January 2008, Issue 8

Cooper Testing Labs, Inc.

Geotesting Newsletter

Inside this issue:

K_0 Sample After Test

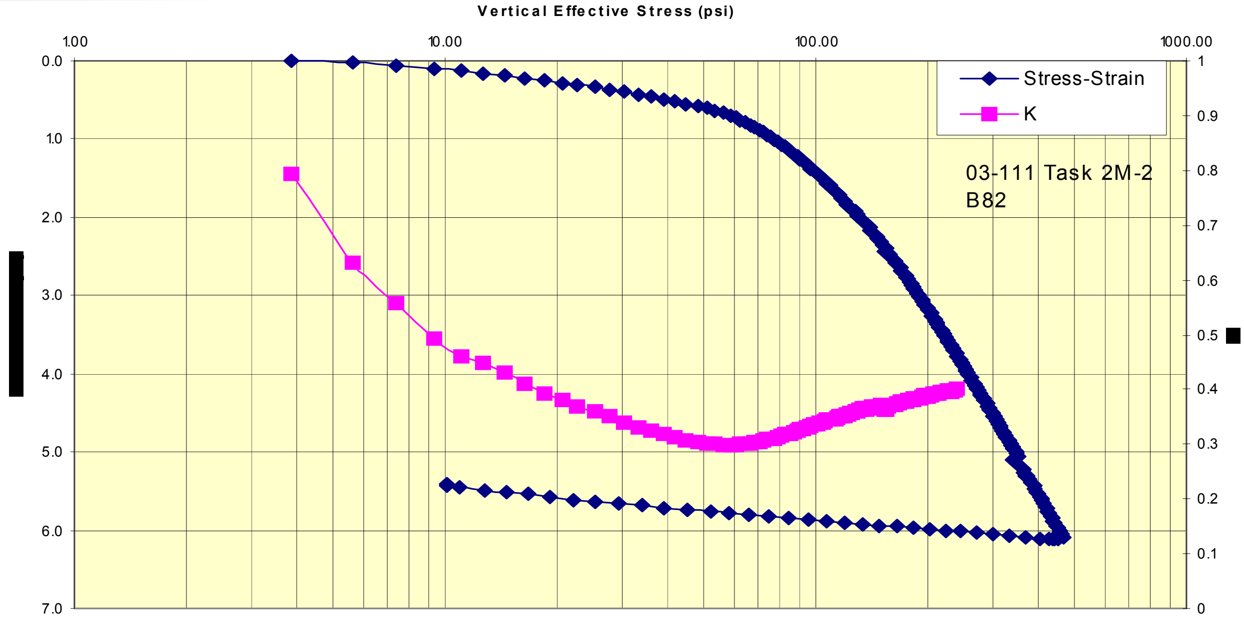
Consolidation Tests on Gravel !?

A southern California company was directed to us after having looked without success for a lab that could perform consolidation on gravel. Which is not surprising since no technician in his right mind would agree to test gravel for consolidation. We never claimed to be in our right minds though. We suggested using the K_0 procedure on 6” diameter samples. The material was a gravel with silt, with up to 1.5” gravel. The project is a landfill that will be experiencing loads from 480’ of fill, so consolidation is of concern. Gravel poses a problem for standard one dimensional (oedometer) consolidation testing, due to the limited sample size and friction from the rigid wall of the oedometer. This has been quite a problem for commercial and research labs, because until recently there was no equipment available to easily perform this type of testing. The K_0 procedure is perfectly suited for gravel, since it is run in a flexible membrane. A K_0 condition is met when the amount of lateral pressure is sufficient to keep the sample from deforming laterally. The standard oedometer test, (consolidation), is considered a K_0 condition due to the rigid wall of the sample cell but the lateral pressure is unknown and the height is limited to one inch or less due to side-wall friction. The K_0 procedure is usually run on specimens with a height to diameter ratio of 2 to 1 if strength testing is needed but can be less if just consolidation is required. The diameter and height of the sample should be six times greater than the largest particle size. Since we are limited to a maximum of six inch diameter samples we had to scalp on the one inch sieve. Our specimens were remolded to 6 inch diameter with a h/d ratio of two. Due to the complexity of the procedure and duration of the test, computer automation is required. The specimen is tested in a triaxial cell while in a flexible membrane. The system used, consists of an automated load-frame and two flow pumps. One pump is used for the confining stress and the other for the back pressure. The appropriate strain rate is set for the material to be tested. As the volume decreases due to the change in height the pore water pump extracts an equal volume of pore water based on the amount of volume change from the axial deformation, while the cell pump adjusts pressure in order to keep the pore pressure constant. “The test control rule is that the volume change in the pore water duct must at all times be equal to the volume of the axial deformation times the original average cross-sectional area. this rule is only applicable to saturated soils” *Bruce Menzies*, *Advanced Triaxial Testing.* After the test is complete the height is shorter but the diameter is the same. It is something to see. The stress-strain curve is surprisingly smooth for gravel. I had never seen anything like it. (Note the stress-strain curve on page two). This equipment not only allows us to test gravel or gravelly samples for consolidation but enables us to run K_0 consolidated triaxial tests without having to guess the ratio of vertical to lateral pressure (K_c) for the consolidation phase. The one major problem with the K_0 procedure is that C_v cannot be computed since the pore pressure is kept constant.

K_0 Consolidation & Triax

Historically triax testing has been run isotropicaly, the consolidation phase of the triax test is isotropic ($sigma_1$ = $Sigma_3$). Very easy to do, just increase the cell pressure to the required stress. Anisotropic (for our purpose) means that the vertical pressure is greater than the horizontal pressure during

(continued on page 2)



It is interesting to note that the k curve usually dips at the break of the consolidation curve.

(Continued from page 1)

consolidation, Sigma$_1$ is equal to the confining or cell pressure (sigma$_3$) plus the vertical (axial) load or deviator stress. In some cases the engineer may have to estimate the ratio of sigma$_1$ to sigma$_3$, also called the k$_c$. If the lateral stress is not enough to support the vertical stress you can fail the sample before ever starting the shearing phase. With the K$_0$ system estimating the lateral pressure is no longer required since the system ramps up to the exact pressure required to keep lateral deformation from occurring. Here is where the K$_0$ procedure is useful with the triaxial test. With the K$_0$ method the triax sample can be consolidated anisotropicaly without overstressing the sample because the system prevents lateral deflection from occurring. The other advantage is if the insitu lateral pressure is unknown one does not have to be estimated. The system will apply the required ratio of sigma$_1$ to sigma$_3$. The system that we have asks whether the type of consolidation is isotropic, anisotropic or K$_0$. If K$_0$ is required all the technician has to do is to pick the appropriate confining procedure and then enter the effective vertical stress and the system will do the following 1) ramp up to that pressure while 2) removing pore water equal to the volume change calculated from the strain times the cross sectional area 3) while adjusting the cell pressure to maintain the pore pressure, therefore keeping the sample deforming vertically not laterally. This also keeps the sample from failing during the consolidation phase. Once the vertical stress has been reached the lateral pressure is now known, which may be of interest to the engineer. We have been purchasing more of these systems, under the assumption that with the current technological advances in geotechnical equipment more advanced testing will be requested. There are still some issues with the advanced testing procedures though. An internal load-cell should be used in conjunction with the external load cell. This enables the system to compensate for piston friction and uplift pressure. With the internal load cell silicon oil should be used rather than water as the confining fluid, which is a mess and time consuming. We can estimate uplift but not friction. Due to the sophistication of the system there are more potential problems too. In order to keep cost down we are currently calculating uplift pressure and assuming friction to be negligible.

K$_0$ System with Flow Pumps

Capabilities of the New Lab

Only tests with significant turn-around-times are listed below.

Test Type: **Simultaneous Testing**

- **Consolidation (ASTM D 2435) ………..…………………………...35**
- **Permeability (ASTM D 5084) ………………………………………17**
- **Triaxial Compression (ASTM D 4767) ……………………………15**
- **Torsional Ring Shear (ASTM D 6467) ….…………………………..2**
- **Direct Shear (ASTM D 3080) …………………………………………...3**

The duplication of equipment allows us to provide our clients with the fastest possible turn-around-time. It also enables us to be much more flexible. If a piece of equipment goes down we have others to take its place.

Specialized Testing Capabilities:

- **High Confining Pressures up to 500 psi**
- **Large Scale Testing— 4 & 6" Diameter Samples**
- **High flow permeameter for drainrock**
- **High Pressure Consolidometers**
- **Constant Volume Permometer (reduce turn-around-time of low permeable materials by days)**

Main Lab Before Renovation

Main Lab After Renovation

Front Before

Front After

Cooper Testing Labs, Inc.

Cooper Testing Labs, Inc.
937 Commercial Street
Palo Alto, CA 94303
T) 650-213-8436
F) 650-213-8437

Address Label Here

Www.coopertestinglabs.com

Why use an Independent Geotechnical Lab?

Historically geotech labs were found in the back room of an engineering consulting company. The smaller consultants that did not have a lab would use the lab of a larger geotechnical consulting firm—their competition. In the 70's and 80's some of the larger consultants with full service labs were: Dames & Moore, Harding Lawson, Cooper Clark, Wahler, Earth Sciences Associates, Kleinfelder & Woodward Clyde. The lab managers from three of these companies Cooper Clark, Earth Sciences Associates and Whaler eventually all ended up working together at Cooper Testing Labs. Dan Martin ran the Wahler lab for 28 years. The lab specialized in large scale testing and advanced geotechnical tests such as cyclic triax, resonant column and all typical geotechnical testing. The lab had the capability of running up to 12" diameter triax testing. Peter Jacke ran the ESA lab for 10 years. The lab specialized in cyclic triax and all other typical geotechnical tests. David Cooper ran the Cooper & Clark lab for 10 years and apprenticed for another 5 years prior. The lab was a full service lab that ran tests for all of the Cooper & Clark offices around the country. There were about 300 employees at about 10 locations. The lab was the first in the S.F. Bay Area to purchase a Cox & Sons R-value press and Kneading compactor. The lab ran R-values for most all of the consultants in the Bay Area at the time. It is this kind of experience and expertise that Cooper Testing Labs brings to the Consulting community in the Bay Area. 2008 will be our 20th anniversary. We are very proud of our personnel and the labs capabilities. Give us a try!