Issue 3

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NEWSLETTER

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Dave's Scale Collection

RAINFALL INDUCED DEBRIS FLOW TEST, BY ANDERSON & SITAR

We have been running a test exclusively for the USGS. The procedure is based on a paper written by Scott Anderson and Nicholas Sitar entitled " Rainfall Induced Debris Flows". The test procedure is fairly simple but takes very sophisticated computer controlled equipment. The equipment used consists of a servo valve controlled load frame and two flow pumps controlled by a computer. One pump is the back pressure which was filled with water and the other pump controlled the cell pressure which was filled with silicon oil because of the internal load cell . There is also an external load cell. The stresses in a debris flow are very low so the internal load cell excluded piston friction and uplift pressure. Any stress can be controlled. The pumps can apply pressures of up to 300 psi accurate to 1/100 psi. The load-frame can be controlled either by stress or rate of strain which is necessary for anisotropic loading during the consolidation phase. The speed can be controlled accurately as low as .0001"/min. maybe even slower. The pumps can be run under pressure or volume control. Basically we can control any stress desired in a stress path test which this testing actually is. For the

back pressure saturation phase the pumps were set to ramp up to 110 & 112 psi over 1000 minutes. A "B" reading was taken and if it exceeded 0.98 the consolidation phase was started. The samples were consolidated anisotropicly to a Kc of 0.4 (2.5). The consolidation phase took typically 36 to 48 hours. Once the samples were fully saturated and consolidated the loading can begin. The axial load and confining pressures were held constant while the back-pressure was increased at a rate of 0.1 psi per hour to insure a fully drained condition. The strain was measured throughout the entire test as shown in figure 1. Four samples were tested per strength envelope. The stress path of each was plotted on a P vs. Q diagram. As shown in figure 2 the test progresses from right to left. The line is horizontal for most of the test because the sample can support the axial load so the shear stress (Q) is constant. As the confining pressure is reduced to the same degree the pore-pressure increases the line will start to drop down toward the origin. The sample starts to strain because it can no longer support the axial load due to the decrease in confining pressure, (see figure 1). This is the yield point. This is the begin-

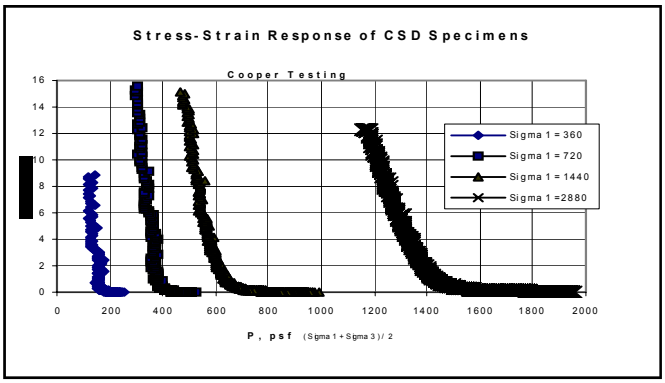

Figure 1

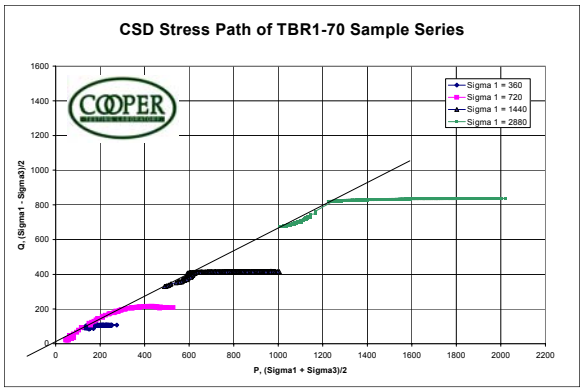

Figure 2

CSD Test by Anderson and Sitar

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ning of catastrophic failure or flow. The test may run for days without any strain at all. When the sample does finally start to strain it may go 15 to 20 percent in a matter of minutes. If allowed to the stress path will go all the way to the origin. It may gently wave up and down a bit on its way but it does go to the origin. It is fun to watch. (I don't get out much). The volume change measurements show an increase during this phase. I assume that the sample is dilating so much that the sample is basically a flowing slurry just like what I imagine a debris flow to be. I was told by Jeff Coe of the Denver USGS that they were using this type of testing as a model for future slides. We are offering this test at $1000 per point. It takes about a month to run four points. You could run one and take it out as far as it will go which would create a linear stress path toward the origin. If it stopped short to use a C = 0 would be a reasonable assumption.

Does Cohesion Exist ?

Ever since we automated the equipment in the lab we have finally been able to run drained tests slow enough to actually be drained. For years when clients asked for drained testing we either said that we didn't do it or told the client how slow we could run the test and let them decide if that was slow enough. We usually ran direct shear tests at .001 inches per minute which was about the speed required to shear a sample 20% in an eight hour day. Now we set the sample up, program the computer to shear it at .0003 inches / minute and let it go for a few days. By doing this I noticed something very strange. We were getting zero cohesion on clays. When we plotted a three point strength envelope the line actually went through the origin. I thought something was wrong so I called some very brainy PhD people and asked them what was up. They told me that was what was supposed to happen. I ran a triax CU -PP on a young soft bay mud at .0003"/min and came up with the same thing. But sometimes we did get cohesion which baffled me. Some time later we were doing some duplicate torsional-ring-shear testing with Tim Stark. We were running four point strength envelopes and noticed that all of the strength envelopes were slightly curved. They would gently slope down to the origin. I mentioned this to Stark who in a state of exasperation said well of course! That's what my paper was all about! I felt kind of stupid and said oh! So I wondered if the reason that we would get cohesion on some tests (even though we sheared them at research speeds) was due to a curved strength envelope. If I went to college I could say non linear but curved it is. So I stopped trying to force a linear best fit to what appeared to be non linear envelopes. Is that why we see so much cohesion I wondered? So I kept on eye on this for a couple of years and I noticed that many strength envelopes are non linear. At least half if not more. You see the problem is the curved envelopes are hidden because the engineer is usually working in fairly low stress or overburden ranges. When you use low normal loads or confining pressures you are only seeing a very small portion of the stress path. If you spread your loads out over a larger stress range (2-4-8 ksf) you will see a slight curvature to the points especially if you use four points. So what is actually happening is your working right on the most severe part of the curve when you are close to the origin (within 2 ksf). So by forcing a best linear fit to what is actually a curved envelope you are creating cohesion that really is not there. You will also get very steep friction angles. What I hear most from engineers is - that is the stress range of interest so that is where we pick our loads. Well that seems reasonable but that may be why you are getting very steep friction angles and cohesion that really is not there. I'll give you a great example. A client had us remold a clayey sand and run some TX-CU-PP tests. The confining pressures that were requested were something around 0.5 0.75 and 1 ksf. Very low stresses very close together. We got a friction angle of 45 degrees. I forget if there was cohesion. The client called and expressed his concern about the high friction angle. I told him about my goofy theory and he actually listened to me. He told me to rerun the tests at what ever confining pressure that I wanted to use. We reran the tests at 1, 2 and 4 ksf. That dropped the friction angle 10 degrees down to 35 degrees. Much more reasonable. So knowing that, there should be no cohesion under drained conditions and if there is it is probably a curved envelope. So what conclusion are we to make about the existence of cohesion? I have been told that over consolidated materials will show cohesion. I instantly thought "non linear" and set out to see for myself. A client sent in a very hard claystone. It was so hard that we had to send it out to a lab that had some concrete coring equipment. They cored several beautiful cylindrical samples, two inches in diameter by four inches in height. I was actually able to talk the client into using confining pressures of 50, 100, 150 and 200 psi. I was trying for 300 psi but they wouldn't go that high. It was a litiga-

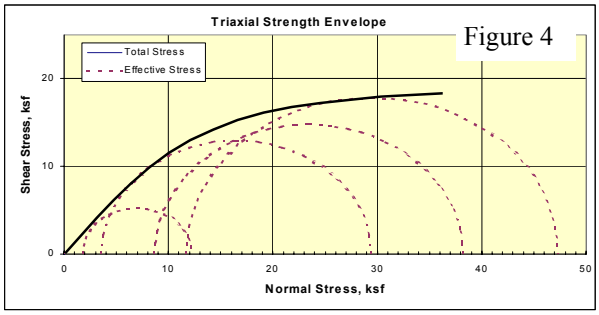

Figure 4

tion case in Idaho and they wanted to prove that there was no cohesion. The engineer that was being peer reviewed used undrained direct shear tests that of course showed a ton of cohesion. We ran four TX-

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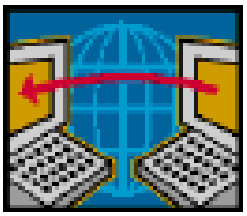
On-Line Reporting

We have had an on-line reporting site set up and running for over one month now. It is very easy to use and the feedback supports that. We are hosting the site on a server that is on our LAN in the office. It is not the same sever that all of our reporting software and data is on and we do of course have a firewall. The test results are posted as they become available so you can check the progress of your project. We have been setting clients up to use this system as they send in work. Here is what will happen. When your job arrives and the first test result comes across my desk I will have Diane call you to get your email address. Once I get that I set you up as a user from your company. Each engineer has their own username and password. When the results are posted you will receive an email with a link to the site, your username and password and some simple instructions about how to use it. If you aren't comfortable with using computers don't worry this system is very easy to use. I will be happy to talk you through it. I don't consider myself to be computer literate. I fumble around and eventually get to where I need to be most of the time. I hire smart people to do this stuff for



me. If you want to take a look at it type http://www.coopertestinglabs.com in the address bar of your browser. This will take you to our website. There you will see a link to REPORTS ONLINE double click on that and enter guest for the username and password. Once

The Effects of Lime on the Proctor Test

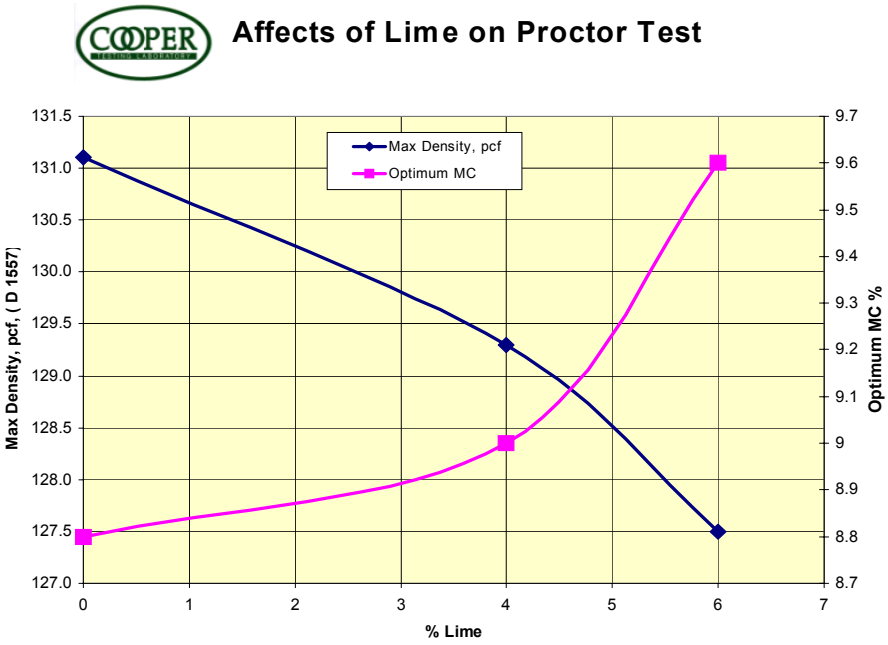
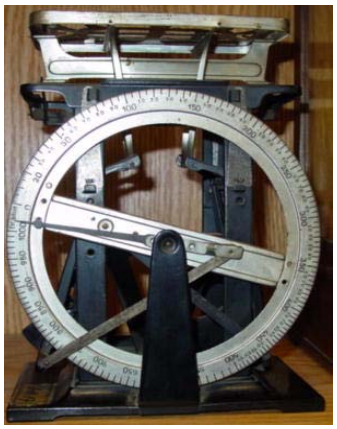


Figure 3

Over the years many people have asked what are the affects of lime on the max density and optimum moisture content. As shown in figure 3 is an example of three lime treated modified proctor tests on sandy clay. It is typical to see the density drop and the optimum moisture content increase with higher quantities of lime.



More of Dave's Scale Collection

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On-Line Reporting continued

Cohesion

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CU-PP tests at .0003 in/min using high capacity computer controlled tri-axial load frames with high pressure flow pumps for the confining pressures. The results were a curved, non linear, strength envelope. The tangent was drawn down to zero cohesion as shown in figure 4. Even though the results were not completely unexpected I was blown away. They actually used the data in a presentation of some sort. So where is the cohesion? I guess where the beef is.

in, there will be a couple of files that you can download or open from current location and print. This will give you the opportunity to kick the tires and find out if there are any set up or other issues to workout. There have been a couple of people that have had some minor problems but I believe everyone has been taken care of and are happy with the site. If you are having problems downloading or accessing the site please do not hesitate to email me at cooper@coopertestinglabs.com or call me at 650-968-9472. If I can't help you I will get the real brains behind the system to call you and help you figure it out. Chris is very easy to work with. The nice thing about the site is that the data is kept there indefinitely. Chris tells me that we will never come close to using all the hard disk storage capacity. He doesn't know the quantity of testing that we do. We will see. Anyways you will be able to access the data from any computer any time of the day. You will no longer have to wait for the originals to arrive in the mail. When you print the reports you have the originals. You actually have a better report than we send you in the mail. We send you copies and file the originals. No more Fed-X priority overnight. Just go to the site and print what you need. You can even use the site as your personal file cabinet. Every once I a while we get a call from a client asking us to track down a report that we did a year ago. That will eventually go away as people get used to using the site. All commerce will be done online eventually. I do almost all of my purchasing on-line. You won't get the personalized service that you get from us though, because you can always call me for

Even More scales from Dave's collection