53 GDS Helpsheet

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

Hardware

Advanced Controller - Air

Use of the Air Pressure Controller

1. Introduction

The following points should be understood:-

- The air pressure controller is a fixed volume device.
- The Gas Laws apply: PV = kRT. Or PV = Constant at constant temperature. P is the absolute pressure, V is the total volume of the gas.
- The pressure that can be generated is determined by the 'dead volume'. This is the volume that is left when the controller piston has moved as far as it can to compress the air.
- Consider the case of a 1000 cc controller connected to a 'dead volume' of 200 cc. Total system volume = 1200 cc. at atmospheric pressure (i.e. 100 kPa absolute pressure). In this case PV = 1200 x 100 = 120,000 kPa.cc. If the pressure is doubled the total volume is halved to give P=200kPa(A), V=600cc. The minimum volume is the 'dead volume' = 200cc. The maximum pressure is therefore 120,000/200 = 600 kPa(A) which is 500 kPa relative. In this example the volume change has been 1000cc but the external volume has not changed - all of the volume change has been used to generate the pressure.

You need to consider the actual volume change of the test specimen and the volume change used to generate the pressure. The calculation of the air volume change in the test specimen is the total volume change measured by the controller minus the volume change necessary to cause any pressure changes.

Interesting points are as follows:-

- You must know; the Volume of the controller + any dead volume in the controller at the start of the test, the volume of any interconnecting tubing.
- From the behaviour of the P/V relationship you can calculate the volume change in the test specimen.
- You can precompress the air in the controller (at a known total volume) before the start of the test to increase the pressure range of the system.
- You can combine the use of the air pressure controller with the use of local strain measurement to get two calculations of the specimen volume change.
- You can carry out tests at constant pressure (and temperature) in which case the sum of the volume changes measured by the air pressure controller and the back pressure (water) controller is the actual specimen volume change.

- You can carry out tests with a constant air pressure but change the 'matric suction' by altering the back (water) pressure. In this case the air pressure controller measures the test specimen air volume change and the back pressure controller measures the specimen water volume change.

Recommendations relating to the use of the air pressure controller depend on the type of testing that it is being used for. In general they are:-

- To understand the Gas Laws.
- To allow time for equilibrium conditions to become established.
- To understand the impact of temperature changes. This can be investigated in a closed controller maintaining a set pressure of say 500 kPa and monitoring the volume/temperature changes over a period of 2-3 days or longer.

2. Air Pressure Controller Pressure Seek Algorithm

The main differences in firmware for the water controller and the air controller are related to the pressure seek algorithm. Water is much stiffer than air with the result that one step of the motor can generate between 0.5kPa and 3kPa. The pressure resolution (for control) of the controllers is 0.5kPa. We therefore use an algorithm which stops the motor stepping when the measured pressure is within 1.0kPa of the target. The target pressure is therefore maintained with a volume change accuracy of less than 1 cubic millimetre.

For the air pressure controller one step of the motor causes a negligible change in pressure. At low pressures several thousand steps are required to generate a 1.0kPa difference. We therefore seek to the target pressure exactly. This means that the measured volume is correct for the selected target pressure. The downside of this decision is that because there is zero deadband on the pressure seek the controller will always keep stepping. This is not a problem for the controller.