



Cooper Testing Labs, Inc.

Sample Diameters and Undisturbed Testing

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Direct observation and testing of the subsurface by the collection of soil and rock samples to characterize the in situ physical and hydraulic properties, chemical characteristics, subsurface lithology, stratigraphy and structural properties is an essential part of site characterization for geotechnical and environmental purposes.

There are several standards in ASTM that discuss the different types of sampling techniques such as D 6169-98, D 1452, D 1586, D 3550, D 4700 and others.

Undisturbed samples are the focus of this article. Hydraulic conductivity, porosity, consolidation, strength, collapse and other such tests require an undisturbed soil core sample. It is important to define “undisturbed” so that the project manager will know the appropriate sample type for the test being requested. (Many times we have received disturbed samples for undisturbed testing and we have to call the client and tell them that the samples cannot be tested). An undisturbed sample is a sample that has preserved the in situ structural properties. Silt and clay samples can have very intricate structures. To help form a conceptual image, clay particles tend to be flat. A very simple analogy of a structured clay might be similar to

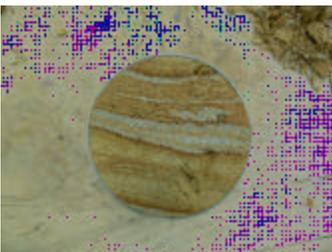
a house of cards. A core sample consists of solids, gas and water filled voids. The clay particles can be in any kind of orientation from a stacked (residual) to a random (sheared or disturbed) to a highly structured orientation. To take a sample from deep under the ground and transport it to the laboratory without disturbing the structure is not completely possible. There will always be an unquantifiable degree of disturbance due to factors such as dilation, stress relief or compression from insertion of the sampler. Then add to that, handling during transportation, temperature change and finally extrusion for testing. So what we are calling an undisturbed sample is actually a partially disturbed sample. The factors that affect physical sample disturbance are numerous and complex enough that professional judgment is still required to determine whether a sample is physically undisturbed.

Representative means that the characteristics of the sample are similar to the in situ conditions. The grain size, moisture content and density, plasticity etc. all approximate the formation from which the sample was collected. The larger the sample the more representative it will be of the in situ conditions especially in het-

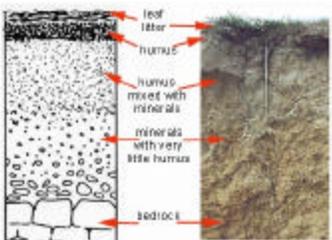


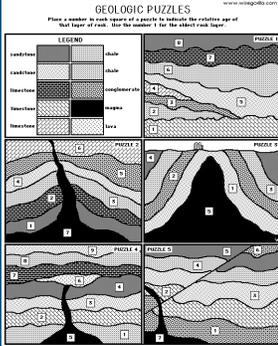
erogeneous soils. If a small diameter (1.4 to 1.6”) acetate liner is used in a gravel or soil with gravel the chances of the sample being representative and / or undisturbed are remote. Especially if the diameter of the gravel exceeds the diameter of the liner.

Particular tests in the lab that are more sensitive to disturbance than others and can be a reliable indicator of the degree of disturbance. The consolidation test is such a test, (see page 3). From running literally thousands of consolidation tests we have found that any sample diameter less than 2.5” is usually disturbed. If it is a 2.5” sample that was taken with a thick wall sampler it will be partially disturbed. Thin wall samplers are the only samplers that have a chance at getting an undisturbed sample. A Pitcher tube with an inside diameter of 2.875” should be used.



Core Samples





ASTM D6169 states that for permeability, density, consolidation and shear testing etc. 2.0" diameter samples are not recommended and that compressible soils should be 3.0" diameter or greater.



ASTM D 5084 (Hydraulic Conductivity) states that the sample diameter should be 6 times larger than the largest particle size.



Sample Diameters (continued)

GRAVEL poses additional problems for both sampling and testing. When sampling by drive or push methods the edge of the tip of the sampler can hit a piece of gravel and as the sampler pushes it to one side or the other it could disturb the sample by either tearing it or possibly increasing the density if it goes inside of the sampler. It could also create a void thereby reducing the density and possibly the shear strength. The smaller the sampler the more damage is done. We suggest Pitcher Tubes when gravel sampling gravels. Pitcher tubes are available in 3, 4 & 6" outside diameters.

I want to stress that we are not experts in drilling and sampling but we do see many different types and sizes of samples and the test results from the different sample sizes, which will be discussed in more detail later on.

INTERNAL WALL FRICTION of a sampler will disturb the outside perimeter of the sample and extend into the sample. If we assume that the distance of disturbance from the perimeter of the sample inward is 1/8" we can compare the percentage of disturbance to different size samples, by determining the ratio of the area of disturbance to the area of undisturbed sample. For instance a Pitcher Tube with a diameter of 2.86 inches would have about 17% of its volume disturbed from wall friction. An acetate liner with a diameter of 1.4 inches would have about 33% disturbance in addition to being less representative.

STANDARD SAMPLE DIAMETERS used in the geotechnical industry historically were 2.0" outside diameter samples but went to 2.5" and 3.0" diameter samples to try to reduce disturbance. In recent years the environmental industry has started to use specialized drilling equipment such as the geoprobe, which use acetate liners that have an outside diameter of less than 2.0" and in some cases as small as 1.0". There are some municipalities that oversee geotechnical and environmental projects that do not accept Geotechnical data when the small acetate liners are used. These small samples may not even be sufficient for disturbed testing of stratified soils. A typical inside diameter of the acetate liners that come into our lab is 1.4" and 1.6".

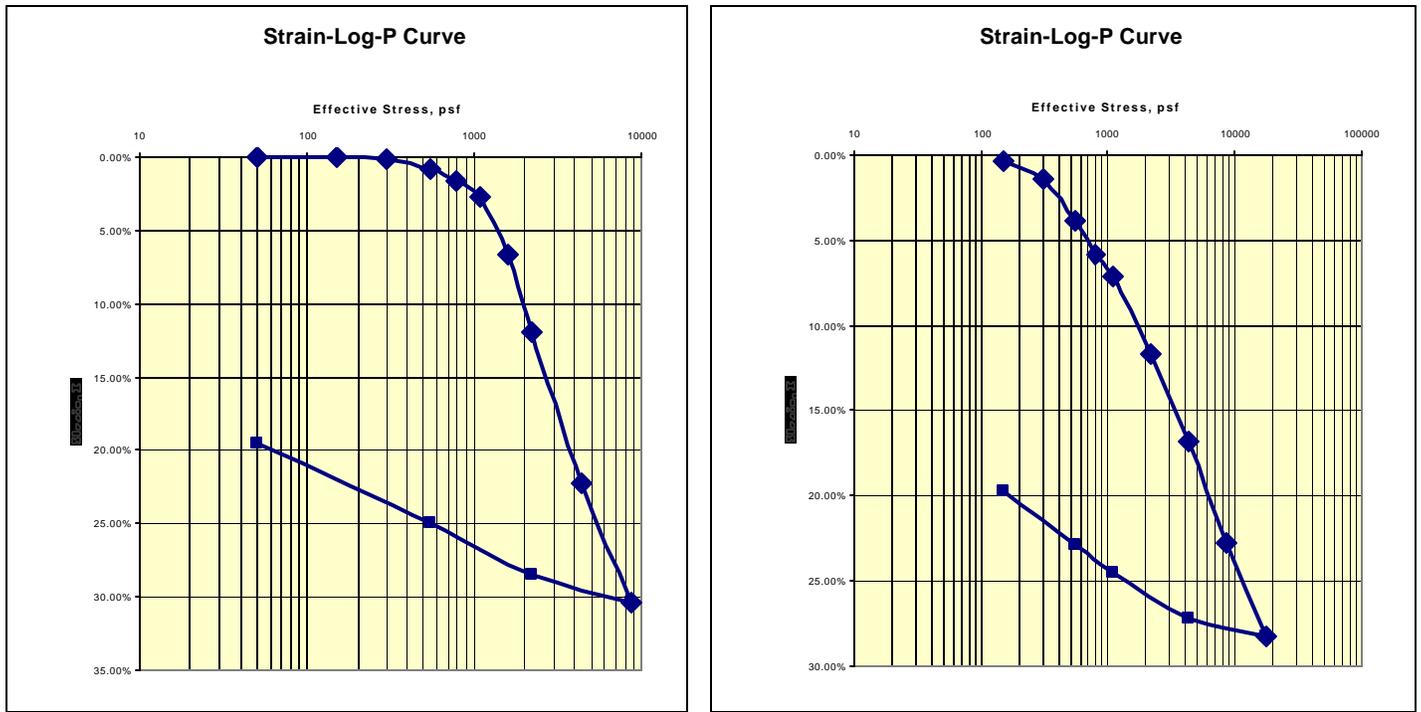
THE PERMEABILITY or hydraulic conductivity test is particularly problematic on small diameter samples, the results are at best questionable. ASTM standard D 5084 Hydraulic Conductivity states that the sample diameter should be 6 times larger than the largest particle size. The following experience is a good example as to why. On one particular project the client delivered the small acetate liners and requested permeability and grain size tests on each sample. The material was a sand and gravel mixture. It is impossible to know whether the material was a sandy gravel or gravel with sand based upon such a small sample. Based upon

the grain size data and experience the material should have had a K value in a range of 10^{-1} to 10^{-2} cm/sec. There were several samples all of which, were in the range of 10^{-5} to 10^{-6} cm/sec. Of course the client was concerned about the data. When the samples were taken out of the permeameter and broken apart it was discovered that there was gravel the same size as the sample diameter which, impeded the flow of water. On a more recent project we were faced with a similar scenario only this time the material was all sand. We tested about 15 samples all except one had K values in the same range as the project previously discussed. The samples were fairly clean (less than 15% fines) and should have been in the 10^{-3} cm/sec range. Based on our observations we concluded that the sample was overly densified during both sampling and extruding. Sand and plastic create a lot of friction. It took several hundred pounds of force to push the sand out of the acetate liners.

IN SUMMARY, if at all possible collect 2.5 or 3" diameter samples for any testing that requires undisturbed samples, the larger the diameter the less disturbance and the more representative they will be.



THE EFFECTS OF SAMPLE DISTURBANCE ON THE CONSOLIDATION TEST



ABOVE ARE TWO CONSOLIDATION TESTS. The curve on the left has a well defined transition from the preconsolidation to the virgin slope. This well defined transition from the preconsolidation to the virgin curve is indicative of an undisturbed sample. The engineer can easily determine the maximum past pressure (p_c). The curve on the right has no distinguishable transition from the preconsolidation to the virgin slope of the curve. This is indicative of a highly disturbed sample. The engineer will not be able to determine the maximum past pressure from the data on the right. The consolidation test is the most sensitive to disturbance and a reliable indication of sample disturbance. The way the data is plotted is a reliable indication of whether a sample is disturbed or not. The test result on the left was from a pitcher tube which, is about 2.86" id. (at the beveled tip) 3.0" OD. The test on the right was from a thick wall 2.375" id 2.5" OD modified California sampler. I think the above graphics pretty much speak for themselves. Unfortunately most geotechnical test results do not readily indicate whether the sample was dis-

turbed or not. The experienced engineer knows what to expect and if the results are too far from the expected range suspicions will be aroused. But most of the time it is difficult to tell whether the results are from undisturbed, representative samples. The only expedient way of dealing with the problem is to get away from using sampling devices that yield anything less than a 2.5" diameter sample for standard geotechnical tests such as unconfined compression, direct shear, triaxial-UU, expansion tests, porosity and the like. Tests such as consolidation, hydraulic conductivity and the more sophisticated triaxial tests should be no less than 3.0" thin wall diameter samples. Unfortunately there is some discrepancy between the many ASTM standards on sample sizes and it becomes very confusing. The recommendation above is from Cooper Testing Labs and is based upon over 20 years of commercial experience and another 15 years prior as a technician in a geotechnical and environmental consulting firm. When in doubt use pitcher tubes! We have had extensive experience with testing on dams. For those types of

investigations 4 to 6" diameter pitcher tubes are typically used. For our environmental clients, the geoprobe may be OK for disturbed testing in homogeneous soils. Heterogeneous or stratified stratigraphy become much more problematic. If you are in a location where a full size drilling rig is not possible, get as long a sample as possible. But even that won't be representative with gravel or stratified samples. You could always go old school and hand auger. I used to use 5' sections of threaded 3/4" pipe and attach lengths as needed to an auger. When it was time to sample a truck jack was used to jack it out of the hole while unthreading each 5' section of pipe as it came out. The auger was removed and replaced with a 2.5" modified California sampler. The sampler was attached to a bell fitting and lowered down the hole while reattaching the 5' lengths of threaded pipe until about 1' above the ground was exposed. Then a custom 40 pound drop hammer was attached and whatever young kid was available (usually me) got to operate the drop hammer. Try it on a slope sometime, in sand!

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Certifications	Foreign Soils	Some Tests You May Not Know That We Run
<p>We now have the following certifications:</p> <ul style="list-style-type: none"> • AASHTO • US Army Corps of Engineers • Caltrans • USDA foreign soils import permit 	<p>To better serve our clients we have received our permit to import foreign soils. Please contact us prior to importing any soils from outside the US so that we can provide you with our permit number and an import sticker. This will assure a smooth importation process through customs. Geological samples that are taken from depths below six feet are exempt from requiring an import permit but can still be problematic when going through customs. We suggest using our permit for all soils. The foreign soils do have to go to the permitted lab.</p>	<p>Chunk Density Effective Porosity Expansion Index Expedited Consolidation High Pressure Triax Max Index Density Min Index Density Point Load Rock Core Compressive Strength Slake Durability</p>