23 GDS Helpsheet

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

Hardware

VIS Axial Loading System

Machine Specification/Performance

1. What is the VIS Concept

The GDS VIS axial loading system embodies a new concept - Virtual Infinite Stiffness. The machine is calibrated at GDS to measure the difference between the system indication of platen displacement and the actual platen displacement for the full load range.

This relationship is stored in the ROM (Read Only Memory) of the system so that the platen displacement and control is automatically corrected for machine compliance under load. In this way the machine appears to be infinitely stiff - hence "Virtual Infinite Stiffness".

2. How Does it Work?

In the VIS system platen displacement is gauged from counting the steps to the stepping motor. The stepping motor drives a gearbox and ball screw which actuates the platen. These internal mechanics will vary under load. Thus the system means for gauging platen displacement changes under load.

Within the machine frame under loading the cross beams flex and the side columns deform. Thus the dimension between the platen and the load cell will change under load.

In the VIS system these load-induced changes are very nearly eliminated. This means that the platen displacement is corrected for machine deformations under load.

Control and measurement and display of platen displacement corresponds to the changes in dimension between the platen and the load cell to within a band of accuracy. This is less than 0.05% of the full range of platen displacement of 100mm over the full load range of zero to 100kN.

This is a remarkable specification being better than many systems that are designed for measurement of displacement alone under no load. Our specification is for a system which applies load and also measures the displacement using the loaded members.

The GDS VIS machine can therefore give very accurate deformation measurements which compensate for the machine compliance. Nevertheless external displacement measurement of triaxial test specimens is subject to a number of errors which are not related to the VIS machine. Internal local strain measurement will therefore give even better results.

3. Checking VIS Operation

Owing to the different loading and unloading load-displacement relationships (i.e. hysteresis) the actual relationship put into ROM is a straight line best fit. This best fit line is high on loading and low on unloading.

For some very stiff (e.g. steel) test specimens which deform by less than 50µm over 100kN this best fit solution means that the VIS can indicate a positive displacement (getting longer) with increasing load and a negative displacement with decreasing load.

While this may seem illogical it is nothing to worry about and simply means that within the error band of +/-50µm that the VIS is making the best correction it can.

For real soils and soft rocks such as chalk this strange apparent behaviour will not be seen.

4. Bedding Errors

The error which we correct for is the machine compliance. Other sources of errors are the bedding errors within the cell and test specimen which we cannot correct. Reference may be made to the paper by Jardine et al (1984) called "The measurement of soil stiffness in the triaxial apparatus". This paper describes the sort of bedding errors that can arise.

One way of decreasing bedding error is to connect the test specimen to the load cell. Another improvement would be to set the cell up on a self-aligning thrust bearing.

The only way to measure real displacement of a test specimen is to do so directly with transducers fixed to the soil/rock. We have Hall Effect transducers for soil. We are investigating adapting these for higher pressures.

5. How is the VIS Calibrated?
Calibration System Overview

The purpose of the VIS calibration is to provide a means whereby the indicated displacement of the machine corresponds to the real displacement under load that occurs between the platen and the button of the load cell.

Such a means has to compensate for the stretch in the side columns, the flexure of the top and bottom cross beams, the shortening of the ball screw which raises and lowers the platen, and the mechanical distortion in the gearbox. Only then can the steps in the stepping motor correspond to the real movement between the platen and the load cell.

6. Calibration Column

GDS has developed a unique calibration column.

There is an inner column of interlocking/stacking cylindrical blocks. This inner column carries the load. On the top of this column are mounted three GDS digital indicators to measure the deformation within this loaded column. The indicators are arranged about the column at 120 degree intervals.

There is also an outer column (concentric with the inner column) of interlocking/stacking toroidal blocks of rectangular cross section. This outer column does not carry load. The purpose of the outer column is to register the platen movement to the digital indicators and so the deformation of the inner column is measured.

7. Calibration Procedure

Under computer control the VIS machine is set to a series of target loads. On reaching these target loads the three digital indicators are read and averaged. The actual deformation of the column is compared to the indicated platen displacement and the error found. The resulting printed table gives the calibration data of the VIS machine. Typically for a 100 kN machine at 100 kN this is about 1mm. This means the machine has a stiffness of about 0.1 kN/µm.

This data is then used to synthesise a load-related correction which is programmed into the memory of the machine. The correction not only varies with load but with beam location and platen location as well.

The calibration procedure is then run again but this time with "VIS ON". The error is now the difference between actual displacement and indicated displacement with VIS in operation. The printed output with VIS ON and OFF represents the calibration certificate of the machine.

8. Reference

Jardine, R.J., Symes, M.J. and Burland, J.B. (1984). "The measurement of soil stiffness in the triaxial apparatus". Geotechnique 34, No.3, 323-340.