# Electromechanical Dynamic Triaxial Testing System (DYNTTS) 2Hz, 5Hz or 10Hz

***Optional frequency ranges***

**2Hz** ✓ **5Hz** ✓
**10Hz** ✓

***Optional load ranges***

**10kN** ✓ **40kN** ✓
**16kN** ✓ **60kN** ✓
**20kN** ✓

***Optional cell pressure rating***

**2000kPa** ✓ **5000kPa** ✓

***Available specimen sizes***

**standard**

**38, 50, 70, & 100mm** ✓

**optional up to 150mm** ✓

**(other sizes available on request)**

**2Hz, 40kN, 2MPa DYNTTS system shown above**

## What is it?

The Electromechanical Dynamic Triaxial Testing System (DYNTTS) is a combined triaxial cell and dynamic actuator, the axial force and axial deformation being applied through the base of the cell. The cell itself is screw-driven from an integral base unit housing the motor drive. Where an optional dynamic radial actuator is not chosen, the cell is provided with a balanced ram to eliminate disturbance to constant cell pressure during dynamic testing. This software-based system is controlled from a PC running GDSLAB in MS Windows®. Data is saved and displayed in real-time for any number of cycles.

**Useful Helpsheets/further information**

- *"GDS software-based dynamic and seismic laboratory soil testing systems".* A technical review of GDS dynamic systems including a section entitled "Electromagnetic, hydraulic or pnuematic control - which is best?"
- *Helpsheet 86*: Why Choose a GDS System?

All datasheets and helpsheets available from the GDS website at www.gdsinstruments.com/support

Independent closed loop control of axial stress *and* cell pressure (dynamic or static) ✓
Sine, havesine, triangular and square waveforms ✓
User defined waveforms ✓
Direct closed loop of axial displacement ✓
Direct closed loop of axial force ✓
ASTM D3999-91 and ASTM D5311-92 compliant ✓
12 access ports as standard ✓
Interchangeable submersible load cell ✓
Balanced ram to keep cell pressure constant ✓
Optional dynamic cell pressure available ✓
8 channel 16bit data acquisition ✓
Volume change measurement ✓
High accuracy electromagnetic control ✓
No manual tuning required ✓

***Technical Specification***

- *Displacement range = 100mm*
- *Displacement accuracy = 35$\mu$m in 50mm (i.e. 0.07%)*
- *Displacement resolution = 0.208$\mu$m*
- *Axial force accuracy = <0.1% of load cell range (i.e. 1N for 10kN load cell)]*
- *Axial force resolution = 16 bit (i.e. <0.4N for 10kN load cell, <1.5N for 40kN load cell)*
- *Control data points = 10,000 pts/sec*
- *Maximum saved data points = 100 points/cycle*

***Technical Features Overview***

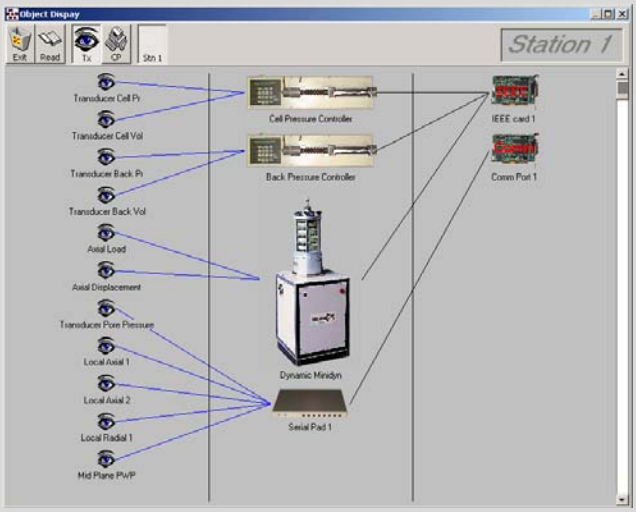
- *Performance specification conforming to the requirements of ASTM Designation D3999-91 "Standard Test Methods for the Determination of the Modulus and Damping Properties of Soils Using the Cyclic Triaxial Apparatus".*
- *Interchangeable load cells (optional) to accommodate very soft to very stiff soils with ranges of 1, 2, 4, 8, 10, 16, 25, 40 and 60kN.*
- *Local strain measurement (optional) and mid-plane pore pressure measurement (optional).*
- *P and S wave measurements with Bender Element system (optional).*
- *Precise control of low consolidation stresses by differential pressure transducer (optional). Direct closed loop control of axial displacement, deviator force, cell pressure, and back pressure.*
- *All tests defined using GDSLAB control and data acquisition software. Data output is ASCII and compatible with Excel and other industry-standard spreadsheets.*
- *38, 50, 70, 100mm diameter test specimens by interchangeable pedestals and triaxial extension top caps.*
- *Simple access for transducers, valves and pipework via built in 12 port Transducer Ring. Plus 8 channels of 16 bit data acquisition.*

## GDSLAB control software

The GDSLAB control and acquisition software from GDS is a highly developed, yet extremely flexible software platform. Starting with the Kernel module and the ability to perform data acquisition only, additional modules may be chosen for your testing requirements. Some currently available modules available are as follows:

- SATCON (saturation and consolidation)
- Standard Triaxial
- Stress Path Testing (p, q and s, t)
- Advanced Loading Tests
- Unsaturated Testing
- K0 consolidation
- Permeability

GDSLAB has the ability to be configured to your hardware choice, no matter how unique the arrangement. A text file (*.ini) or initialisation file is created that describes the hardware connectivity to the PC. The hardware layout is available in graphical format via the GDSLAB 'object display'. This makes setting up the devices and checking the connectivity extremely simple.

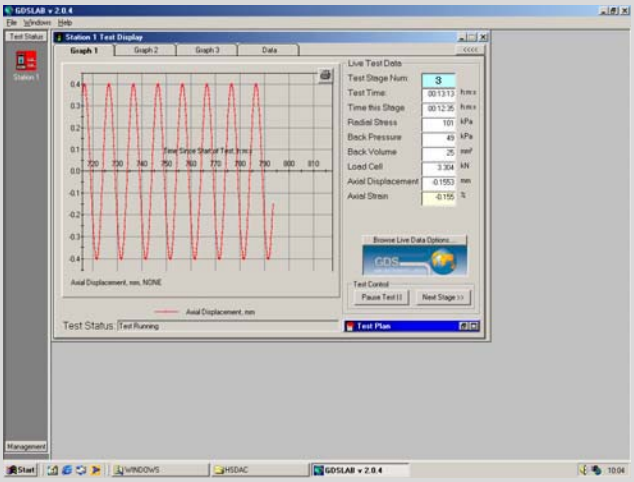



**GDSLAB object display showing a DYNTTS setup**

*For further information on GDSLAB, please refer to the dedicated GDSLAB datasheet.*

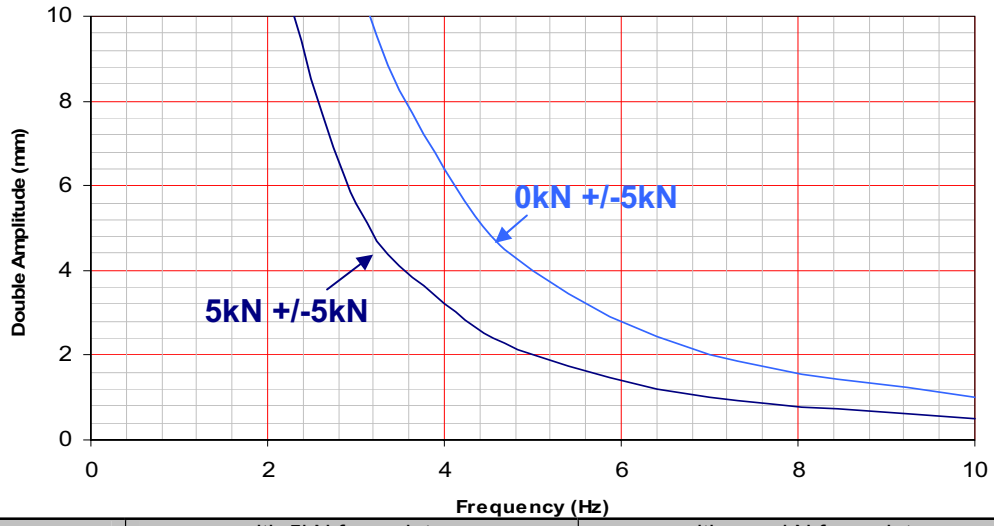
## GDSLAB dynamic test module

- Dynamic cyclic loading tests at frequencies up to 2Hz, 5Hz or 10Hz (depending on the model).
- Provides sinusoidal cyclic control of axial displacement or axial force and cell pressure with optional dynamic cell pressure controller.
- Plotting saved results gives cyclic stress paths based on average cross-sectional area i.e. the area of the volumetrically equivalent right cylinder.
- A complete cycle of data can be saved every N cycles where the value of N is defined by the user.
- Dynamic stress paths (with optional dynamic cell pressure controller).
- Controlled data displayed in real-time.
- Up to 1000 points saved per cycle.
- Built in standard waveforms: Sinusoidal, triangular, square, havesine.
- User defined waveforms using 1000 point ASCII file.



**Test display showing a dynamic test in progress**

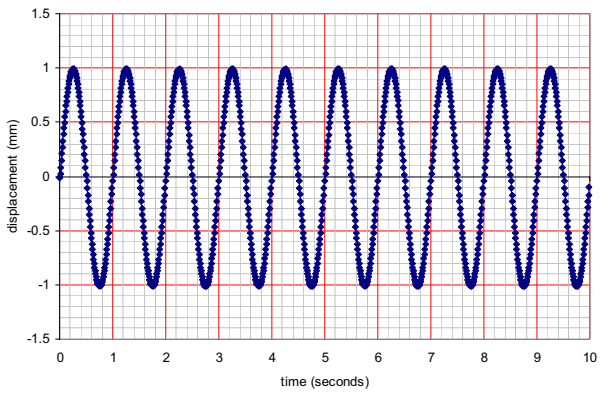
## System Performance

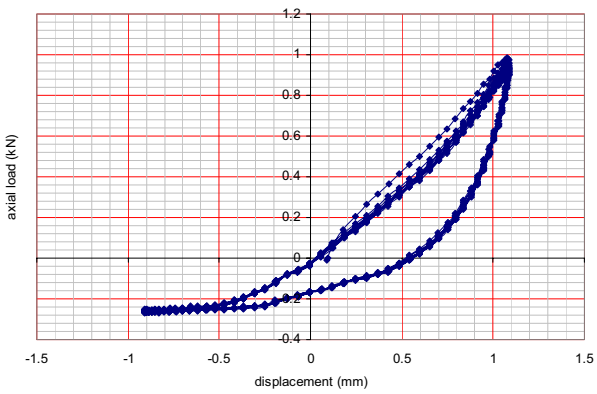



| Frequency (Hz) | with 5kN force datum | | with zero kN force datum | |
|---|---|---|---|---|
| | Amplitude (mm) | Double Amplitude (mm) | Amplitude (mm) | Double Amplitude (mm) |
| 0.1 | 50 | 100 | 50 | 100 |
| 0.2 | 50 | 100 | 50 | 100 |
| 0.5 | 26.5 | 53 | 26.5 | 53 |
| 1 | 13.3 | 26.6 | 13.3 | 26.6 |
| 2 | 6 | 12 | 6 | 12 |
| 3 | 2.8 | 5.6 | 4.4 | 8.8 |
| 4 | 1.6 | 3.2 | 3.2 | 6.4 |
| 5 | 1 | 2 | 2 | 4 |
| 7 | 0.5 | 1 | 1 | 2 |
| 10 | 0.25 | 0.5 | 0.5 | 1 |

## Typical Test Results

| Axial displacement feedback control | |
|---|---|
| Frequency (Hz) | 1.00 |
| Peak to peak (mm) | 2.000 |
| Radial stress (kPa) | 200.0 |



**Specifications overview**

- The axial load/deformation control sub-system is screw-driven through the base of the cell. The built-in dynamic axial loading system is driven by a brushless dc servomotor. Manual or programmed computer control is via the GDS data acquisition and control card installed in the PC. This control can be initiated from the GDSLAB software. The GDS Digital Control System downloads the control signal into firmware for sine, square, triangular and user defined control up to 2Hz, 5Hz or 10Hz (depending on the system model). For closed loop load control, feedback is taken from the internal load cell output. For closed loop deformation control, feedback is taken from the axial motor high speed shaft encoder. The axial load capacity has options of 10kN, 16kN, 20kN, 40kN and 60kN for the 2Hz and 5Hz machines, with the 10Hz machine being available in 10kN or 20kN. The axial displacement stroke is +/- 50mm.

- The radial pressure and back pressure control sub-system is by one GDS digital pressure/volume controller 200cc/2MPa to give precise control of cell pressure to 1kPa resolution. Manual control is via the 16 key keypad and 40 character LCD. Computer control is via the integral IEEE-488 GP-IB computer interface. Functions include target pressure, target volume change, ramp/cycle pressure and ramp/cycle volume change.

- Optional dynamic cell pressure available. See further in datasheet for details.

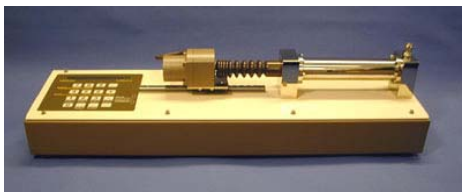
- Where optional dynamic cell pressure control is not used, the cell is provided with a balanced ram. This compensates for the volumetric displacement of the loading ram into or out of the cell. Down the centre of the hollow ram, the cell fluid is hydraulically connected to a chamber through which the ram passes. In this chamber the ram has an annular piston attached to it. The annular area is exactly equal to the area of the ram. When the ram moves in the cell and causes a volume change, the annular piston causes an equal and opposite volume change. In this way the net volume change in the cell is zero. In addition, cell pressure acting on the annular ring automatically compensates for the effect of cell pressure acting on the ram. This means that the axial force capacity of the cell is independent of cell pressure.

- On-board computer control is via the GDS Digital Control System (GDS DCS). See below for further details.

## Pressure/volume controllers

The Cell Pressure and Back Pressure controllers may be 'mixed and matched' between any of the following devices:**0.5MPa, 1MPa, 2MPa, 3MPa** *Standard digital Pressure/Volume controllers* with serial PC connectivity and 200cc volumetric capacity.

**2MPa, 3MPa and 4MPa,** *Advanced digital Pressure/ Volume controllers* with serial or IEEE PC connectivity and 200cc volumetric capacity (advanced 2MPa controllers can be bought as 1000cc volumetric capacity items)



The back pressure controller applies back pressure and also measures volume change of the test specimen.

## GDS DCS – Digital Control System

The GDS dynamic systems are all based around the GDS DCS high speed digital control system with closed loop feedback of displacement and load.

With 16 bit data acquisition (A/D) and 16 bit control output (D/A), the GDS DCS runs at a control frequency of 10kHz per channel. This means that when running at 10Hz the system uses 1000 control points per cycle. When running at 1Hz, it uses 10000 control points per cycle

The advantage of GDS DCS system is that no matter which dynamic system is purchased, they all use the same high speed control system. This ensures that the system has the highest level of functionality and reliability because all of our dynamic systems, over our complete range, use the same high specification control system. A result of this is that the accuracy and resolution of the test is only a function of the actuator used, whether it be a low cost pneumatic actuator, high accuracy elecromechanical actuator or high capacity hydraulic actuator.

**Optional dynamic cell pressure**

The dynamic capability of the actuator is described in terms of the maximum double amplitude of volume change. At 10Hz the maximum double amplitude of volume change is 24,000cu.mm. At 5Hz the maximum double amplitude of volume change is 96,000cu.mm. The system performs at speeds defined by these frequencies and double amplitudes. How this translates into radial stress control depends entirely on the cell fluid and soil stiffness and specified radial stress double amplitude. For stiff soils at small radial stress double amplitudes, higher frequencies will be possible than for soft soils at large radial stress double amplitudes. As a guide only, tests performed at GDS indicate that for a datum of cell pressure of 1000kPa, the following combinations of frequency and double amplitude of cell pressure can be achieved: at 10Hz, 400kPa; at 5Hz, 800kPa. The typical variation of cell pressure with axial displacement is +/-5kPa at 5-10Hz and +/-3kPa at <5Hz.

*Electromechanical dynamic cell pressure actuator*
The electromechanical dynamic cell pressure range is 1.4MPa. For closed loop cell pressure control, feedback is taken via the cell pressure 2MPa range transducer installed directly in the cell. This hydraulic actuator is driven by a brushless dc servomotor.

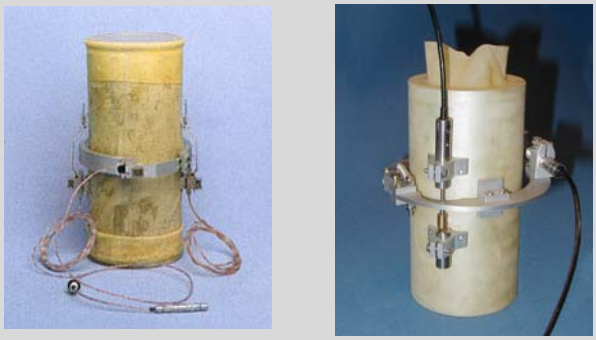
*Low cost pneumatic dynamic cell pressure actuator*
The pneumatic dynamic cell pressure range is 1 MPa. For closed loop cell pressure control, feedback is taken via the cell pressure 2MPa range transducer installed directly in the cell. This actuator is driven by an air servo valve working with an air water interface.

**Upgrade to local strain measurement**

Any DYNTTS system may be upgraded to perform Local Strain measurement using either Hall Effect or LVDT transducers. Both device types enable axial and radial deformation to be measured directly on the test specimen via lightweight aluminum holders.

Hall effect transducers may be used in water up to 1700kPa. LVDT transducers come in 2 versions:

- Low pressure (up to 3500 kPa) version for use in water
- High pressure (up to 200 MPa) version for use in non-conducting oil



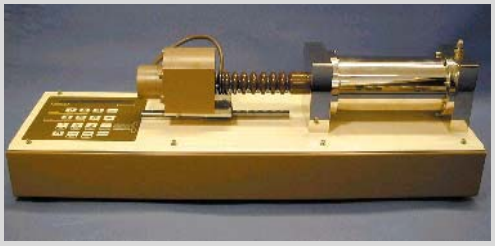
**Hall Effect and LVDT local strain transducers**

*For further information on Local Strain Measurement, please refer to the dedicated Hall effect Local Strain and LVDT Local Strain datasheets.*

**Upgrade to unsaturated testing**

Any DYNTTS system may be upgraded to perform unsaturated triaxial testing with the addition of the following items:

- Unsaturated pedestal with high air entry porous stone.
- 1000cc Digital Air Pressure/Volume controller (for application of pore air pressure and measurement of air volume change).
- Optional HKUST double cell.
- Optional double walled cell.



**1000cc air pressure controller**

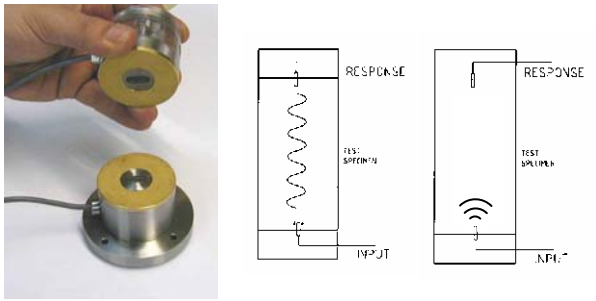
*For further information on Unsaturated Testing, please refer to the dedicated Unsaturated datasheet.*

**Upgrade to bender element testing**

Any DYNTTS system may be upgraded to perform P and S wave bender element testing with the addition of the following items:

- Bender Element pedestal with *new* inserted element
- Bender Element top-cap with *new* inserted element
- High speed data acquisition card

Signal conditioning unit, amplification of source and received signals (P and S-wave) with user controlled gain levels (via software).




**P and S wave elements**

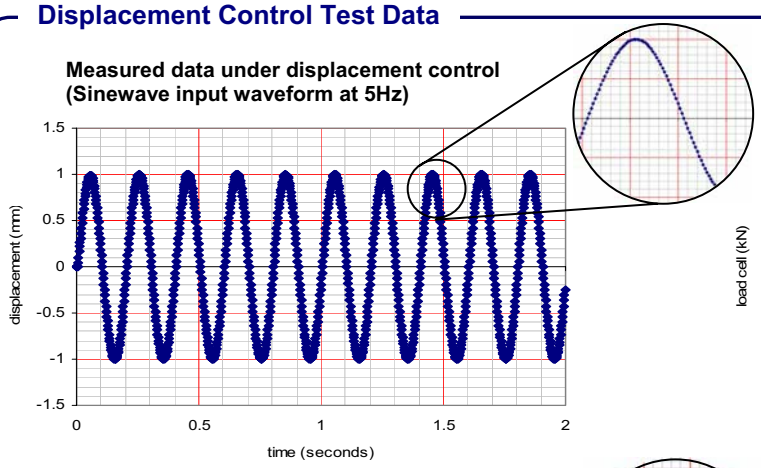
*For further information on Bender Element Testing, please refer to the dedicated Bender Element Testing datasheet.*

**Why buy DYNTTS?**

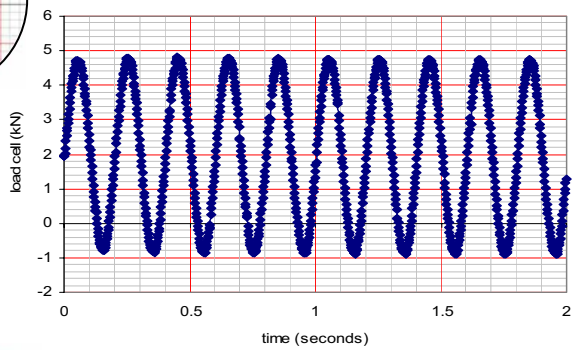
- GDS DCS – no requirement for manual tuning.
- As well as extremely good control of axial displacement and axial load for dynamic testing the DYNTTS system is excellent for performing static and small strain triaxial tests.
- With GDS software and hardware there are unlimited possibilities for upgrading the system in the future (i.e. Bender Elements, Unsaturated testing, Mid Plane PWP, Local Strain etc).
- Independent control of each axis (i.e. axial, radial) whether dynamic or static testing.
- Optional on-site training by experienced geotechnical engineers.
- Reputation for world class technical support – check the website for testimonials.
- 24 hour technical support by e-mail.

## Displacement Control Test Data

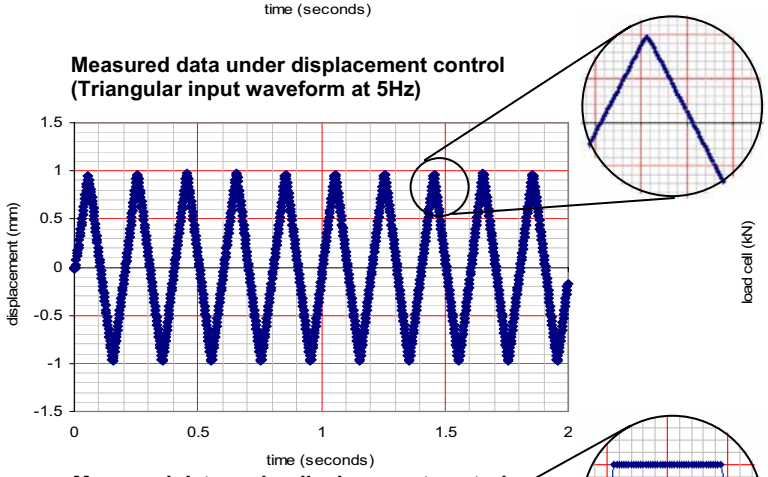
**Measured data under displacement control (Sinewave input waveform at 5Hz)**



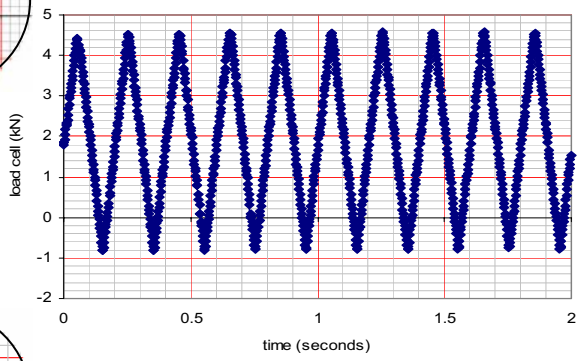

**Measured reaction**



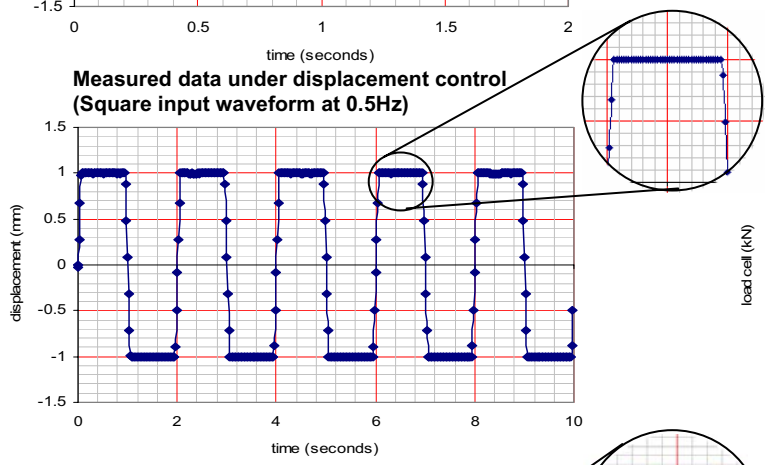

**Measured data under displacement control (Triangular input waveform at 5Hz)**



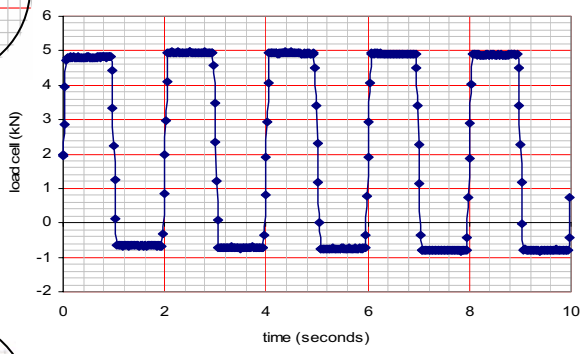

**Measured reaction**



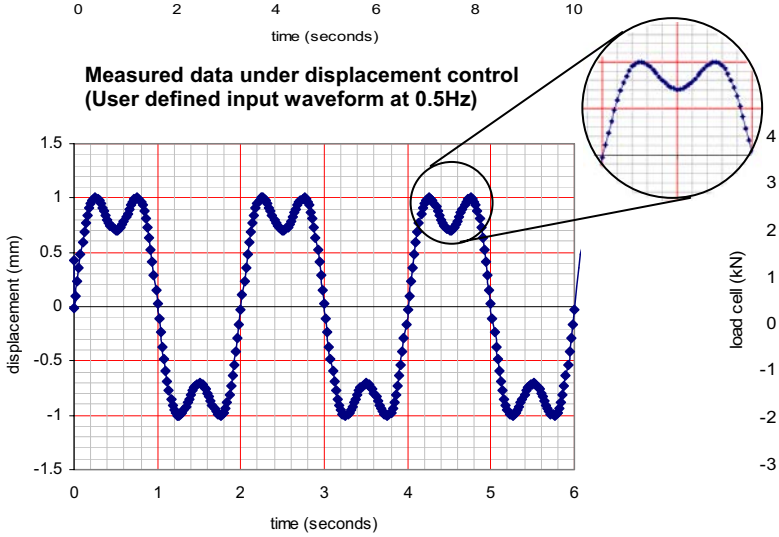

**Measured data under displacement control (Square input waveform at 0.5Hz)**



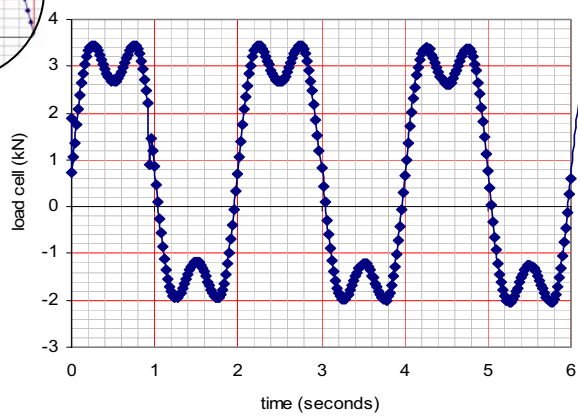

**Measured reaction**




**Measured data under displacement control (User defined input waveform at 0.5Hz)**



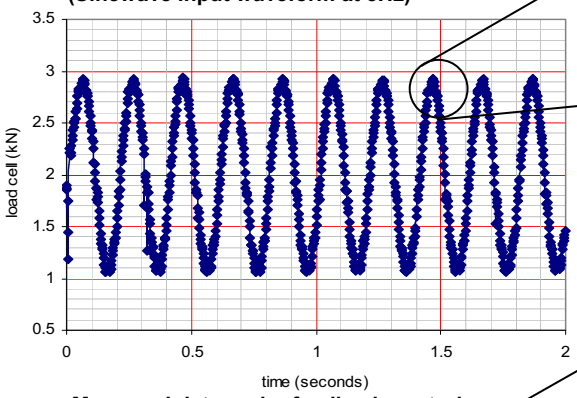

**Measured reaction**



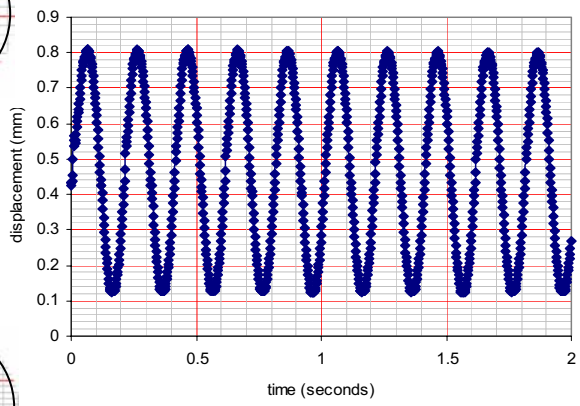

**Note: Above test data obtained using elastic test specimen to demonstrate machine performance capability.**

## Feedback Control Test Data

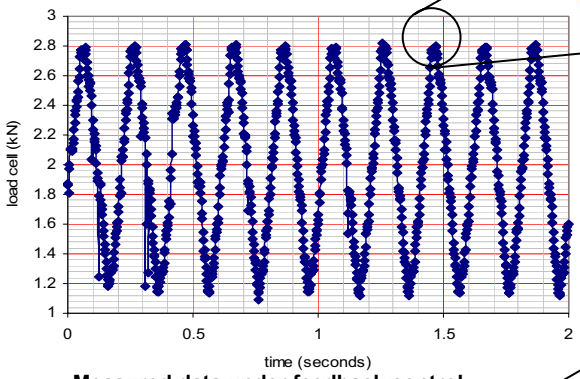
**Measured data under feedback control (Sinewave input waveform at 5Hz)**



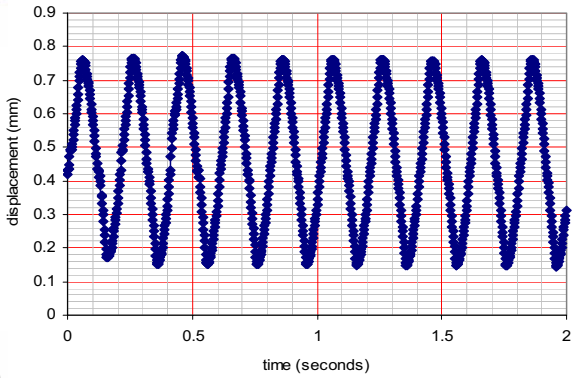

**Measured displacement reaction**



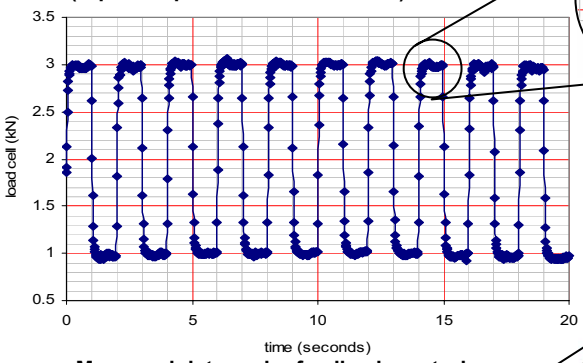

**Measured data under feedback control (Triangular input waveform at 5Hz)**



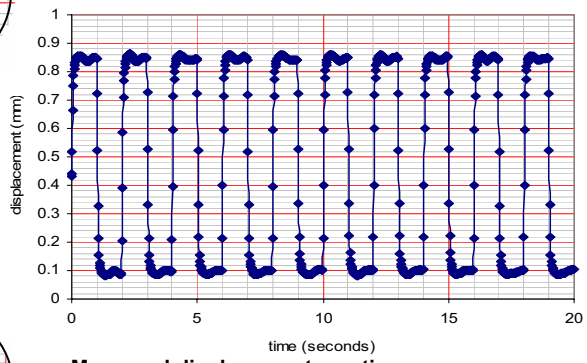

**Measured displacement reaction**



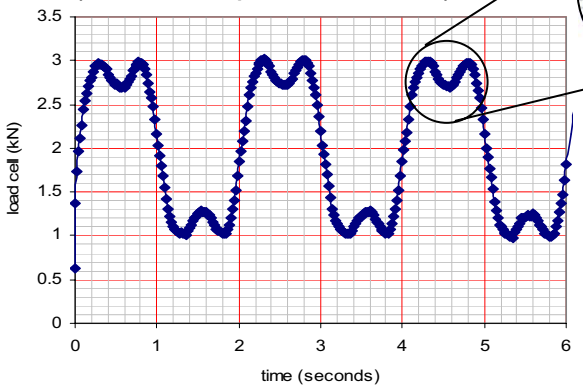

**Measured data under feedback control (Square input waveform at 0.5Hz)**



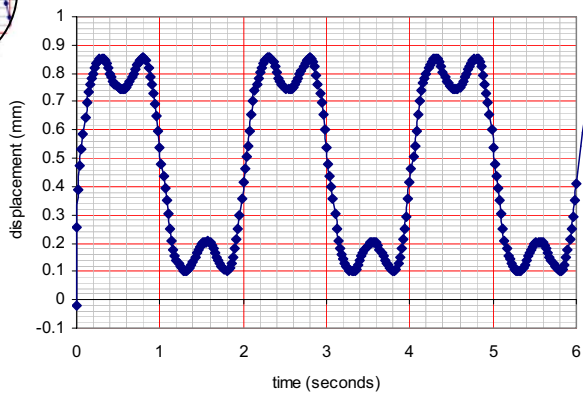

**Measured displacement reaction**




**Measured data under feedback control (User defined input waveform at 5Hz)**




**Measured displacement reaction**




**Note: Above test data obtained using elastic test specimen to demonstrate machine performance capability.**



**Due to continued development, specifications may change without notice.**