100 Helpsheet

World Leaders in Computer Controlled Testing Systems for Geotechnical Engineers and Geologists

Hardware

Triaxial Testing Systems

Static and Dynamic Axial and Radial Performance Envelopes

1. Overview

GDS static triaxial, dynamic triaxial and Hollow Cylinder Apparatus' have performance specifications defined in terms of the relationship between frequency and maximum double amplitude of displacement. Amplitude and frequency are interdependent. If you increase one, you decrease the other. If you decrease one, you increase the other. All cyclical variations are sinusoidal.

The maximum static force is determined by the combination of the mechanical advantage of the system ("gear ratio") and the maximum torque available from the motor. Under dynamic loading, as frequency increases, so more and more torque is required to accelerate and decelerate the motor. This means that less torque is available for axial force and so axial force capacity reduces.

The dynamic performance envelope of these systems broadly classifies into three parts depending on frequency. Consider, for example, the 2Hz system. From static to about 0.1Hz, the machine is mechanically limited by the stroke of the actuator. The maximum double amplitude is therefore constant for all frequencies less than about 0.1Hz. From 0.1Hz to about 1-2Hz, the performance of the system is limited by the maximum velocity or speed of the motor. Here, maximum amplitude is inversely proportional to frequency. At frequencies higher than 1-2Hz, the system is limited by the maximum torque from the motor and the inertia of the system. Here the maximum double amplitude is inversely proportional to the square of the frequency. At frequencies greater than the maximum rated frequency we specify for the system, the torque is increasingly taken up by accelerating and decelerating the motor and so both load and displacement drop off rapidly.

2. Axial Performance Specifications

The axial dynamic capability of the system is described in terms of the maximum double amplitude of the axial actuator. For the10Hz/20kN system, for example, at 10Hz the maximum double amplitude is 2mm. At 5Hz the maximum double amplitude is 8mm. The system performs at speeds defined by these frequencies and double amplitudes. When the system is carrying out a stress controlled dynamic test, the stress is controlled to vary sinusoidally. The machine is displacement controlled, however, and must remain within its displacement controlled performance envelope. For example, a stress controlled dynamic test with a stress double amplitude of 50kPa may work perfectly on a stiff soil. On a softer soil, however, the machine might need to exceed its displacement limits at that frequency to generate the required stresses. In this case, the machine could not maintain the required stress control. In general, therefore, for stiff soils at low axial stress double amplitudes, higher frequencies will be possible than for soft soils at high axial stress double amplitudes.

Over the page there now follows two tables showing how we define the performance of the

systems. You will see that for a given axial force capacity (or for the case of cell pressure control, pressure capacity), there is a trade-off between frequency and displacement. For completeness, the static version of the 2Hz system is also specified under 0Hz.

Parameter	**2Hz/10kN 0Hz/40kN**	**2Hz/16kN**	**2Hz/40kN**	**10Hz/5kN**	**10Hz/20kN**	
Static axial load	10kN 40kN	16kN	40kN	5kN	20kN	
Stroke	±50mm ±50mm	±50mm	±50mm	±50mm	±25mm	
Dynamic load(av.)	6kN	9.5kN	24kN	3kN	9kN	-
Max double amplitude						
@10Hz	-	-	-	3mm	2mm	-
@5Hz	-	-	-	10mm	8mm	-
@2Hz	5mm	5mm	7mm	30mm	40mm	-
@1Hz	14mm	14mm	14mm	100mm	50mm	-
@0.1Hz	100mm	100mm	100mm	100mm	50mm	-
Accuracy axial disp.	0.07% 0.07%	0.07%	0.07%	0.07%	0.07%	
Resolution disp.	0.08µm 0.1µm	0.08µm	0.125µm	1.00µm	0.625µm	
Resolution force	0.1%FRO 0.1%FRO	0.1%FRO	0.1%FRO	0.1%FRO	0.1%FRO	

3. Radial Performance Specifications (10Hz/20kN system only – Maxidyn)

The radial dynamic capability of the system is also defined in terms of displacement - the maximum double amplitude of volume change of the radial actuator. 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 stiffness (and to a lesser extent, soil stiffness) and specified radial stress double amplitude. For stiff systems at low radial stress double amplitudes, higher frequencies will be possible than for soft systems at high 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.

Frequency Hz	**Double Amplitude of (stroke) Volume Change**	**Double Amplitude of Cell Pressure kPa**	**Datum kPa**
10	(4.7mm)24000cu.mm	400	1000
5	(19mm)96000cu.mm	800	1000
2	(33mm)168000cu.mm	1400	700
1	(33mm)168000cu.mm	1400	700
0.1	(33mm)168000cu.mm	1400	700