World Class Geotechnical Testing

GTC Advanced Geotechnical Testing Laboratory

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Figure 1: GTC advanced laboratory

GTC ADVANCED GEOTECHNICAL TESTING LABORATORY

1. Introduction

GTC is an ISO 17025 accredited laboratory by Dubai Accreditation Centre (DAC), focusing on advanced geotechnical testing. The laboratory has been equipped with fully automated with the most advanced testing systems (Figure 1, Figure 2). All apparatus has been regularly calibrated and validated up to current testing standards.

Figure 2: In house calibration of load cell

Figure 3: Advanced Oedometer tests

Tests are undertaken by world-class leading experts, coming from the UK, using state-of-the-art testing techniques, ensuring high test quality, reliability, and consistency. Tests conducted at GTC can be tailored to suite any testing specifications and standards.

2. Specialised Tests Offered By GTC

GTC offers various advanced and specialised tests to deal with both normal and problematic soils and rocks (Table 1).

Table 1: Advanced and Specialised tests offered by GTC

Tests that GTC offers	Soil parameters that GTC can provide
• Standard and advanced triaxial tests with (local) strain gauges, mid-height probe, radial belt; • Multiple-stage triaxial tests; • Stresspath (including K0) triaxial tests; • Cyclic triaxial tests with local instrumentations; • Resonant column tests (both torsional and flexural modes); • Bender Element tests in Triaxial cell; • Large Rowe cell (250mm in Diameter) tests; • Oedometer tests; • Permeability tests in triaxial cells; • UCS tests for soil/rock/soil-cement mixing; • Etc.	• Small strain stiffness, G_0, and shear modulus degradation G/G_0 (shear strength from 10^{-4} % to 0.1%) • Small strain Young's modulus, E_0 • Young's modulus degradation E/E_0 (at shear strength from 10^{-3} % to failure) • Shear strength in both compression and tension • Shear strength envelope (c' and ϕ') • Stress-strain, stress-path, PWP behavior (in undrained conditions), volume change behavior (in drained conditions) • Damping ratio (form resonant column and cyclic triaxial tests) • Cyclic stiffness degradation, cyclic stress-strain and EPWP behavior; • Soil cyclic/ liquefaction resistance; • Poisson's Ratio • K_0 value • Consolidation and permeability properties; • Swelling/settlement of rock/expansive soils • Etc.

3. Do your projects require soil parameters from advanced lab testing?

• Soil and rocks exhibit strong non-linear stress strain behaviour (Figure 4), however this has been ignored in conventional testing due to the apparatus limitation. Only advanced laboratory testing can fully address the issue.

• Advanced laboratory testing has become compulsory in some design standards (e.g. DNV).

• Therefore, advanced laboratory testing has been increasingly required for various important and large-scale geotechnical structures, e.g. nuclear power stations, tunnels, runways, high-rise buildings, dams, foundations for wind turbine generators, piles subjected dynamic loads, foundations for vibrating machines, and deep excavations, etc (Figure 5).

• A relatively small investment in advanced laboratory testing will return cost-efficient foundation solutions, hence great saving in total building cost.

• Advanced laboratory testing can also help to reduce project insurance premium.

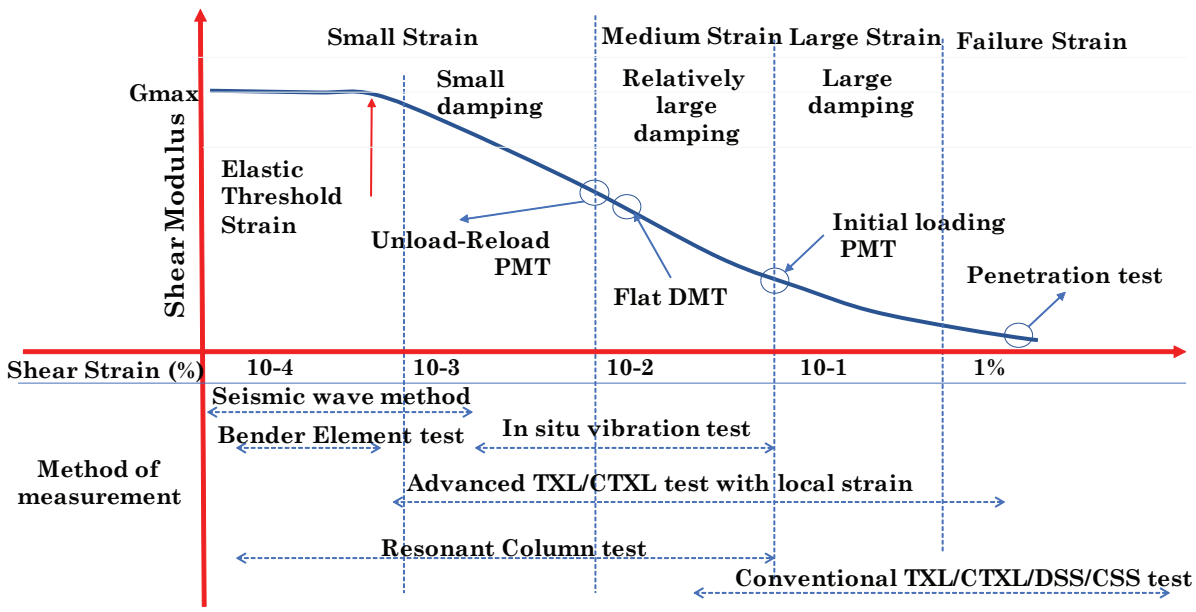


Figure 4: Nonlinear behaviour of geomaterials

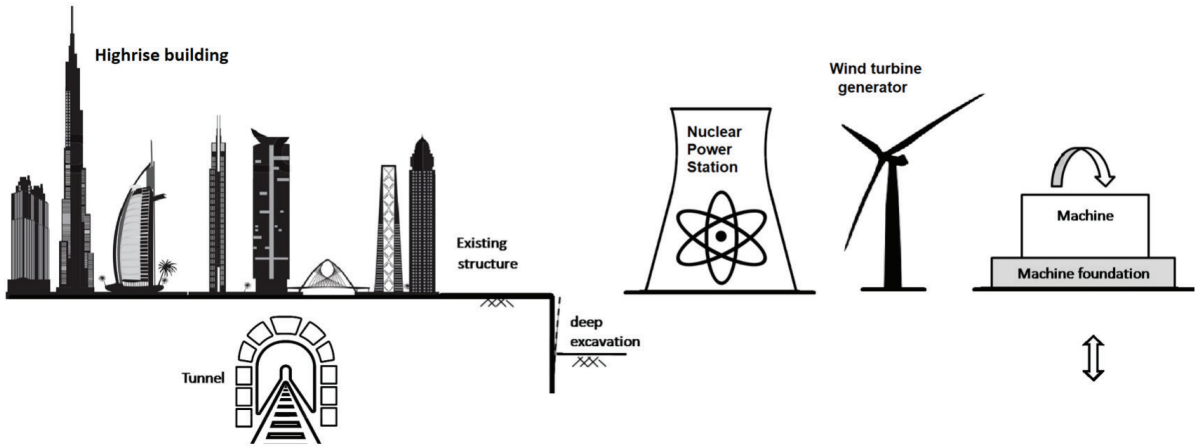


Figure 5: Various projects that required advanced laboratory lab testing

4. How can GTC support your projects?

• Our equipment is calibrated to obtain the highest possible precision in testing and data reduction
• Thanks to our vast experience in testing various types of soil & rocks, we can undertake tests following any strict specifications and standards.
• We can design the test specifications to suite the project.
• We can optimise your laboratory test schedules to get more value from the project budget and to suite the project time frame.
• We can help you to answer the following questions:

- Are the samples suitable for the test? What are the (key) depths required for the tests? What is the right sample diameter?
- How does the sample quality influence the test results.
- What geotechnical parameters are required from the test?
- How applicable is the test method to a particular problem?
- How will these results be used, and will the person interpreting and using them be sufficiently knowledgeable?
- Separate tests need to be carried out on each type of soil to give an acceptable degree of confidence in the results?
- What is the likely cost of the sampling and testing and is the expense justified in terms of the potential for a more economical design?
- What is the likely duration of the testing, and does this fit in with the design programme?

• We can also interpret (liquefaction/dynamic analysis) and/or synthetize your data to support your ground investigation report (e.g. Figure 6), as well as select the design soil parameters

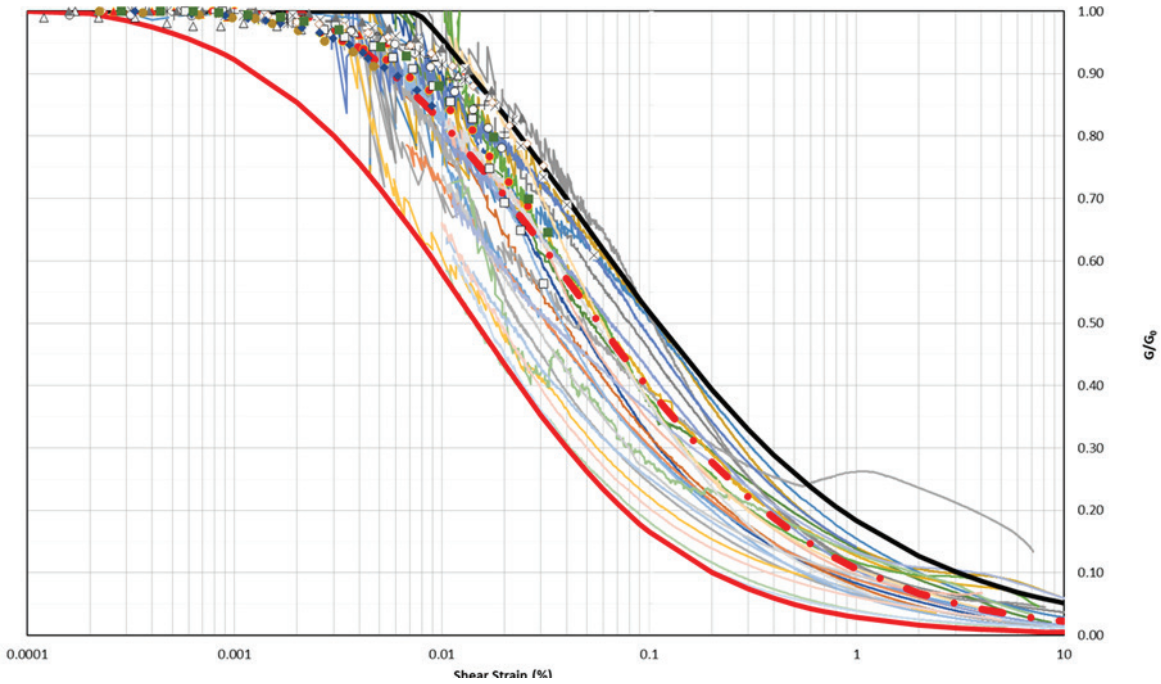


Figure 6: Stiffness degradation curves synthetised from various tests (e.g. Advanced triaxial tests, and resonant column tests)

5. GTC Advanced Triaxial Testing

• GTC provides bespoke advanced laboratory testing for major construction projects in the GCC area and around the world. We use fully Computer Controlled Testing Apparatus manufactured by GSD Instrumentations (UK). All of the test parameters including axial load, vertical deformation, pore water pressure at base, cell pressure, back pressure, volumetric changes are all automatically recorded (Figure 7).

• Advanced triaxial (TXL) tests, which should be distinguished from 'standard' or 'routine' triaxial tests, can provide very important information about stress-strain behaviour of soil/rocks used for design of geotechnical structures. In general, axial strain measured using strain external LVDT includes both specimen's deformation and system compliance, which is due to the beddings and possible elastic deformations of filter papers, porous stones, test base, top cap, loading rod, machine frame, etc. Therefore, strain gauges have been developed and instrumented to directly (hence precisely) measure the strains induced in the soil specimen.

• A consolidation stresspath can be applied to re-establish the insitu stress history before shearing the materials.

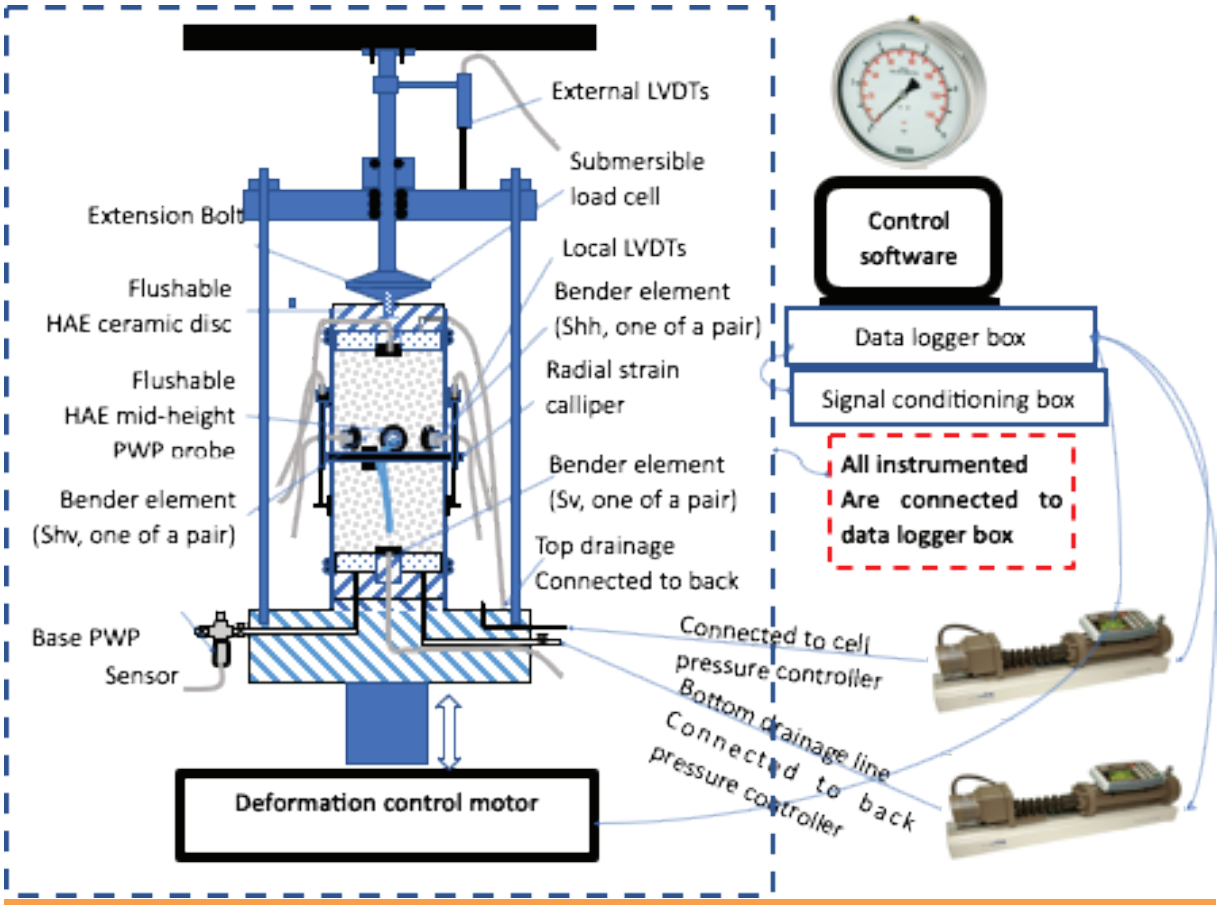
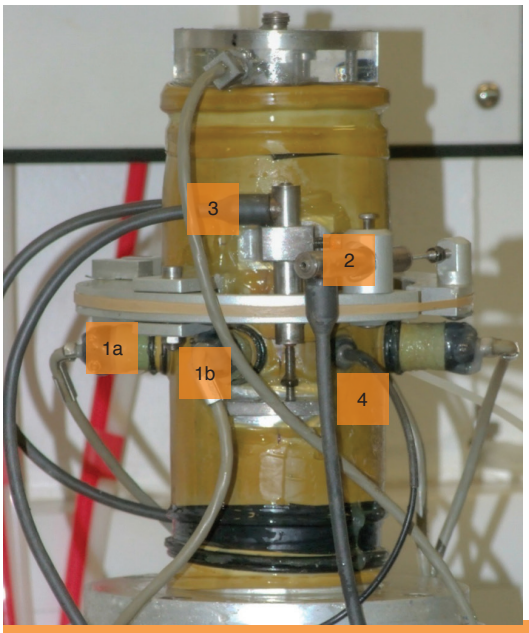


Figure 7: Schematic of GTC Advanced Triaxial testing System



1a: Horizontal bender elements, (Vhh)

1b: Horizontal bender elements, (Vhv)

2: Radial belt

3: Vertical LVDT

4: Mid-height probe

Figure 8: Example of triaxial sample setup with various instruments

6. GTC Resonant Column Test (RCT)

• RCT is one of the most usual and advanced techniques that can precisely estimate the shear modulus, G_0, Damping ratio, D, shear modulus degradation G/G_0 and damping change for soil from very small to medium strain (<0.1%).

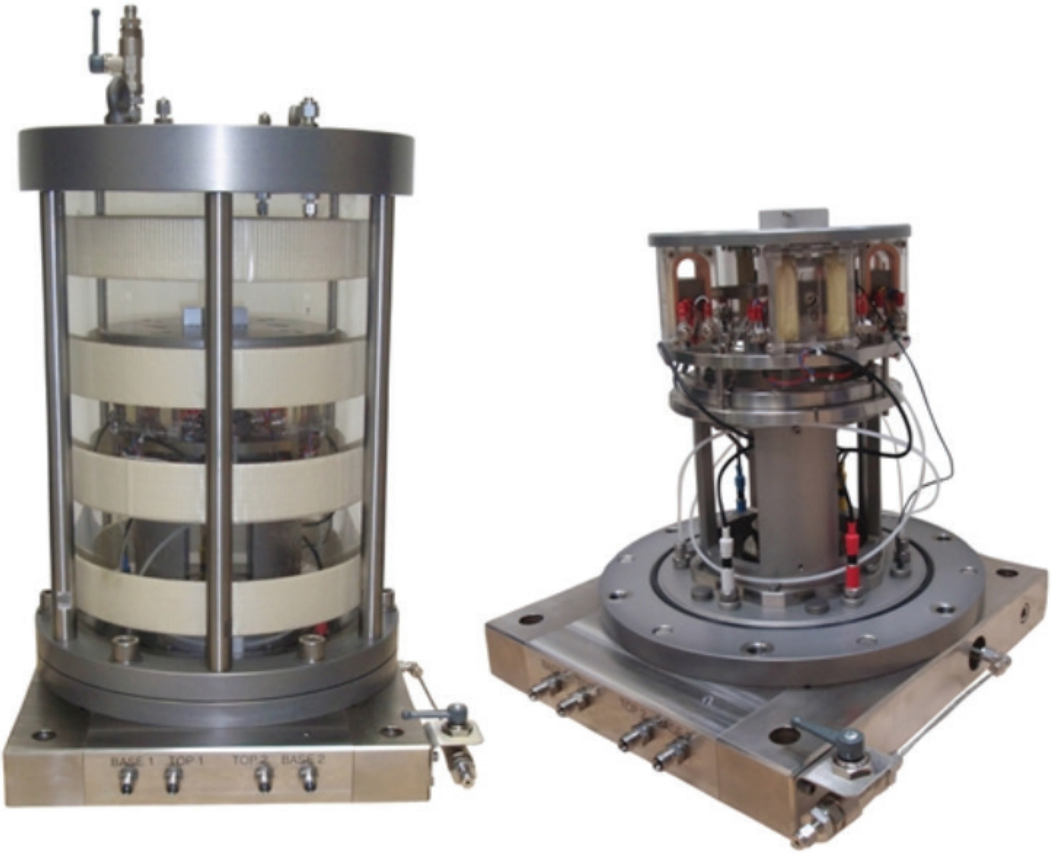


Figure 9: Resonant Column Apparatus

• The non-linear soil behaviour parameters obtained from RCT allow an engineer to undertake dynamic numerical analyse (FEM/FDM) of foundations and structures subjected to seismic/dynamic load, such as earthquakes or wind/wave, or historical storm/ gut loads etc.

• At GTC, the test results are derived by taking into account the system compliance to provide precise soil parameters at small strains for the tested geomaterials.

• RCT can be classified as a non-destructive technique, hence the RCT can be repeated for various effective stresses.

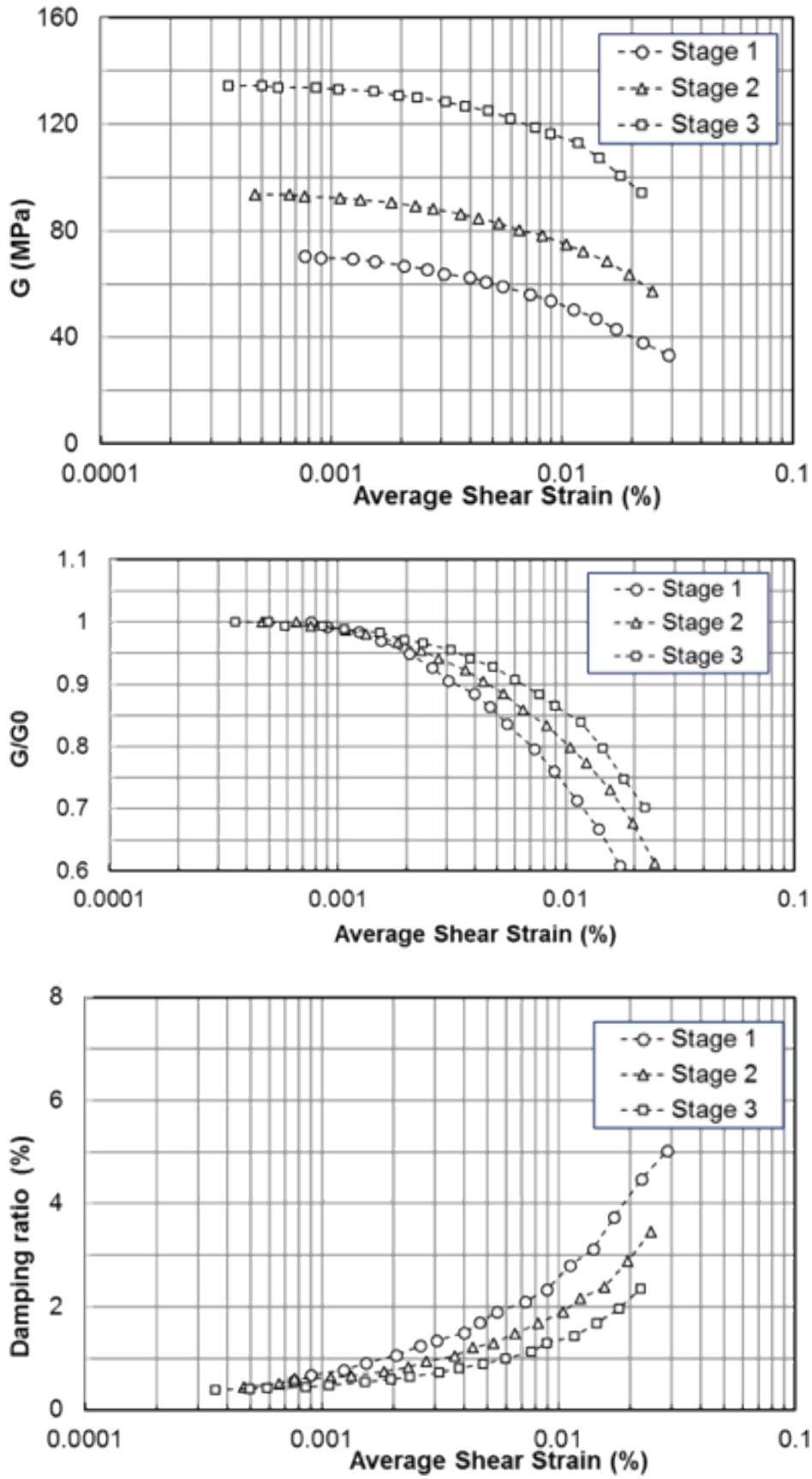


Figure 10: Example of resonant column test results at various consolidation pressures.

7. GTC Cyclic Triaxial Tests (CTXL)

• We are proud to be a unique laboratory in the Middle East and internationally, which is accredited to ISO 17025 for cyclic triaxial tests.

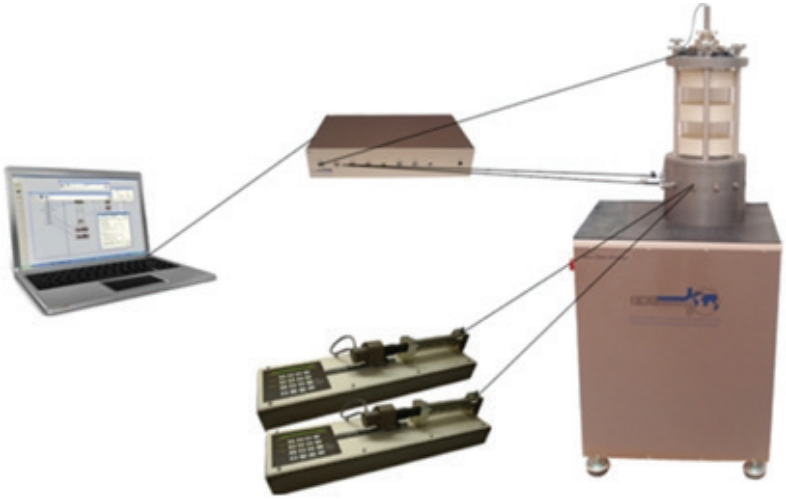


Figure 11: Dynamic Triaxial testing System Used at GTC

• Cyclic triaxial test results provide important information about cyclic behaviour of the geotechnical materials subjected to seismic/cyclic loads such as (i) cyclic stiffness (Young's modulus) degradation, (ii) damping change, (iii) stress-strain behaviour, (iv) accumulated strains and (v) excess porewater pressure behaviour. Those parameters are crucial for dynamic/liquefaction analysis of foundations and structures.

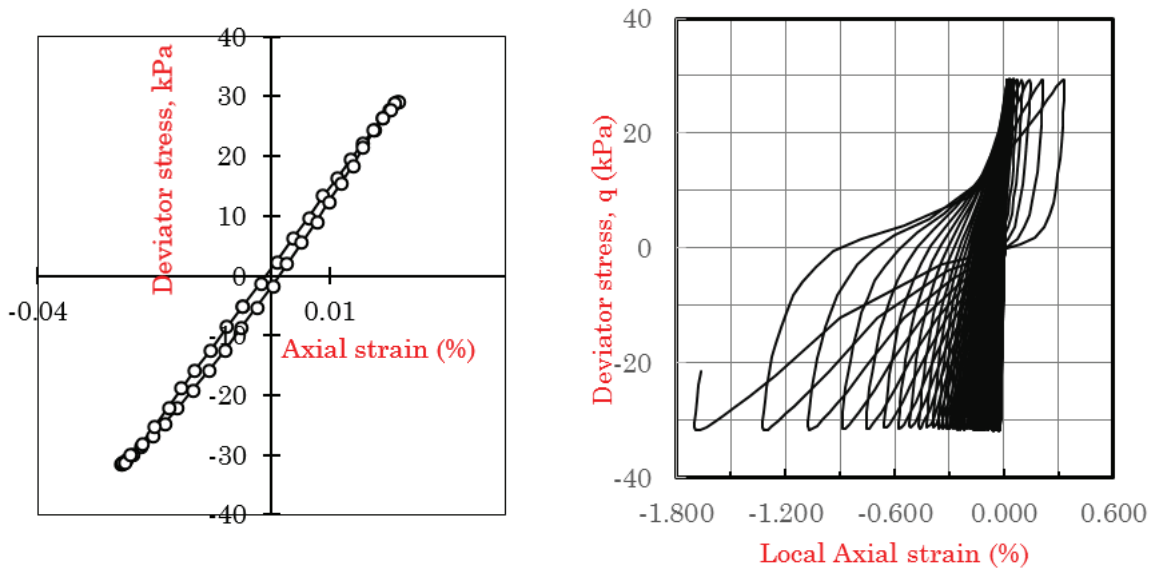


Figure 12: Hysteresis loops in cyclic triaxial test for damping ratio and cyclic Young's Modulus

• The GTC Advanced Dynamic Triaxial Testing System is a high-quality testing apparatus equipped with a dynamic actuator capable of applying load, deformation and stresses up to 10Hz. Axial stress and strain applied through the base of the cell. The system can be combined with a dynamic cell pressure actuator in such a manner that cell pressures may also be applied dynamically up to fundamental frequency of the machine (i.e. 2Hz, 5Hz or 10Hz).

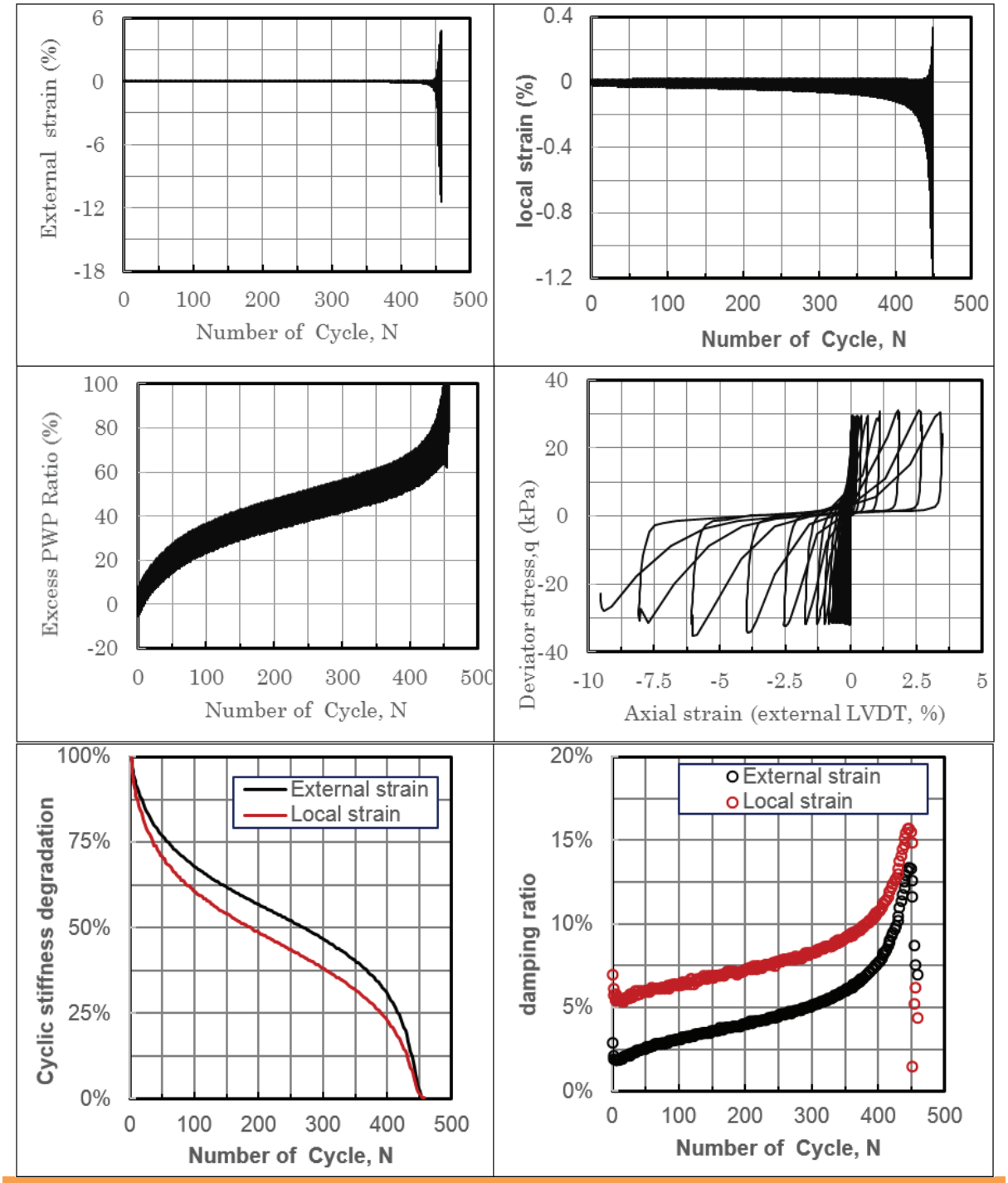


Figure 13: Example of Cyclic Triaxial Test

8. GTC Bender Element Tests in Triaxial Cell

Bender elements are composite sheets of piezo-electric material bonded together. An applied voltage across a triggering bender element causes the sheets to flex. Conversely, flexure of the sheets causes a voltage to be induced in the receiving bender element. Test results measured using Bender element tests are comparable to those obtained from geophysical surveys.

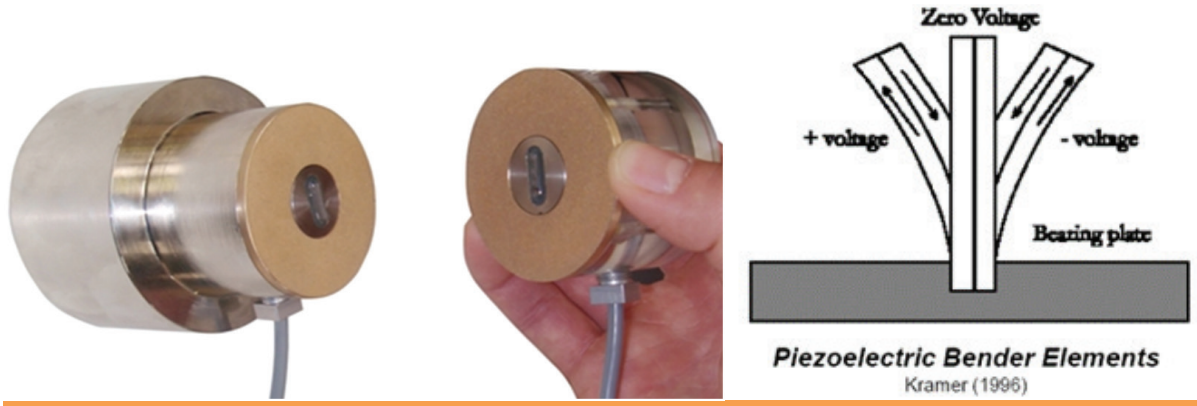


Figure 14: Bender Elements

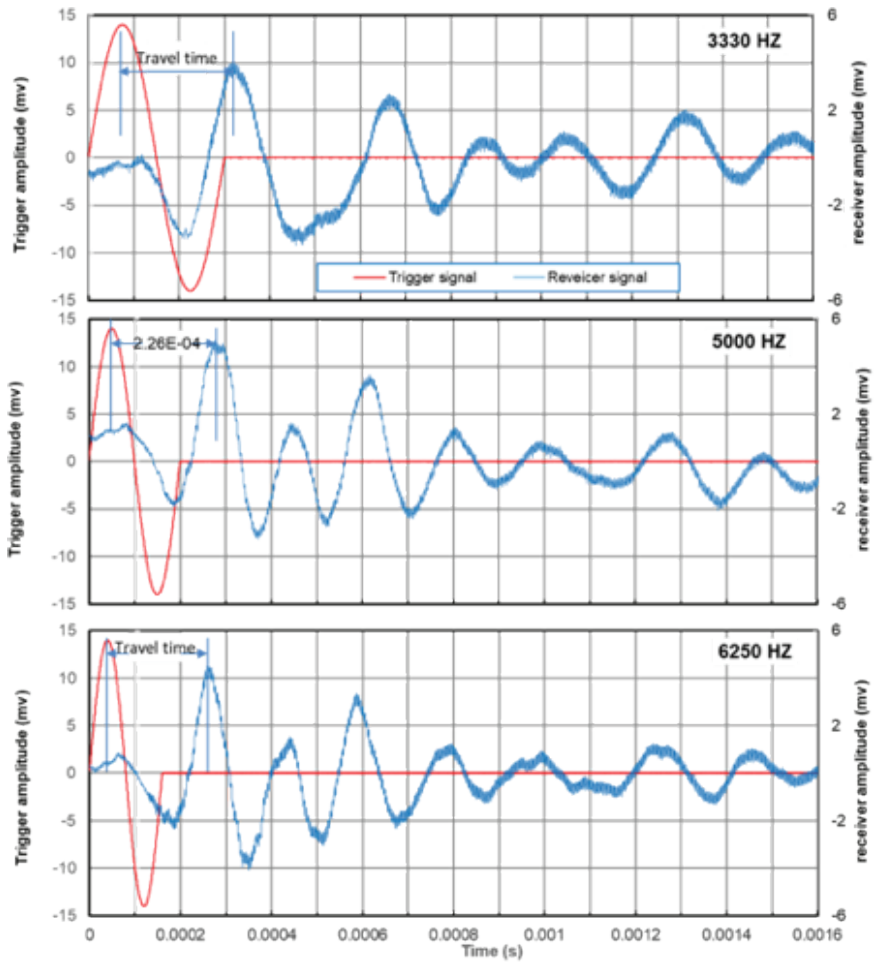
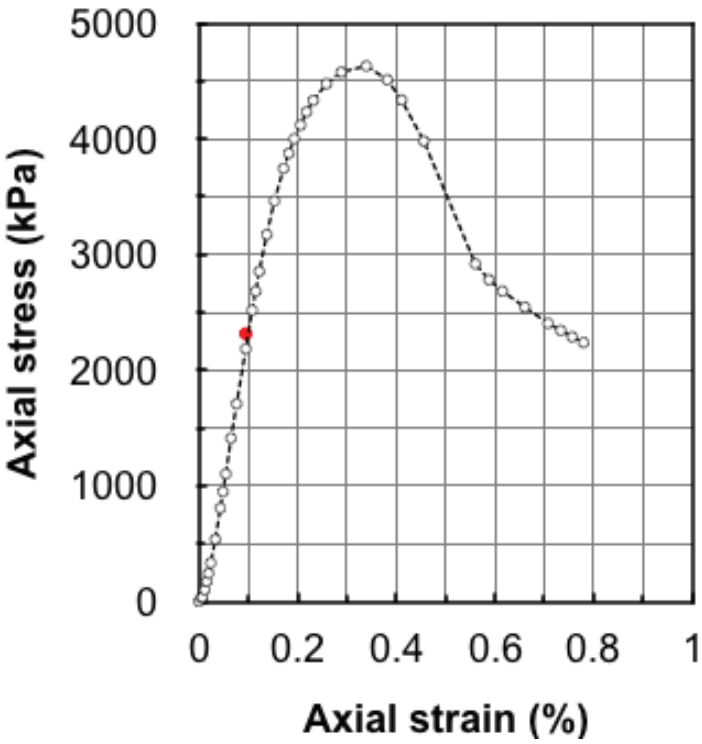


Figure 15: Example of Bender element test results on weak Rock

9. GTC UCS System

Figure 16: GTC 100 KN fully automation UCS system



a. Stress-strain curves reported.

b. Sample photo taken after testing.

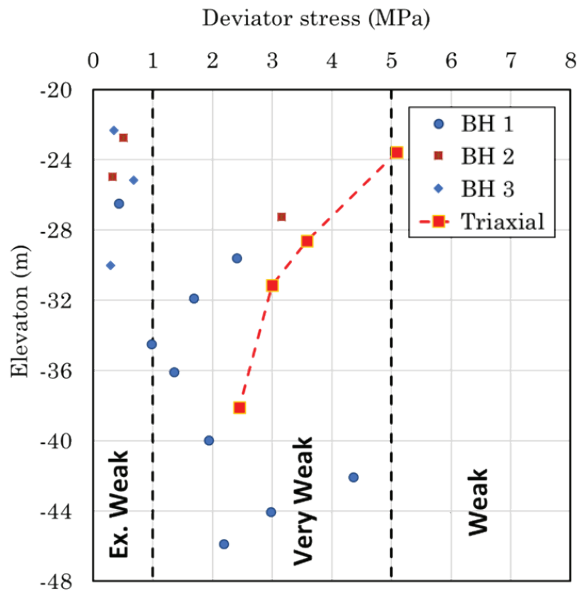
Figure 17: Example of UCS Test Results

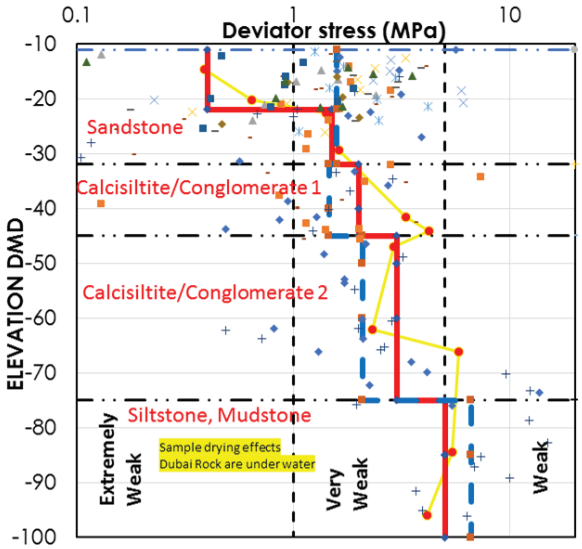
It is widely appreciated that USC test results could be significantly influenced by the sharpness tolerance (flatness, straightness, parallelism, and perpendicularity) of the tested rock cylindrical specimen. After a large amount of sample preparation trials, we have experienced that it is not always possible to prepare rock specimens that fully satisfies the acceptable shape tolerance specified by ASTM D4543-08. Because of this, we have adapted a new capping method, in which a steel cylindrical mould with vertical guide (Figure 18) is used, to prepare rock sample in such a manner that both end flatness, parallelism, and perpendicularity of the specimen can be significantly improved.

Figure 18: A perfect cylinder is used to confirm perpendicularity of the capping mould and guide walls

Figure 19: Using a Straight Edge and 0.025mm Filler gauge to verify the surface flatness

Comparison UCS vs Triaxial on Dubai Rocks





10. GTC Consolidation And Permeability Tests

Oedometer Tests

To support, settlement analysis, differential settlement, settlement vs time, compressibility parameters, swelling pressure, swelling/shrinkage index of, (e.g. expansive soil) permeability.

Large Rowe Cell Test 250mm in Diameter

Consolidation properties of soil with: either/both vertical and horizontal drainage; PWP, vertical deformation, and volume of water flow can be monitored and measured; therefore hydraulic gradient can be well controlled.