Technological Advancements in Laboratory Testing of Soil for Engineering Properties

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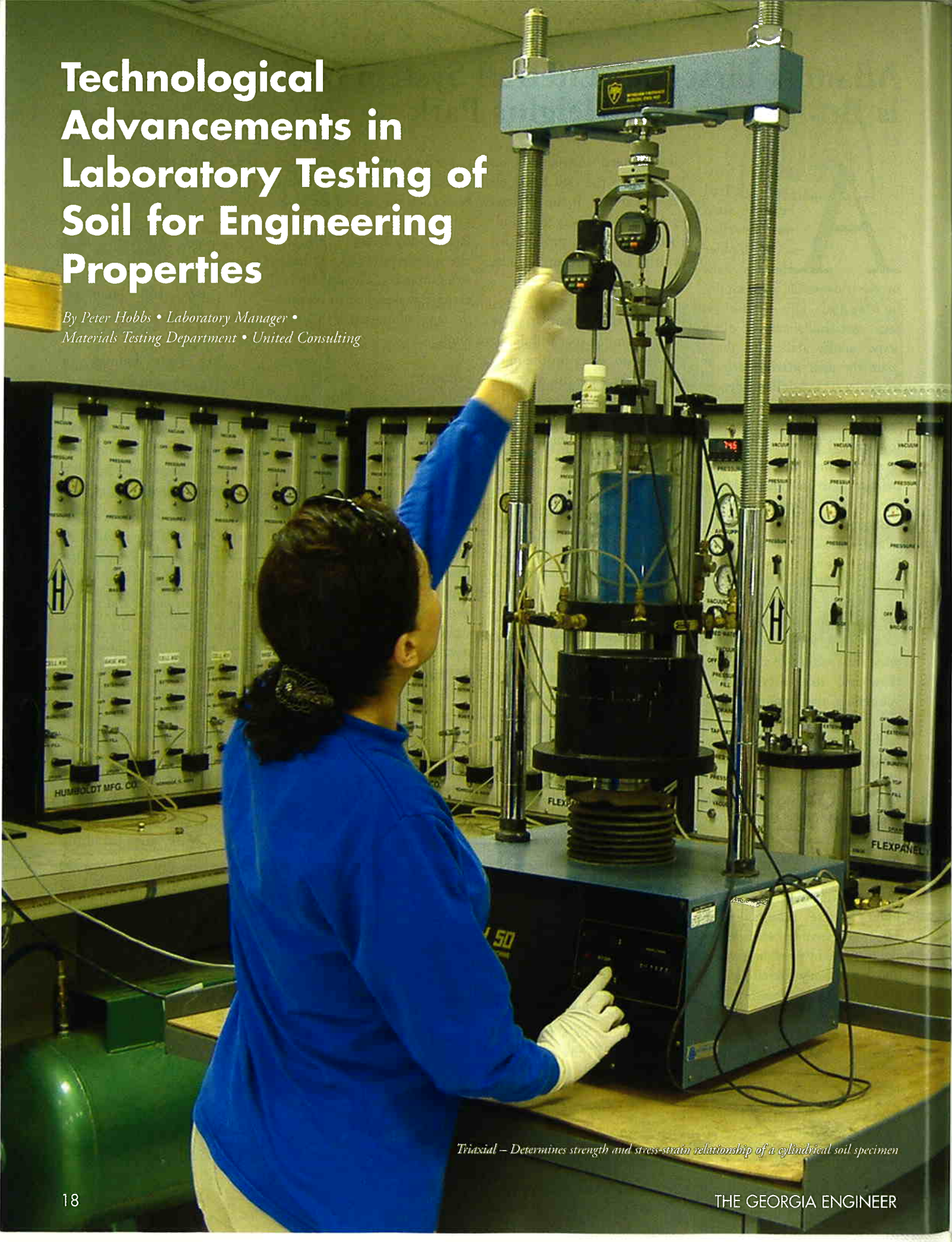

Triaxial – Determines strength and stress-strain relationship of a cylindrical soil specimen

When recently asked to write an article on how technology has improved laboratory testing of soil for engineering properties, I was immediately transported back to 1970 working in the back of a warehouse in a hot, dusty soil testing laboratory. At the time it all seemed so modern. All we had to do was the fundamental tests and give hand written results to the geotechnical Engineer.

Although much of the basic testing equipment has not really changed much since then, except for the odd tweak here and a bell or whistle there, the real technological advancements in laboratory testing have come about with the advent of the computer. Prior to the computer age, readings on tests were taken manually and recorded on a laboratory form. The data was then reduced by use of a calculator, or slide ruler in some instances. Graphs were then hand-drawn by the laboratory technician and given to the Engineer. As can be imagined this system was fraught with the possibility of human error in almost all steps of the test. A reading at the wrong time could adversely affect the result of a permeability test, a number transposed and recorded could alter a grain size distribution curve, an incorrect calculation could change the clay fraction of a hydrometer test, the possibilities were endless. This required many hours of the Engineers time to check the laboratory calculation prior to using the data or test results in a design.

Now, however, most state of the art soil testing laboratories have data collection systems and specialized laboratory computer software. The readings of such tests as permeability, consolidation and triaxial sheer just to name a few are now collected by a data logger, or as the laboratory technician prefers to call it, the magic box, which sits beside the laboratory computer. The software programs do everything that the laboratory technician had to do in the old days from reducing the data to generating plots and graphs providing the Engineer with more reliable data and resulting in less of the Engineer's time in checking calculations. Errors in tests typically show up in the computer programs like little red flags, making it much easier for the laboratory technician to stop a test in progress rather than wait until the calculation stage to find out there is an error. By correcting these errors during the test, the need for re-running tests has been greatly reduced.

The same computer software is used by quality laboratories to reduce, calculate and plot the results of other tests such as the standard and modified Proctor tests, grain size analysis tests, Atterberg limit tests as well as hydrometer tests just to name a few. With these computer software programs the laboratory technician is now capable of entering raw test data and quickly seeing the results of the test in graph or table format. The calculations are precise and most software even allows for combining the results of tests such as the limit, grain size and Proctor test on a single form. What would have taken several hours of calculation, plotting and review can now be done in minutes.

The introduction of the electronic balance in the early 1980s was also a significant technological advancement in laboratory testing. Before the electronic balance all laboratory weights were determined on mechanical scales, either a large triple beam pound or gram scales and smaller triple beam gram scales. The accurate use of these mechanical scales was a practiced art to say the least. The laboratory technician had to wait until the beam of the scale had stabilized and was pointing at zero mark. A technician in a hurry would often just estimate the final gram or two of weight based on the swing of the beam pointer. This estimation was compounded when first wet weights and then dry weights were obtained. Errors in such a simple test as moisture content could be in the order of two percent or more.

The two main electronic balances used in modern laboratories are now the large pound scale weighing up to 100 pounds with a degree of accuracy of 0.05 pounds and the smaller grams scale. The grams scale has varying maximum capacities, but typically are in the range of 4,000 to 5,000 grams with an accuracy of 0.01 gram. The results are almost instantaneous saving time when multiple weights are being recorded. Final results of tests are much more accurate and reliable when these balances are used.

Electronic dial indicators for consolidation and triaxial testing in the laboratory have also reduced operator error in collecting data. The indicators are connected to the data collector and are automatically entered into the computer software program. Now there is no chance of a technician recording a number incorrectly, or entering the number incorrectly into the calculations.

Although the predominant advancement, the computer age is not the only area where more accurate soil testing results are now achieved. As mentioned previously there has been some bells and whistles added to some of the standard soil testing equipment. Basic sample preparation has seen a major advancement with the arrival of the soil processor. Although each manufacturer has slight variations, essentially the soil is placed on a screen the size of which is dictated by which test methods are to be used. A weight, usually in the form of a

Consolidation Loading Device – Tests rate and magnitude of soil consolidation

solid top is lowered onto the sample and the screen moves back and forth and the sample is ground to a size finer than the screen. The processed sample is collected beneath the screen and is ready for testing. This system replaces the method of hand breaking the sample and pushing through the required sieve by rubbing with a block of wood or some other solid object. The advantage to this system is the reduction in sample preparation time and the bonus advantage of not wearing out the fingers and hands of the laboratory technician.

Other advancements in the mechanical part of testing include the automated Proctor hammer that compacts the soil in precisely distributed blows across the area of the sample. Each blow is exactly the drop required by the specifications eliminating operator error in the number of blows and the distribution of the blows.

Although not a technological advancement, the accreditation of laboratories by such entities as the American Association of State Highway Transportation Officials (AASHTO) and The United States Corps of Engineers, to name a few, have brought consistency to laboratory test results through refining specifications and assessing laboratories for compliance with common specifications.

All of these technological advancements in the soils testing laboratory have resulted in two marked improvements, namely accuracy and reliability of the test results and a major reduction in the amount of time required by the Engineer in painstakingly checking calculations and graph plots. This reduction in time has allowed the laboratories to more efficient and productive. In some cases test results that would have taken several hours of calculations and plotting to determine are now available in seconds with the use of computer software. These advancements have lowered the manpower cost for testing and increased the technicians' production by allowing more time for physical testing rather than calculation. Laboratories can now pass on these savings to their Clients in the form of reduced rates for testing and provide the Client with the bonus of quicker turn around times on critical path projects ❖