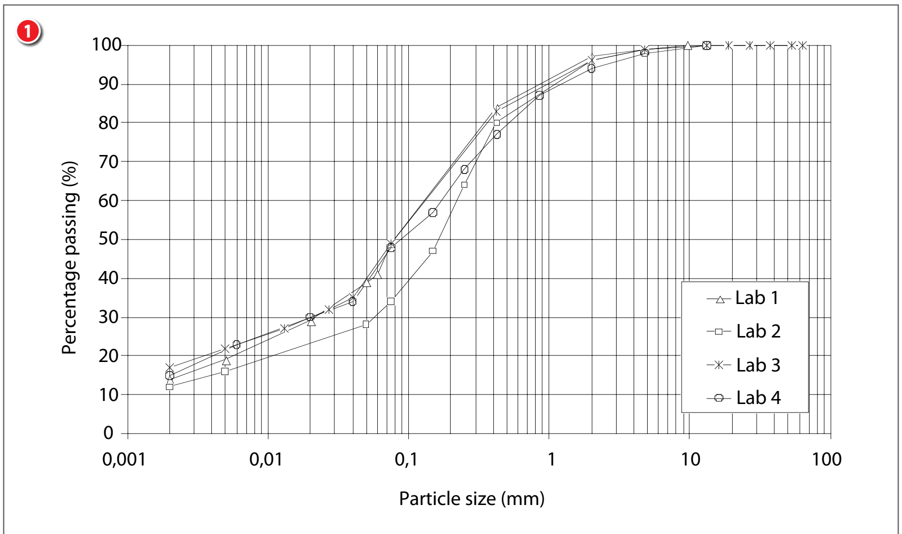
Text S W Jacobsz
Jones & Wagener
Johannesburg
sw@jaws.co.za

Peter Day
Jones & Wagener
Johannesburg
day@jaws.co.za

Are we getting what we pay for from geotechnical laboratories?

Geotechnical engineers use the results of soil tests when assessing the likely behaviour of foundations and other geotechnical structures and assume professional responsibility for these assessments. But how reliable are the results they receive from the soils laboratories? This article compares the results of basic soils tests on two samples sent to four commercial soils laboratories in the Gauteng area in late 2006. The variation in the values obtained was sufficiently wide to lead to an incorrect assessment of soil behaviour. A follow-up trial was carried out at the beginning of 2008. No improvement in the consistency of results was noted. Possible ways of addressing this problem are explored



FOUNDATION MOVEMENTS of a single-storey industrial structure in Mpumalanga led to re-testing of the founding soils. When significant discrepancies were noted between the original test results and those from the repeat tests, the accuracy of both sets of results was questioned.

To assess the reliability of the results, identical samples of a clayey and a sandy soil were sent to four Gauteng-based soils laboratories in 2006. Care was taken to ensure that the individual samples were identical by passing them through a riffler and re-combining them four times before splitting the sample into four approximately equal parts which were then submitted for testing. The laboratories were requested to determine the particle size distribution to clay fraction (0,002 mm) and to determine the Atterberg limits and the specific gravity of each sample.

These comparative testing trials were repeated early in 2008. The results of both trials are presented below.

COMPARISON OF RESULTS: 2006 TRIALS

Particle size distribution

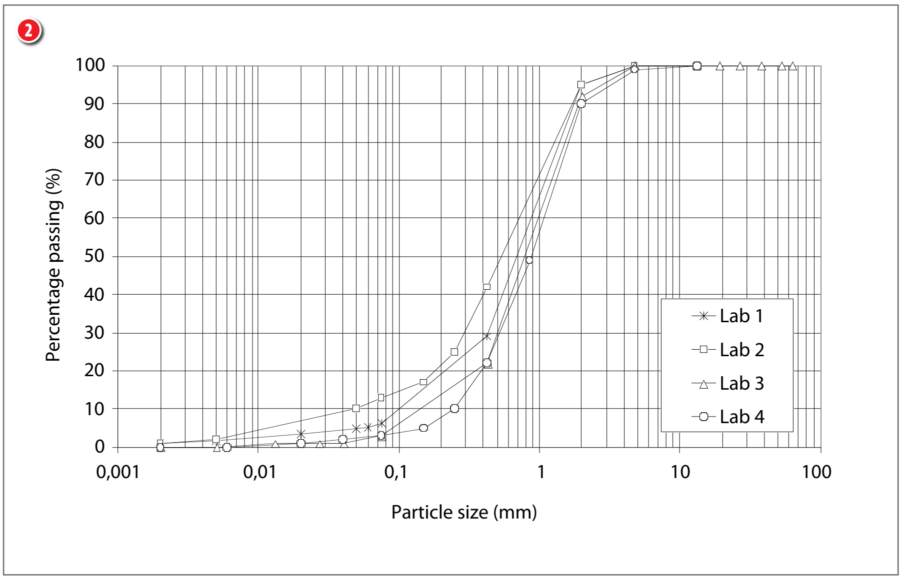
Figure 1 presents the particle size distributions for the clayey sample obtained from the four laboratories. Three results correlated relatively well, but one indicated a substantially coarser grading than the others below a particle size of 0,425 mm.

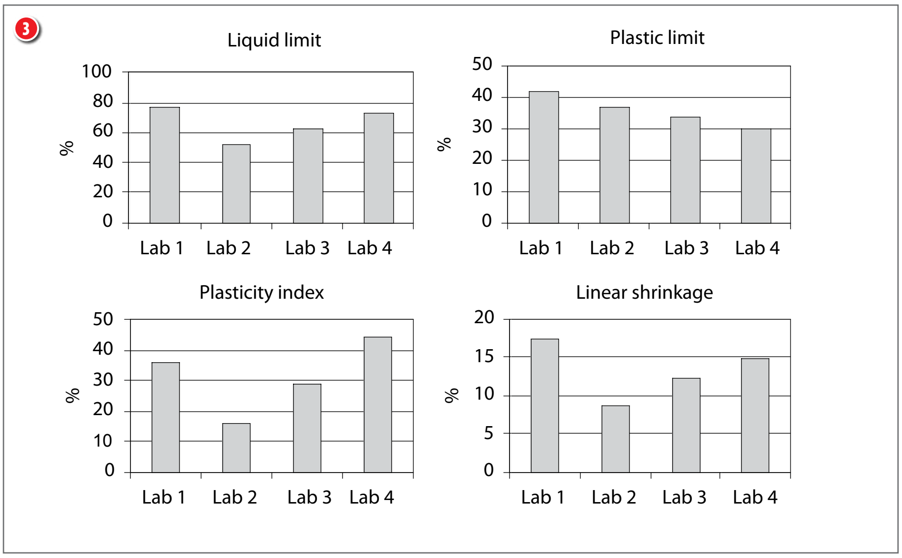
Although not evident in these results, a common problem is a discontinuity in the grading curve at 0,075 mm, the transition between the sieve and hydrometer parts of the grading analysis. Lower fine fractions than would be expected from a smooth extrapolation of the coarser part of the grading curve could indicate incomplete dispersion, possibly as a result of problems with the dispersing agent.

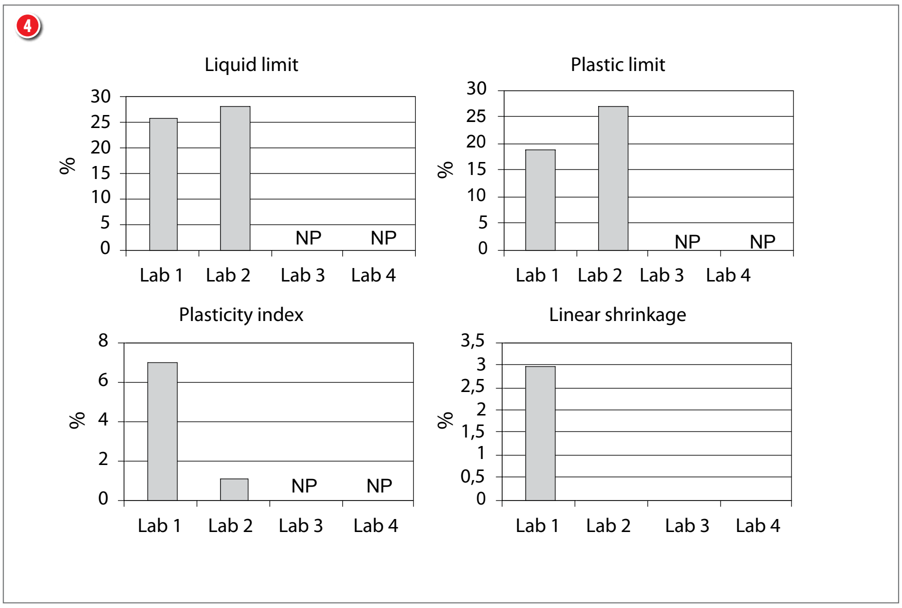
In the case of results from Lab 2, a change in slope is evident in 0,425 mm, possibly indicating that fine particles clinging to the coarser material have not been adequately washed through the 0,425 mm sieve.

Figure 2 presents the particle size distribution curves for the sandy sample.

1 Particle size distributions of clayey sample
2 Particle size distributions of sandy sample
3 Atterberg limits and linear shrinkage values for clayey sample
4 Atterberg limits and linear shrinkage values for clayey sample







Surprisingly, a wider scatter is evident than was the case with the clayey sample. The percentage passing the 0,425 mm sieve varies by more than 20 %. This is all the more significant when it is realised that the <0,425 mm fraction is the fraction on which the Atterberg limits are determined.

Atterberg limits

Figure 3 presents the liquid limit, plastic limit, plasticity index and linear shrinkage for the clayey material received from the four laboratories. The liquid limit varies from 53 % to 78 %, the plastic limit from 30 % to 42 % and the plasticity index from 16 % to 45 %. Owing to the variation in the initial moisture content at which the material was placed in the shrinkage troughs, wide variations in linear shrinkage values were reported (9 % to 18 %).

The results for the sandy sample are presented in figure 4. Again wide variation is evident, with two laboratories classifying the material as non-plastic, while the others reported plasticity indices of 7 % and 1 % respectively.

Specific gravity

The laboratories were also requested to measure the specific gravity of both the clayey and sandy samples. In the case of the clayey sample, values were found to vary from 2,66 to 3,07 and for the sandy sample from 2,66 to 3,34.

Figure 6 presents the Van der Merwe heave chart, indicating potential expansiveness, based on the plasticity index of the whole sample and clay fraction. Owing to the relatively low clay percentage, all results fall within the medium expansive zone. However, had the clay percentage been higher, that is, around 30 %, the large variation in PI would have resulted in the potential expansiveness ranging from low to very high.

2008 FOLLOW-UP TESTING – HAS THE SITUATION IMPROVED?

Early in 2008, a second set of two samples was again sent to four Gauteng-based laboratories. The first sample comprised a highly active sandy clay containing some calcretised material, and the second sample was a silty sand. The laboratories were requested to carry out grading analyses including the determination of the clay fraction (<0,002 mm) and to determine the Atterberg limits.

Since carrying out the first set of tests in 2006, one of the above laboratories has closed down. The new laboratory added to the list is referred to as Lab 5. Note that all four laboratories claim

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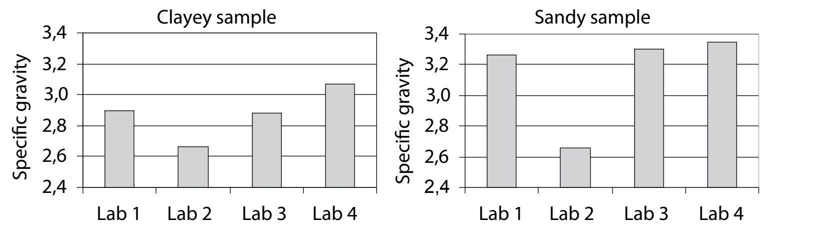

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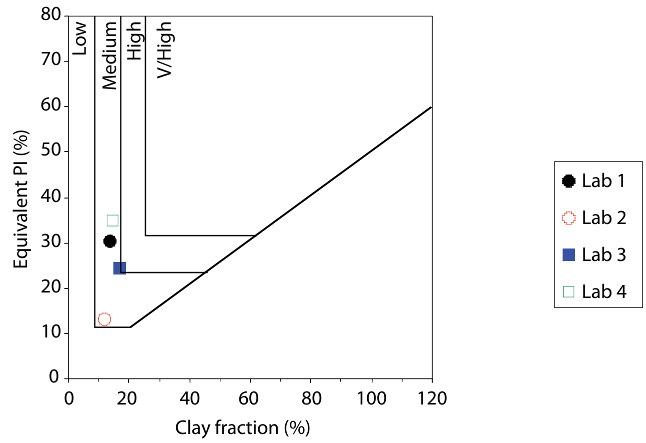

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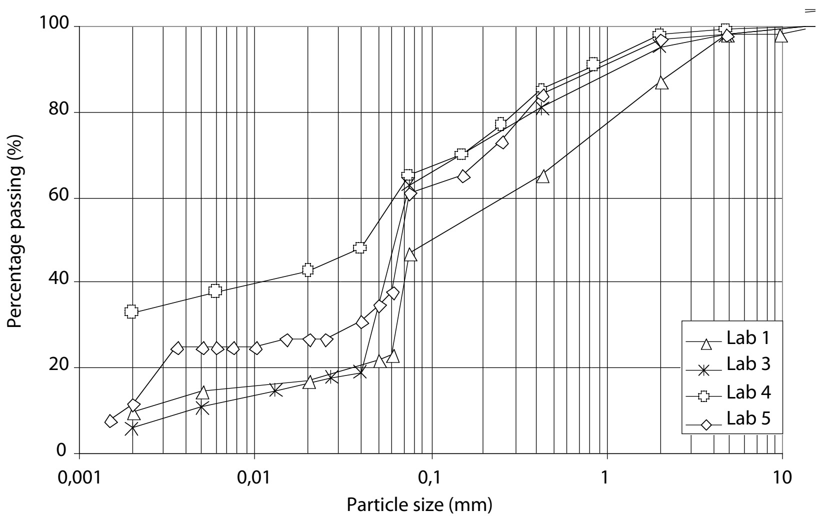

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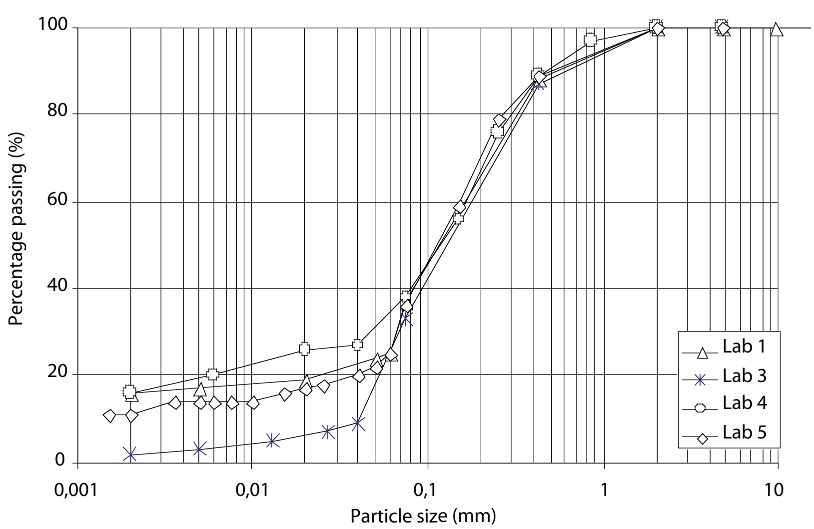

to be accredited by the South African National Accreditation Agency, SANAS.

Particle size distribution

The grading curves for the clayey samples are presented in figure 7. Reasonable agreement was obtained down to a sieve size of 0,075 mm between three of the laboratories. It is suspected that Lab 1 did not apply the wet sieving method correctly, resulting in an apparently much coarser grading. The hydrometer sections of the grading curves differed substantially, with the clay content varying by more than 30 %.

In defence of the laboratories it could be mentioned that the clayey material submitted for testing comprised a micro-shattered structure, causing lumps of material to break up very rapidly to approximately 1 mm particles when immersed in water. These particles did not, however, break up further even after having been left in water for several weeks. This was probably because of the presence of calcium carbonate in the soil which caused the 1 mm particles to be well cemented. Proper dispersion using a suitable dispersing agent and probably also acid treatment to break the calcium carbonate bonds (see Head 2006) were therefore important. The material was therefore difficult to test and the standard procedures as described, for example, in TMH1 would not have been adequate to ensure proper dispersion.

The arguments above do not, however, apply to the silty sand samples for which the grading curves are presented in figure 8. Relatively good agreement was evident between all four laboratories down to a sieve size of 0,075 mm. Wide scatter was again evident from the hydrometer part of the grading curves, with reported clay fractions varying by more than 15 %. It appears that laboratories have difficulty in applying the hydrometer test correctly.

Atterberg limits

Figure 9 presents the Atterberg limits for the clayey sample. The most important parameter used in making decisions based on grading and indicator test results is arguably the plasticity index (PI). The four laboratories reported PIs ranging from 28 % to 68 %. Not one PI was within 10 % of another and it is virtually impossible to determine from these results where the correct value should lie.

The situation in the case of the silty sand sample is nearly as disheartening. The Atterberg limits are presented in

5 Specific gravity values for clayey and sandy materials
6 Van der Merwe heave chart for clayey material
7 Particle size distribution of second clayey sample
8 Particle size distribution for second silty sand sample
9 Atterberg limits for second clayey sample
10 Atterberg limits for second silty sand sample

figure 10. Lab 4 reported the material as being 'slightly plastic', while Lab 1 reported a PI of 10 %.

Should a contractor, for example, be interested to know if the material is suitable for the construction of the impermeable zone of an earth dam, the results from Lab 1 would suggest that it is (according to Van Schalkwyk 1991), while the result from Lab 4 suggests that it is definitely not! Taking correct decisions based on such results is clearly not possible and one cannot help but wonder how many decisions in recent years have been based on incorrect laboratory test results. Contractors and consultants are clearly being exposed to a possibility of damaging claims.

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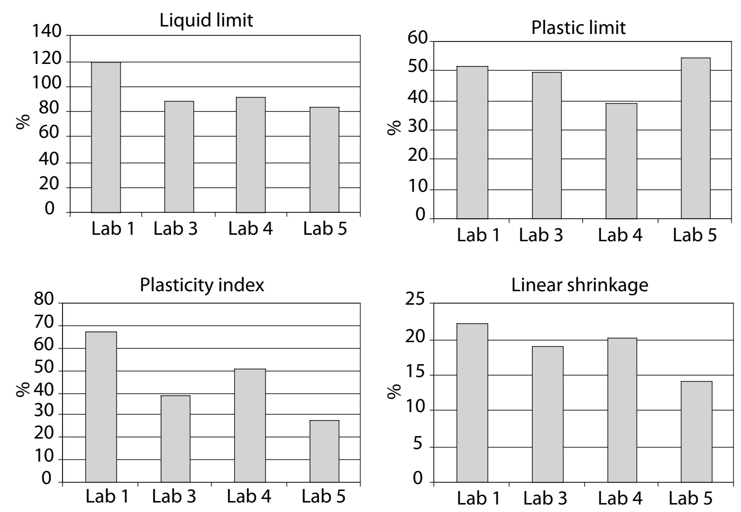

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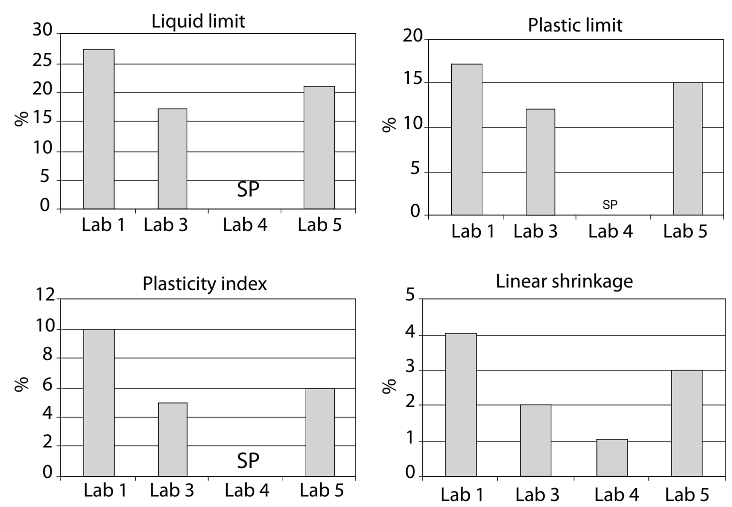

WHAT SHOULD BE DONE

Many reasons can be suggested for the large scatter in reported results. These include the condition of equipment, lack of adherence to standard procedures, absence of quality control, operator dependence of the tests and staff training. In some cases, there is doubt whether tests were done at all. In the authors' experience at least one laboratory has admitted to simply reporting a linear shrinkage of about half the PI.

Clearly the above situation is unacceptable. The consumers of laboratory testing services could adopt a hard line and require laboratories to improve standards or close their doors. However, this would not solve the problem. Many laboratories are regarded by their principals as marginal, non-core activities and would probably choose the latter option. This would place further strain on a service that is already overloaded.

There are two observations that may assist us in resolving this dilemma. First, it should be noted that, despite the increase in demand for soil laboratory testing services, some laboratories have not increased their testing rates for over two years. Second, discerning engineers are queuing up for testing services rendered by academic laboratories who are able to deliver a testing service of the required quality, albeit at double the price.

In our opinion, the commercial testing laboratories have allowed themselves to stagnate for too long. As far as can be seen from the outside, there has been little or no investment in staff training and new equipment. Many of our laboratories are still using equipment that was manufactured in the 1960s, using mechanical measurement devices and recording data manually. Significant recapitalisation is long overdue.

The message the authors would like to send to the laboratories is that the geotechnical fraternity is prepared to pay the price required for laboratory tests that are executed in accordance with the acceptable standards using modern equipment operated by well-trained staff. What is needed is a commitment from the commercial laboratories to respond to the challenge.

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