Specialist soil support

Correct evaluation of the geotechnical characteristics of a specific subsoil requires expertise at the laboratory

University of Szcecin

An accurate and proper response to the analysis of the behaviour of construction foundations, located at sites where the geological soil conditions are complex, requires the aid of sophisticated multi-parametric processing models.

These models, in turn, require evaluation of geotechnical parameters based on experimental data (in-situ and laboratory tests): specific physical and mechanical tests, performed on representative and high-quality soil samples taken from the sites.

"This procedure simulates the effects of an earthquake on a specific soil and investigates the influence of the seismic action on its undrained shear strength"

The Faculty of Geotechnics at the University of Szczecin in Poland relies on a team of technicians and researchers and on a suitably equipped laboratory where different specific tests are carried out and different stress and strain conditions can be replicated and simulated by computation models, so that representative and specific parameters can be correctly determined.

The faculty's main activities concern offering solutions to geotechnical problems, such as designing foundation works for different types of buildings and facilities, and co-operating with engineering companies and contractors specialising in this sector.

The division of mechanical and hydraulic characterisation of soils has

benefited from a recent grant programme from the Ministry of Science and Higher Education. This grant enabled the university to acquire equipment for performing on-site geotechnical tests and taking samples (undisturbed samples with a diameter corresponding to the size of the samples tested in the laboratory).

Focus on equipment

Laboratory technicians have recently been trained to use an automatic apparatus for static tri-axial (UU, CU, CD) and controlled stress path tests, called Autotriax, made by Wykeham Farrance, the Soil Mechanics Division of Controls – Italy.

This system can automatically manage up to three tri-axial chambers and three 50kN Tritech 50 compression machines, operating in controlled-load or displacement conditions, at infinitely variable speed of 0-9.999 mm/min.

For each tri-axial chamber, the force measurement sensor consists of a submersible strain gauge load cell, contained inside the tri-axial chamber itself, and allows the axial force to be measured directly on the soil sample, eliminating the effects of friction caused by the piston of the tri-axial chamber. This instrument has been specifically designed for this application, being unaffected by changes in applied hydraulic pressure of the tri-axial chamber and by the electrical drift occurring over time, that could invalidate the measurements in long-term tests.

The tri-axial tests take place under complete automation and the test programme is exercised in multiple stages: application of several pre-set steps of radial and axial stress, for each of which the operator predefines the deformation or stress targets it is intended to achieve, on the basis of the design conditions being tested.

The system can conduct up to three simultaneous and independent tests on samples with different diameters automatically – as a function of the physical characteristics of the soils being tested (38mm, 50mm, 70mm, up to 100 and 150mm) – in special tri-axial cells which allow pressures up to 2,000 and 3,500kPa to be reached and maintained. These pressure systems, which allow linear ramps to be applied, on loading and unloading, and constant pressures to be maintained, are formed of Hydromatic hydraulic pumps, controlled by an 'on-board' stepping motor, managed by the Autotriax system.

The tri-axial tests are divided into successive phases, which the operator can set or change each time as a function of the test sample response:

- **Saturation:** carried out by subsequent pre-set steps of cell and back pressure, with monitoring of volume change and pore pressure and measurement of Skempton's B parameter;
- **Isotropic consolidation:** with monitoring of volume changes and water-pore pressure;
- **K_0 consolidation:** where application of axial and radial stresses are managed so that the diameter of the specimen is maintained constant. This control is performed through direct radial displacement measurement with submersible sensors in contact with the test specimen, or through measurement of the ratio between change in volume and change in height of the specimen;
- **Controlled stress path stages:** control and target measurements can be

Below: Autotriax system complete with three testers Tritech 50 with three tri-axial cells

selected by the operator including load and displacement control ramps; target values in terms of total horizontal and vertical stress, average stress and deviator stress; and

- **Static monotonic shear:** with or without drainage, simulating compression or extension of the specimen.

New additions

The most recent equipment in operation at the university is Wykeham Farrance's Dynatriax system. This system allows high flexibility with tri-axial tests. From a unique system, it is possible to carry on basically different tests: static tri-axial; cyclic and dynamic; stress path controlled; and tri-axial tests on unsaturated soil.

Also in this system, the different software packages are designed to perform the relevant tests via a series of pre-set steps, so that the user can manage and complete the tests automatically.

In the case of dynamic tri-axial tests, for example, it is possible to set up subsequent steps starting with the preliminary static stages (saturation and consolidation), enter dynamic and/or cyclic stage and once again return to static stages. This procedure simulates the effects of an earthquake on a specific soil and investigates the influence of the seismic action on its undrained shear strength.

The different software packages on both Autotriax and Dynatriax systems include the procedures indicated by the standards (e.g. ASTM for dynamic testing, ASTM and BS for static testing) or customised procedures that each user can perform, for routine tests or for specific research investigations.

The Dynatriax system also includes dynamic tri-axial tests on soils and aggregate materials for road construction, performed according to the AASHTO Standard T307-99, for determining the resilient modulus of compacted soils used for sub-grade, base and sub-base beneath flexible pavements.

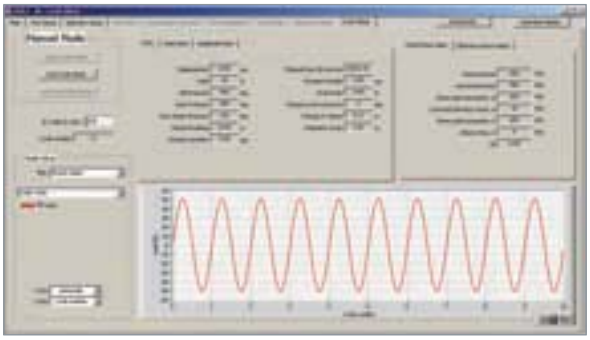
For the cyclic stage of the tri-axial tests, the system can operate under stress/load control or displacement control, with effective frequencies of 0.01-10Hz, setting different types of cyclic waveforms and test end conditions (maximum number of cycles, maximum deformation, Skempton's parameter A).

Another feature of the software is the possibility to replicate seismic events recorded or defined by the user.

The research programmes under development on the systems described above allow the design parameters to be determined and, in particular, the bearing capacity of foundation works, in terms of shear strength and compressibility.

Tri-axial tests on cohesive soils are performed at much lower compression and deformation speeds than tests on rock samples with much longer testing times. Therefore, in the field of soil mechanics, the possibility of working with fully automatic equipment, like those described here, allows the real situations in the field to be replicated with higher accuracy: e.g. long-term tests with measurement and interpretation of the development and dissipation of water-pore pressure, of consolidation and filtration phenomena.

Data processing also allows the different stress and strain parameters to be determined with higher accuracy: cohesion, angle of internal friction, volumetric compressibility, coefficients of primary and secondary consolidation and swelling parameters. The tests can be performed according to the relevant standards used all over the world and also according to specific and appropriate test programmes.



Top: Dynatriax system

Above: Dynatriax software: example of cyclic stage under controlled stress

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