Prediction and Performance of Construction in Soft Ground

GEOTECHNICAL ENGINEERING TECHNICAL DIVISION

reported by

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Professor Andrew Whittle of the Massachusetts Institute of Technology (MIT) conducted a one-day seminar on Prediction & Performance of Construction in Soft Ground at the C&S and TUS Lecture Room in Wisma IEM, Petaling Jaya, on 15 January, 2016.

Jointly organised by IEM's Geotechnical Engineering Technical Division and the Malaysian Geotechnical Society, it was attended by 76 participants.

Prof. Whittle started by demonstrating the ability of the MIT-E3 constitutive soil model in simulating the responses of natural Boston Blue Clay (BBC) samples under a variety of laboratory test paths that better matched measured behaviours than was possible using the pioneering Modified Cam-Clay (MCC) constitutive soil model. MCC does not allow for anisotropy and it also computes excessive dilation, leading to overly high undrained shear strengths in simple shear and triaxial extension. He then satisfactorily repeated the same with the updated MIT-S1, a unified material model for clay and sand. He also touched on the Mohr-Coulomb (MC) model which he regarded as "ancient".

With the MIT-E3 and MIT-S1 models incorporated into finite element (FE) packages and executed in 2-dimensional (2-D) and 3-dimensional (3-D) modes, Prof. Whittle showed results from analyses for a number of actual underground constructions. These involved supported excavations for deep basements, cut-and-cover tunnels and bored tunnels in soft ground, comprising varied support systems as well as with complex construction sequences such as the Stacked Drift Cavern excavation for a tunnel constructed in Puerto Rico. Attributes such as ground deformations and loads in structural support elements generally matched well with those values measured by field instrumentations. The back-evaluation for the 2004 Nicoll Highway tunnel collapse in Singapore was, however, less satisfactory. Professor Whittle found that the demands of conducting 3-D analyses exceeded the capabilities of FE software packages using conventional Direct or Iterative Solvers and could, instead, only be accomplished with the use of Parallel FE computation with Scalable Algorithms on a Scalable Computing infrastructure.

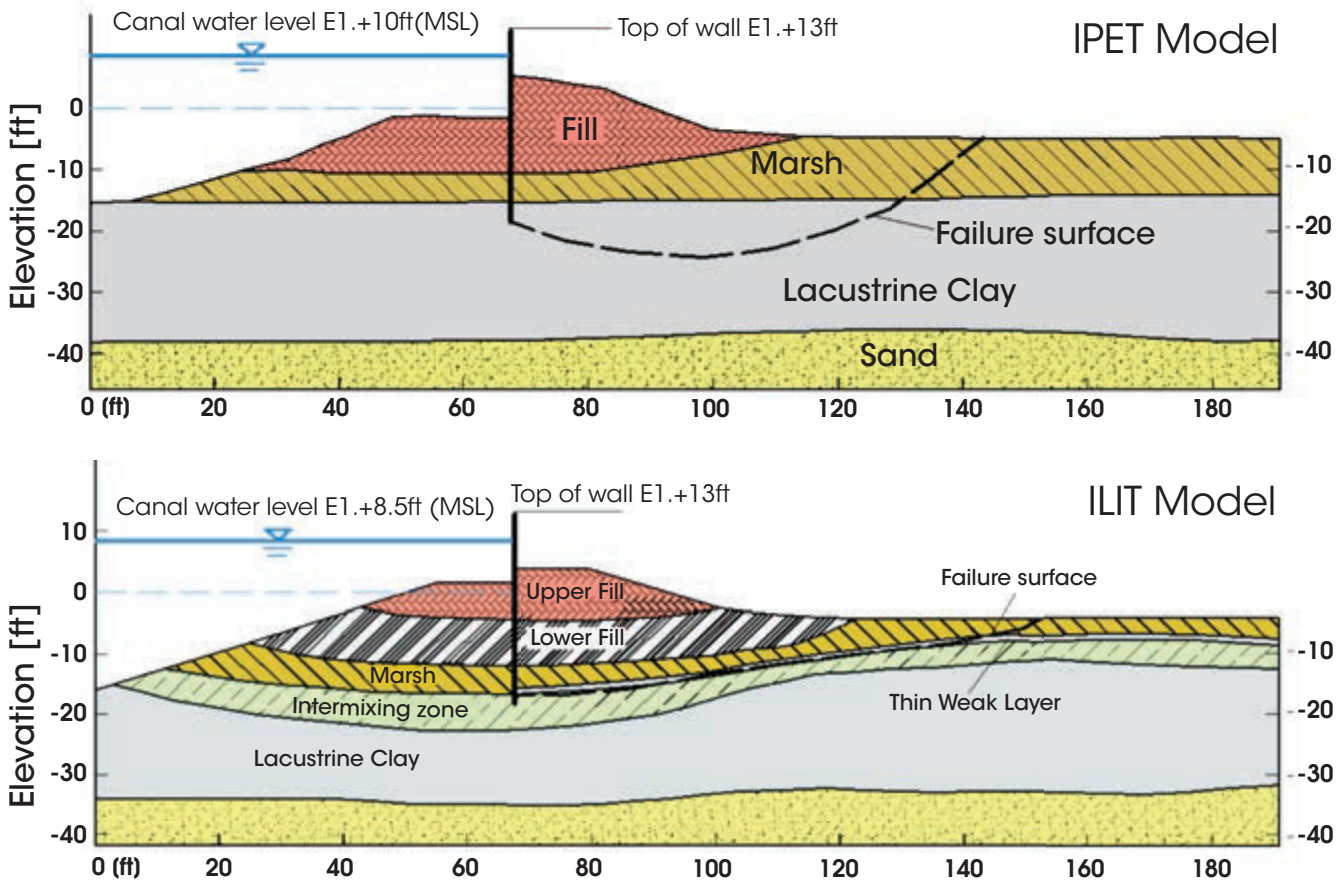
Then Prof. Whittle dealt with the issue of evaluating undrained stability of embankments on soft ground. He demonstrated the superiority of the Numerical Limit Analysis (NLA) over the legacy Limit Equilibrium Method (LEM) as well as the FE method which had difficulties coping with shearing/deformations concentrated along discrete planes in the ground. The NLA is a hybridised limit analysis relying on effective stresses from the FE method to determine shear strength reductions required to "induce" the collapse of earth structures and is suited to rigid-perfectly plastic problems.

He emphasised the importance of first establishing the correct stratigraphy in the ground for satisfactory analyses to be carried out, by showing the New Orleans Hurricane Katrina levee failure case where 2 authoritative organisations produced starkly different stratigraphies from the same set of site investigations data (see diagram).

On the subject of settlement computations for embankments constructed over soft soils, Prof Whittle demonstrated the importance of employing soil models that reproduce the lateral spreading behaviour in the underlying soft soils during consolidation to ensure reasonable computed settlements. The matches between actual field measurements over time and computed ones were satisfactory without the need to include creep in the computations even when the field data on settlements and pore water pressures suggest the existence of creep during consolidation. He pointed out that there were serious limitations with most viscoplastic soil models in dealing with soil creep behaviour and disclosed the availability of a new generalised Elasto-Viscoplastic (EVP) model – the MIT-SR model with the ability to represent all rate dependent clay behaviours.

Finally with availability of capable computational tools to the industry, Prof Whittle expounded the benefits of conducting real-time review of performance data collected and the updating and calibration of analysis models in the course of construction of Temporary Earth Retaining Structures (TERS) to reduce the risks of a catastrophic failure.

17th Street Canal: Stratigraphy – Two Versions



Two different ground stratigraphies from same set of site investigations data

Wireless networks allow a dense array of sensors to be deployed to monitor the whole structure simultaneously. This allows captured measurements of structural loads, deformations and pore water pressures to be accessed online to permit real-time reviews of the state of the engineering system. Imaging devices and sensors mounted on remotely controlled multi-rotor copter drones would facilitate inspection and mapping to areas of the construction that are of interest to the engineer, with little attendant risks to personnel.

The seminar was concluded at 4.30 p.m. ■

IEM DIARY OF EVENTS

Title: IEM Form of Contract for Civil Engineering Works & IEM Form of Contract for Mechanical and Electrical Engineering Works

25 Nov 2017

Organised by: Sub Committee on Engineering Contracts of Standing Committee on Professional Practice
Time : 9.00 a.m. - 5.30 p.m.
CPD/PDP : 7

Title: Talk on "Healthcare Engineering – Optimizing The Healthcare Delivery Through Interdisciplinary Technology Integration"

29 Nov 2017

Organised by: Engineering Education Technical Division
Time : 5.30 p.m. - 7.30 p.m.
CPD/PDP : 2

Title: IEM Form of Contract for Civil Engineering Works & IEM Form of Contract for Mechanical and Electrical Engineering Works

5 Dec 2017

Organised by: Sub Committee on Engineering Contracts of Standing Committee on Professional Practice
Time : 9.00 a.m. - 5.30 p.m.
CPD/PDP : 7

Title: ICTSIG Digital Class (December 2017) - Introduction to PYTHON Programming (Part 1)

9 Dec 2017

Organised by: Special Interest Group - Information and Communications Technology (ICT)
Time : 11.01 a.m. - 1.00 p.m.
CPD/PDP : 2

Kindly note that the scheduled events below are subject to change. Please visit the IEM website at www.myiem.org.my for more information on the upcoming events.