Evening Talk on Analysis for Slope Stability

GEOTECHNICAL ENGINEERING TECHNICAL DIVISION

reported by
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On 10 November 2014 Professor Jim Graham from the University of Manitoba, Canada, gave an evening talk at the Tan Sri Professor Chin Fung Kee Auditorium, Petaling Jaya. The talk, "Analysis For Slope Stability", started at 5.30p.m. and was attended by 92 registered participants. It was also webcast live to the IEM Perak branch.

Professor Graham began by looking at the morphology of landslides to serve as the background for modelling embankments, river banks, flow slides and rock slides in Canada and Scandinavia. Although numerical modelling tools are excellent and numerically "precise", he said, our ability to characterise the ground is not as successful, particularly in identifying critical pore water pressures when failure actually occurs.

Hence, the "accuracy" of numerical solutions depends largely on the competence and informed judgement of the analyst. He also cautioned against the use of total stress analyses as these can produce unsystematically unreasonable solutions. He illustrated this with two case analyses which subsequently required re-analyses with effective stress strengths to arrive at acceptable solutions.

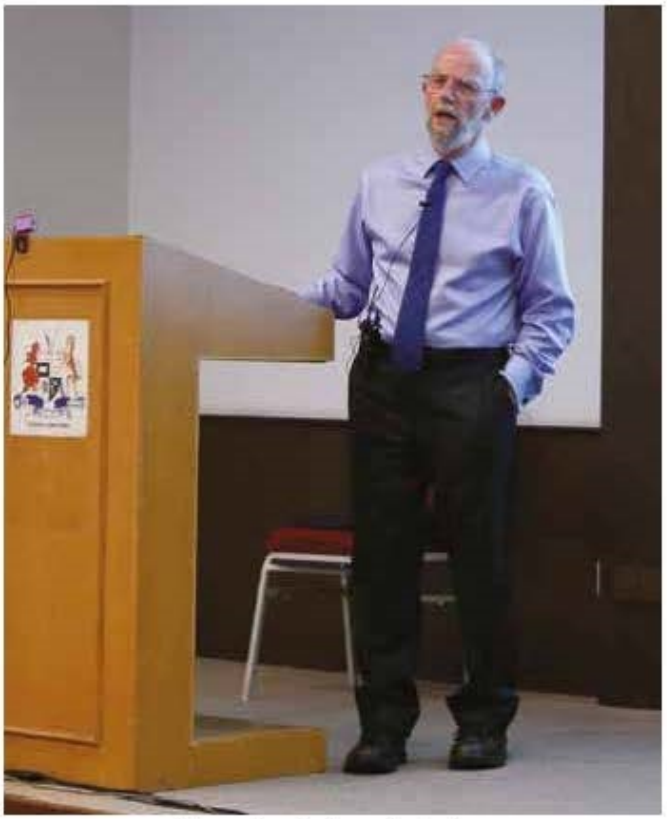
Professor Graham reminded the audience that commonly-used General Limit Equilibrium (GLE) method of analysis only addresses force and moment equilibrium conditions at the time of failure, without taking into consideration displacements or displacement rates. Even after making assumptions needed for these "slices" methods (a large variety is available), the solutions must be solved iteratively for the Factor of Safety (FoS). Force and moment equilibrium should be satisfied simultaneously.

The Simplified Bishop, Spencer and Morgenstern-Price methods all meet this requirement. With the same inputs, results from the analyses do not vary significantly. It is important to note, however, that input data used for characterising the ground profile, for example ground geometry, ground water conditions, geology (material stratifications), and material properties such as shear strengths and hydraulic conductivities will impact the quality of the solutions much more than the mathematical assumptions that have to be made.

Nowadays, Finite Element Method (FEM) solutions for stresses and deformations can provide realistic shear and normal stresses acting on each slice and permit improved GLE solutions. Analyses incorporating FEM-derived stresses are particularly valuable for problems with external point loads such as tiebacks that lead to highly non-uniform stresses in the ground. Professor Graham provided a case study where a river bank stabilised with rock-fill columns, was satisfactorily evaluated with the GLE analysis using FEM-derived stresses.

The issue of whether peak or post-peak strengths should be employed in a slope stability analysis was also discussed. Professor Graham mentioned a series of small dams and dykes in Manitoba that failed even though these had been designed with acceptable factors of safety in terms of peak strength parameters. After the failures, they were re-analysed using post-peak strengths and all had FoS close to unity. This and other case studies reinforced the practice established by the late Professor A.W. Skempton more than 40 years ago.

Professor Graham also discussed a river bank that experienced seasonal instabilities due to water pressure potentials rising in aquifers in wet autumns and a highway cut slope that failed as a result of loss of soil suctions during rainy seasons. Both examples showed the important effect of pore water



The speaker, Professor Jim Graham

pressures on slope stabilitys. They demonstrated the importance of specifying correct water pressure regimes when using effective stresses to analyse for slope stability.

Owing to unavoidable uncertainties in assessing both loading and soil resistance in GLE analyses, the computed FoS does not indicate uniquely whether the slope will or will not actually fail. Slopes with acceptable safety factors still have a probability of failure, even if that is low. Professor Graham showed that some engineers in Canada have started presenting hazard evaluations using probability density functions to establish the probability of slope failures.

The talk ended at 7.35p.m. after Professor Graham answered thought-provoking questions from the audience, including one from the IEM Perak branch. ■