducting his short course

After a short description of geotechnology, Prof. Graham took the participants through the development of constitutive models for soil behavior, beginning with Andrew Schofield and Peter Wroth's book (1968) titled Critical State Soil Mechanics (CSSM).

He then described the research work instrumental for defining the important critical state failure criterion for soils in shear. The critical state is defined as the state at which continued shear straining in the soil element takes place with no change in volume, no change in mean effective stress, no change in pore water pressure and no change in shear stress. It is a definitive state not emphasised previously in classical soil mechanics.

Following this, Prof. Graham introduced Modified Cam-Clay (MCC), a CSSM-compliant elasto-plastic model unveiled in 1968 using the associated flow rule. It is able to simulate the behaviour of lightly-over-consolidated reconstituted clay from start of loading till the critical states in isotropically elastic fashion. MCC, which modelled elastic behaviour, yielding and plastic volume changes reasonably well, has a state boundary surface comprising elliptical yield locii. The model describes that soils (including clays) derive their shear strengths from friction and effective stresses.

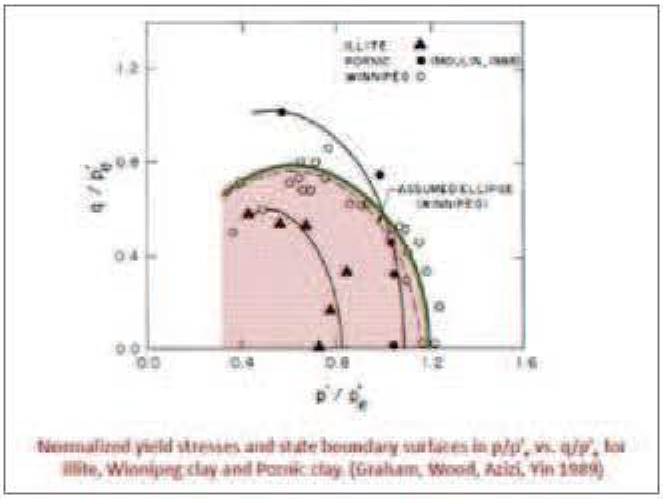


Figure 1: Symmetrically elliptical state boundary surfaces for natural Winnipeg and Pornic Clays and reconstituted illite

However, natural clays (owing to anisotropy) do not obey the isotropic elastic responses accorded by MCC in its original form, particularly in undrained shearing. But with the incorporation of the coupling between mean stresses and shear strains and coupling between shear stresses and volumetric strains (both features not considered when MCC was originally created), the MCC model could be improved to reproduce the anisotropic elastic behaviour of natural clays. Prof. Graham then provided test data during elastic shearing to show that the symmetrical elliptical-shaped MCC-type state boundary surface (Figure 1) remains valid for natural clays in spite of their display of non-elliptical yield envelopes. The careful study of plastic strains suggested that the associated flow rule adopted in MCC also applies to natural clays to dispel the misconceived notion that MCC is not useful for natural soils.

After demonstrating the validity of the MCC state boundary surface for natural clay behaviour, Prof. Graham showed how clay yield behaviour (and the state boundary surface) is affected by creep arising from varied rates of straining and loading and how capabilities could be built into the MCC model to accommodate soil creep behaviour. High temperature effects on soil behaviour (of great importance in underground nuclear waste storage facilities), have also been successfully incorporated into the MCC framework. Finally, he revealed a glimpse into on-going research to include behaviour of unsaturated soils within the elasto-plastic framework.

Throughout the course, Prof. Graham provided numerous data from field constructions and laboratory tests to illustrate the various aspects of soil behaviours (including dilation, the apparent source for cohesion strength) being dealt with in the course topics, in particular soil yielding. He also took the participants through a number of simple examples to familiarise them with the calculation process for working with elasto-plastic soil behaviour analyses.

At the end of the course, Prof. Graham presented certificates of attendance to the participants before he himself was presented with a certificate of appreciation and mementos by Ir. Dr Ooi Teik Aun, President of the Southeast Asian Geotechnical Society, on behalf of IEM. ■

Ir. Yee Thien Seng is the Deputy Chairman for Geotechnical Engineering Technical Division. In 1994, Ir. Yee set up his own practice, Geo.Consult, to offer the construction industry expert and specialist consultancy, in particular on geotechnical engineering aspects. He has authored/co-authored more than a dozen technical papers in local and international conferences. Ir. Yee is an expert witness and accredited checker for design of geotechnical engineering works registered with the Board of Engineers Malaysia.