DEPARTMENT OF ENGINEERING

UNIVERSITY OF CAMBRIDGE

Module 5R5:

Advanced Experimental Methods in Geomechanics

Leader: Dr S K Haigh

Timing: Lent Term

Prerequisites: This module is available only to Graduate Students. The use of Matlab to process data is essential, and an additional afternoon class will be offered at the outset to those who are unfamiliar with the software.

Structure: 8 afternoon classes, one per week, typically including a 1 hour lecture and a 1 hour demonstration either in the DPO and then the Geo-Environmental Laboratories on the main site, or at the Schofield Centre on the High Cross Site.

Mode of Assessment: Coursework

AIMS

This module aims to convey the key principles and practices of geotechnical testing and physical modelling required for research, for advanced industrial testing of granular materials, and for the monitoring of geotechnical structures in the field. It should leave students able to create appropriate plans for the acquisition and analysis of test data including computer-controlled triaxial tests, centrifuge model tests and earthquake records. The course will feature the use of Matlab software, and will include the latest applications of digital image analysis to derive displacement and strain fields, and of wavelets to display the changing dynamic response of structures deteriorating during an earthquake.

The four coursework exercises will be based on real geotechnical data some of which will be produced by the class during laboratory sessions and some of which has been created in the last year by research students working on industry-supported research projects. The interpretations of these tests and events will introduce students to four issues of cutting-edge relevance to geotechnical practice – the role of soil anisotropy revealed by element testing, the scaling laws applicable to centrifuge models of deformation and flow, the progressive failure of brittle clay soils, and the question of seismic liquefaction of saturated sands.

SYLLABUS

Topic A: Centrifuge Modelling Techniques (2 classes, Professor S P G Madabhushi)

- Principles of centrifuge modelling
- Models and prototypes; scaling principles and modelling errors;
- Centrifuge facilities; beams and drums;
- Boundary conditions of models
- Dynamic centrifuge modelling

➢ Centrifuge tests at the Schofield Centre leading to class discussion of:
  - Bearing Capacity of footings
  - Settlement of footings

Introduction to Matlab (1 class, Mr Mark Stringer and colleagues at the Schofield Centre)

Topic B: Signal Processing (2 classes, Dr S.K Haigh)

- The acquisition, filtering, digitisation and handling of dynamic data streams
- Use of Matlab software to visualise data in both time and frequency domains
- Fast Fourier Transforms (FFT), power spectra, response spectra
- Simple applications to experimental data

Topic C: Image Analysis (2 classes, Dr SK Haigh/Mr Charles Heron)

- Image formation with digital cameras
- The camera model, transferring to real-world coordinates, camera calibration
- Use of Matlab routines to analyse data
- Centroiding
- Particle Image Velocimetry (PIV) for displacement fields

Topic D: Centrifuge Test (2 classes, Dr SK Haigh & Professor SPG Madabhushi)

- Design a centrifuge model to represent shallow foundations
- Build a centrifuge model using the automatic sand pourer
- Carry out the centrifuge test by applying loading onto different shallow foundations
- Collect and interpret the data from load cells, LVDT's etc.

COURSEWORK

Three reports are to be produced by each student covering the following topics:
Report A: **Centrifuge model scaling principles:** observations and interpretation of the centrifuge test results & simple data acquisition problems
Report B: **PIV analysis:** Analysis of images from previous tests to determine the soil deformations and strains.
Report C: **Centrifuge Test Results:** Analyse and report centrifuge test that was carried out as part of this course. Interpret the data to identify the physical phenomena occurring at different stages of a centrifuge test.

OBJECTIVES

On completion of the module, students should be able to:

- Plan and execute simple centrifuge model tests
- Use observed centrifuge model behaviour to hypothesise and then test scaling laws
- Recognise in soil performance the evidence for stress-dependence, scale-effects, dynamic amplification, liquefaction, cracking and progressive failure
- Plan, execute and analyse computer-controlled stress-path tests on soil
- Arrange the logging, plotting and analysis of experimental data
- Use digital photography to create precise and accurate displacement and strain fields

ASSESSMENT

Material:	*Submission date*	*Marks*
Report A:	Lent term, end of week 2	33%
Report B:	Lent term, end of week 5	33%
Report C:	Lent term, end of week 8	34%

REFERENCES

		CUED Library Shelfmark
Taylor R.N.	Geotechnical Centrifuge Technology	GA 295
Head K. H.	Manual of Soil Laboratory Testing , Vol. 3	
Newland D.E.	Mechanical vibration analysis and computation	RT100
White D.J. and Take W.A.	CUED-Soils/TR322: GeoPIV	
