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Technical Specification for **High Pressure Temperature Controlled Direct Shear and Triaxial** **System**

Overview:

Triaxial system should have the ability to test for rock properties including deformation, strength, permeability, hydraulic fracture, solid-fluid-thermal coupling, and thermal conductivity. Direct shear system should be capable shearing the rock sample under constant normal load to determine the influence of material stiffness, shear rate, joint roughness, humidity condition, joint infilling materials, and cycle of shearing. This apparatus should be applicable for static and dynamic stress/ strain controlled direct shear and cyclic triaxial tests. It is desirable to have a common axial load frame for direct shear and triaxial cell, setup with two separate vertical frames can also be considered. Pre-dispatch inspection and on-site certification. The equipment will be delivered, installed, and made operational at IIT Bombay.

Important accessories:

1. 150 t (1500 kN) load frame with stiff standing assembly.
2. Split shear box (30 t (300 kN) shear capacity with its bottom mounted on sliding plane.
3. High pressure 120 MPa confining pressure cell, 1500 kN axial load.
4. Temperature control unit -20 to + 80 °C for triaxial cell.
5. Servo based cell pressure/volume controller for permeability measurement, hydro fracture tests.
6. Servo based direct shear test and Triaxial test modules, controller, and acquisition system.
7. Pump and reservoir or similar device for pressure and load controls.
8. Acoustic measurement complete with accessories and software.
9. Load cells, pressure sensors, thermocouples, and other transducers to achieve the desired measurements.

Important description and function of the device/ facility:

DIRECT SHEAR AND RESIDUAL SHEAR: Automatic direct shear, residual shear, and incremental shear tests. Computer/ servo controlled constant vertical stress/ constant

vertical deformation test, and tests in which the normal load is a function of prescribed stiffness. Electro-hydraulic or electro-mechanical testing system with digital servocontrol of shear load.

TRIAXIAL: Stiff compression frame with automatic load and deformation control. 1500 kN Capacity with two pressure controllers for the performance of user defined stress/strain path, Permeability, hydraulic fracturing, and proper post failure control.

Description of Important accessories and components of the high-pressure temperature controlled direct shear and triaxial system.

150 t (1500 kN) load frame with stiff standing assembly:

Includes: Over 100 mm travel of platen, 1500 kN compression and 750 kN tension capacity (double acting for dynamic testing), and speed controlled. Sufficient clearance between platen and standing assembly should be available. Mechanism or easy lift to engage triaxial cell or direct shear box with ease on the load frame. If two separate load frames one each for triaxial and direct shear test are provided, then each frame should have enough stiffness and strength to perform the tests. High pressure and high frequency-controlled solenoid manifold and accumulator using electro-hydraulic/electro-mechanical servo valve whichever has low maintenance and meets the requirement to perform static and dynamic testing. Lowering or raising of cross-assembly, triaxial cell pushed-in/ pushed-out and testing, and direct shear box pushed in/ pushed out and testing, should easily be done by one person.

Shear box:

Split shear box with its top fixed and bottom mounted on sliding bearings, including control over the rotation of the box during the test. High pressure control solenoid manifold and accumulator for testing 150 mm cylindrical samples (spacers or rings provided to fit 150 mm x 150 mm cuboidal samples). Deformation sensors with +/-50-mm range and 0.02% precision or better. Shear load applied using a +/- 25 t (250 kN) double acting actuator with 50 mm stroke, High-Frequency Two-Stage Electro-hydraulic or electro-mechanical servo valve.

Triaxial cell:

High pressure stainless steel triaxial cell of 120 MPa confining pressure and 2000 kN axial load, with frictionless piston seals, should accept NX sample size (CAD drawings of adopter to accommodate two other sizes e.g., AX and BX should also be supplied). Sufficient electrical feed-through lines for instrumentation be available in the cell (e.g., for fluid input for pressure, permeability and hydro fracture tests, temperature and other sensor connectors, cell pressure, pore bottom and pore top pressures. Drain ports are separate). The cell should be able to accommodate 150 mm tall samples with on-sample axial and circumferential measurement transducers for samples up to NX size with ease.

Environment/ temperature control chamber:

For controlled heating and cooling the triaxial cell and control of temperature gradient in the cell. Includes: cooling and heating System -20 °C. to +80 °C. All insulations should be available complete with thermocouples.

Cell pressure and volume control:

Servo controlled pressure and volume regulators for confining fluid, permeability, and hydro fracture tests. Pressure transducer with 0.005 MPa accuracy and volume change transducer with 0.01 cc accuracy. Other parts include:

- * 120 MPa Pressure transducer with 0.25% minimum accuracy.
- * 500 cc volume transducer with 0.25% minimum accuracy.
- * Fluid reservoir with power pack unit with ports complete with vacuum pump for filling and draining. Air pressure supply if needed, is available in IIT Bombay laboratory.
- * All necessary high pressure plumbing and valves for filling triaxial testing.
- * Rigid housing for the equipment and its accessories, complete with safety checks for the operator and machine.

Other necessary tests to run the machine :

On-sample axial and circumferential strain measuring transducers. Acoustic measurement complete with signal processing, software for interpretation and graphical display. Software and part assembly for electrical resistivity measurement, ultrasonic P and S measurement, pulse decay permeability, hydro fracture, and permeability testing.

Other necessary accessories:

Universal load cells (compression and tension testing) for triaxial and direct shear testing with excellent precision, LVDT's and deformation sensors and temperature sensors.

Any other sensor necessary to run the experiments can be shown as accessories. One NX dummy sample made of aluminium or steel should be available at the time of trial testing on-site and at IIT Bombay laboratory.

Data acquisition and controller (digital I/O unit):

Digital data acquisition, controller with function generator with communication ports. Should be configured to read over all transducer input from sensor and control output. Readouts should be available for all safety checks. The system should have the capability to detect any equipment normality during the test and help in forceful but safe shutdown. Desktop PC is not needed as many old desktops are already available in our lab. Let us know the minimum configuration you require, and we will dedicate a PC machine for this equipment.

Test modules:

Direct shear and triaxial test modules to perform these tests. The modules should have the minimum below capability:

For direct shear and residual/ incremental tests: Shear stress and shear deformation control, Normal stress, and normal deformation control.

For triaxial tests: Conventional triaxial and other advanced stress path and strain path tests.

In either of the two tests, the modules should be able to show the final output in graphical and spreadsheet format.

***Warranty: Warranty is 5 Years from date of installation**