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Pressuremeter testing in waste

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Date: 23/09/1998

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Pressuremeter testing in waste

There is considerable interest in measuring the engineering properties of waste. Cambridge Insitu have used a self boring pressuremeter (shown in Figure 1) to make in situ tests in and around domestic waste sites.

The tests so far have fallen into two sorts - tests in the waste and tests on natural ground underlying waste sites. In general tests in the natural ground present few problems for the pressuremeter equipment and there is no difficulty in determining the hydraulic conductivity, strength and stiffness of the soil. Tests in the waste itself are more difficult and this short leaflet gives some idea of what is possible in newly deposited (less than two years) and old (more than ten years) domestic waste. Although we have had some success the waste will remain a difficult and unpopular material to test.

Fig. 1 A Cambridge Self Boring Pressuremeter

Pressuremeters make a lateral loading test by inflating a thin flexible sleeve to press against and expand a cylindrical hole in the ground. The hole can be pre-formed, or made by the pressuremeter itself by tunnelling or pushing. The loading curve obtained by plotting increments of pressure against radial displacement of the cavity can be solved by rigorous mathematical expressions for the expansion of a cylindrical cavity.

Figure 2 shows the loading curve produced by a self boring pressuremeter in newly deposited waste. The test is relatively shallow, and the drilling was conducted from the surface through about 1 metre of capping clay.

The material is unsaturated, will compress during loading and strength parameters cannot be derived using conventional analyses that depend on deformation being purely shear. However stiffness values can be obtained by calculating the slope bisecting small cycles of unloading and reloading. This is a proven technique that gives consistent and repeatable values for shear modulus and is insensitive to disturbance caused to the material during the process of inserting the instrument.

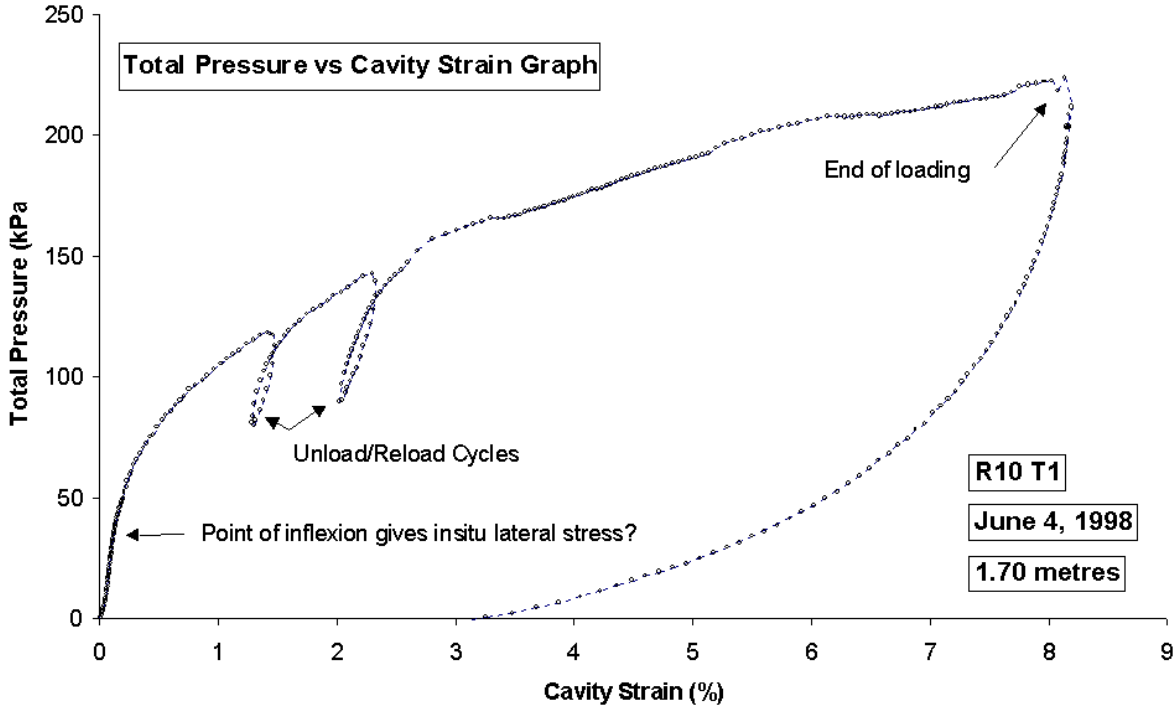

Fig. 2 Plot of Self Boring Pressuremeter test in domestic waste

It happens that in this example insertion disturbance seems reasonably small and it is possible to see a point of inflexion near the start of loading that may correspond to the insitu lateral stress.

This test was made with a conventional Self Boring Pressuremeter (SBP) similar to that shown in Figure 1. The instrument is a miniature tunnelling machine that cuts a hole into which the probe very precisely fits. Both jacking force and rotation are required to accomplish this. We used a portable system to carry out the test in figure 2 but a conventional rotary rig has also been used to drive the SBP and has some advantages as it is able to core through layers too difficult for the SBP to penetrate - such as car suspension parts.

Figure 3 shows some results from a series of tests carried out at a single site. Data from five locations are included, and there is a single test in old waste at 11 metres. Testing old waste proved more difficult than the new, presumably due to consolidation increasing the likelihood of encountering impenetrable objects.

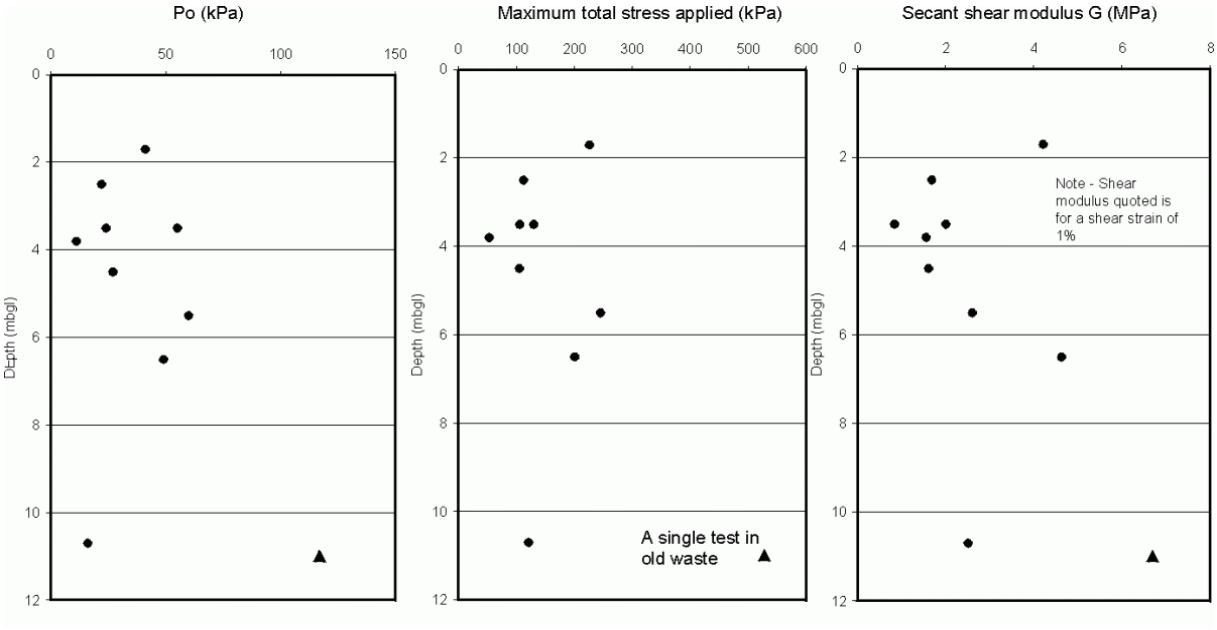

Fig. 3 SBP testing in fairly new domestic waste, parameters plotted against depth

The maximum stress reached during the test has been plotted, not as an engineering property but as a guide to the variability of the waste. Disturbance accounts for some but not all of this variation. The plot of insitu lateral stress mirrors that of the maximum stress and is consistent with a view of the material as underconsolidated. Shear modulus has less scatter and although not attempted here there are indications that normalising stiffness with the insitu stress will be a worthwhile step.

We have also carried out some trials using the portable system and a Cone Pressuremeter (CPM). This instrument is pushed into the material and carries a 15cm2 piezocone on its lower end. Figure 4 shows the instrument. It can give good results for stiffness and strength but estimates of the insitu lateral stress are more questionable. It has the advantage of giving the cone profile. It is much simpler to use than the SBP, can easily be moved to a new position in the event of difficulties but requires probably 5 tons of kentledge to jack against. This is not always easy to obtain although a cone truck or crawler could supply the necessary reaction without difficulty.

Fig. 4 The Cone Pressuremeter

Observations

In the light of the work carried out so far we have the following observations:

1. Pressuremeter testing is always worth considering for problems such as deriving parameters from waste. The volume of material influenced by the test huge - it will be a cylinder of material about 0.5 metres high extending to at least 10 times the inflated diameter of the probe. Pressuremeters can make their own hole, be pushed or be used in pre-bored holes. So far we have tried self boring and pushing.
2. In many ways pushing (the CPM) is the ideal method. The penetration of the cone takes the material to an enormous strain, and although there is a slight relaxation behind the cone the pressuremeter expansion has the capability of restoring the stress and strain conditions around the probe to a limiting condition. Unloading from this limit state if kept small will give data for the stiffness of the material - unloading completely will give the strength properties of the material. Insitu stress parameters will be more difficult to determine, but not impossible. No water is added to the soil, and if problems are encountered the CPM can be moved easily to a new location.
3. The snag is that the cone needs to be pushed with some force. We used 2 tonnes with only limited success; probably 5 tonnes will be required. 5 tonnes is not easily portable, so a vehicle mounted system is called for, perhaps an adaptation of a crawler or similar piece of heavy kit. It may be possible to make a system that could be

mounted easily on a standard item such as a JCB that could be hired as required.

4. Self boring was reasonably successful in making a test but self boring was used as a convenient and cheap means of making a hole in the ground rather than for the minimal disturbance test that is the usual reason for using the device. These tests were significantly disturbed and the instrument does not have the expansion capability to be confident of erasing the evidence of the insertion disturbance. Most of the drilling fluid used during boring is lost into the strata and is not returned to the surface as intended. This is a cause of concern. There is no way of assessing the consequences for the derivation of stiffness and strength properties.
5. The real aggravation of self boring is the poor rate of testing - there is no certainty that putting the instrument into the ground will result in a successful test and certainly on the first series of tests damage to consumable parts was high. Later tests used a toughened version of the SBP and this certainly seems to have reduced damage. However one test per day appears to be the likely score rate, which is probably too low to be economically viable.
6. On consideration, therefore, it is now felt by us that pre-bored pressuremeter testing should be tried. In this system a conventional rotary rig makes a 100mm diameter hole about 2 metres long into which a high pressure dilatometer (HPD) is placed. This device is intended for tests in rock but has an enormous expansion capability that can be exploited for testing the waste. Shear strains greater than 100% can be imposed.
7. A lot depends on how well the test pocket is made and how the ground responds to being left open for the interval (about 15 minutes) between removing the coring bit and placing the HPD. Possibly a purpose built coring tool will be required to make the test pocket, but the evidence is that the waste stays open without difficulty.
8. The advantages of the pre-bored method are the certainty of achieving a successful test and the large strains to which the waste can be taken. However all three pressuremeters written about are capable of good resolution of the stiffness/strain characteristics of the waste and there are pluses and minuses for each system.
9. In order to produce a full set of parameters from the tests in waste analyses have to be developed for the loading of a non-saturated medium. Although some work has been done in this area it is a much less widely understood problem than the saturated soils where pressuremeters are usually employed.