

# Laboratory assessment of the influence of the proportion of waste foundry sand on the geotechnical engineering properties of clayey soils

Paper 563 Vol 48 (1) 2006

## COMMENT

The author, Dr M B Mgangira, is to be commended for tackling the subject of the usage of industrial waste which, as far as the writer is aware, is an almost ignored topic in South Africa.

There are, however, apparently some anomalies in the paper and it would be useful if these could be clarified so that a better understanding of the results could be gained.

The first is that the properties of the foundry waste are not complete; a particle size distribution curve or a table of the data is necessary so that the implication of what seems to be relatively high Atterberg Limits can be understood. In addition the author states that the foundry sand contains 10 % bentonite whereas table 2 shows the clay fraction is only 4 %: are these values compatible or is the apparent discrepancy due to the very high temperature to which the foundry sand must have been subjected?

The data on figures 1 and 2 appears to be contradictory in that the plasticity index in figure 1 at 80 % weight proportion is 7 % whereas in figure 2 it is given as 5 %; in these figures the data for 100 % FWS is not given.

With respect the writer would suggest that the data given in figures 4 and 5 is presented in such a way that the reality is hidden. The density scale selected suggests that there is a relationship between the maximum density and the proportion of waste sand but in fact the range in densities is only from about 1 905 kg/m<sup>3</sup> to 1 930 kg/m<sup>3</sup>, that is, 1,3 %, probably of the same order as experimental variations. Similarly the optimum moisture content variation is small.

The deduction from this is surely that the addition of FWS has a remarkably small influence on the compaction characteristics for this particular weathered shale. If one examines the Grading Moduli given in table 3, however, it can be seen that as expected there is a consistent relationship between the moduli and the sand proportion. Conventional wisdom suggests that

there would also be a relationship between the moduli and the maximum dry density, but in this case it does not appear to be so. It may be that the high maximum density for the weathered shale, 1 898 kg/m<sup>3</sup> (table 4) 1 898 kg/m<sup>3</sup> (figure 4), is distorting any maximum density versus proportion of sand relationship.

Specific gravities of the materials would be useful so that air voids lines can be plotted on the compaction data. If one assumes an SG, it can be shown that the air voids for all the samples are very similar at maximum densities, which must be so since the maximum densities are similar, and this indicates again that the density for the weathered shale is relatively high for a material which in other respects, that is, classification A-7-5 and CBR of 2, is very poor. A further difficulty illustrated by figures 4 and 5 is that the optimum moisture is higher for the 80 % sand mix than for the unmixed weathered shale.

Perhaps figure 6 (and later figure 9) is the most revealing. This shows that to achieve any improvement in the CBR at least 50 % sand has to be added to the weathered shale. The intuitive reaction to this would be that the shale can not sensibly be improved by adding foundry sand since about 70 % sand is required to achieve a laboratory CBR of 8 %. Or to put it in another way, why contaminate the sand with the addition of 30 % clay?

This observation does not of course necessarily apply to the other materials tested, the CBR data for which are given in figure 9.

The PEWS, weathered shale, data in this figure is different from that in figure 7; in the latter there is a marked change in CBR at 50 % sand whereas the change is at 20 % sand in figure 9. Depending on which is correct, this may invalidate some of the foregoing comments. Nevertheless, what can be observed from figure 9 in broad terms is that the addition of the foundry sand to all the selected materials makes relatively small improvements to the CBRs. For example, at 20 % sand there is no improvement for PEWS, for SDW 6 % to 9 %, for UT1 11 % to 15 % and for UT2 15 % to 16 %.

The question which arises is, what can reasonably be deduced from the laboratory data. In broad terms the laboratory results show that large proportions of sand must be added to achieve any worthwhile improvement in the characteristics of the tested materials.

The reference material, in particular PEWS, weathered shale, would seem to be so poor (CBR of 2 %) that even after the addition of 50 % sand it could barely be considered as suitable for any construction purpose.

It is interesting to consider the available quantities of foundry sand. The author gives a figure of 5-6 t per day at Port Elizabeth and two or three times this for a single foundry in Gauteng. These quantities are too small for use on an ongoing basis and presumably there are large stockpiles of the material and there may well be merit both economically and environmentally in disposing of such stockpiles. In this case, however, the best option may be to use the material alone as a good quality fill and avoid the complication of mixing it with other much poorer material. In this regard it should also be noted that mixing sands with clayey materials in the field is no easy task.

On a lighter note, the author should not ignore the sad truth that generally the moment the usefulness of a waste is proved, it becomes a by-product with a price and the economics of the exercise becomes by definition marginal.

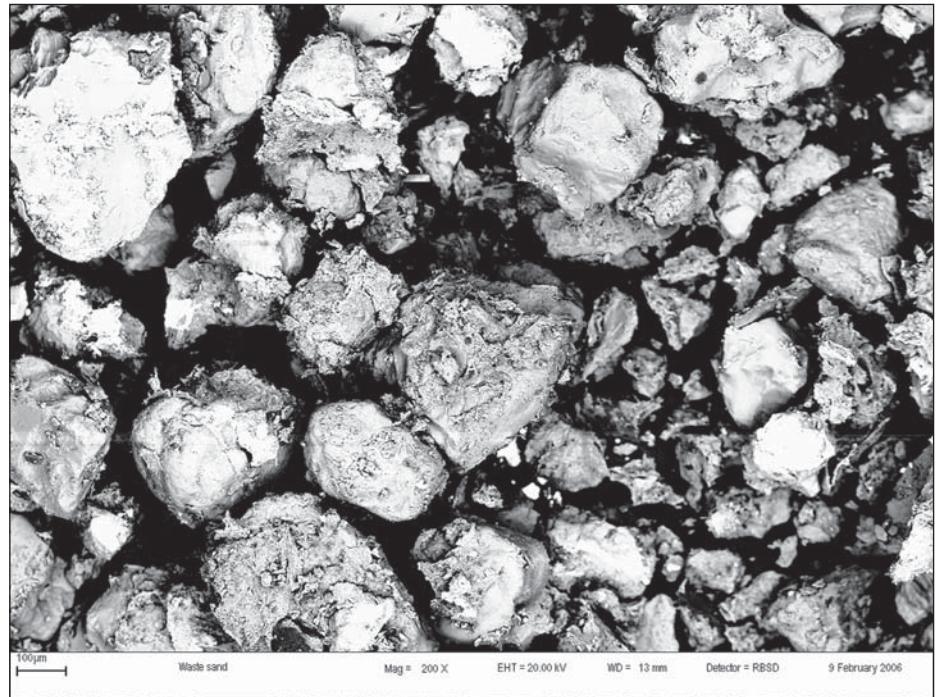
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## RESPONSE BY THE AUTHOR

The comments made by Professor Jones are very much appreciated. The response to his comments is as follows.

The table below gives the grain size distribution for the foundry waste sand which had a specific gravity of 2,52.

Sieve size (mm)	19,00	13,20	4,75	2,00	0,425	0,075	0,05	0,005	0,002
% Passing	100	99,0	99,0	99,0	89,0	15,76	8,85	4,43	4,0



**Scale bar on left bottom corner is 100 µm**

Indeed, if one were to consider the base material, based on the composition, one would expect to have about 10 % of the material passing the 0,002 mm sieve. However, the material under consideration is the by-product, that is, the excess sand that is discarded after reuse in the metal casting process, which has undergone a process of mixing before its use. The scanning electron microscopy (SEM) image of the foundry waste sand shows that some of the clay particles become attached to the main sand grains and therefore one can not expect to have the same value of material passing the 0,002 mm sieve.

With respect to data in figures 1 and 2, the correct value is indeed 7 % as noted by the discussant and not 5 %. The corresponding values for 100 % FWS are given in table 4.

The presentation of the data for PEWS was distorted in figure 9 because of not including the values that were obtained for 50 % and 60 % proportion of FWS as given in figure 6. The data in figure 6 applies.

The cited literature in the paper give examples of the beneficial use of foundry waste sand. The motivating factor in carrying the study was to explore alternative use of the foundry sand presently in large stockpiles. The discussion in the paper clearly pointed out that there is a slight improvement in strength, but at higher foundry waste sand proportion. For practical purposes, yes, it is not significant. Figures 4 and 5 are, however, presented as such to amplify the very existence of slight observable changes with the addition of foundry waste sand. The high optimum moisture content for the mixture at 80 % can be attributed to foundry waste sand's moisture affinity.

What can be deduced from the laboratory data is that, for the purpose of achieving any significant improvement in strength in clayey material, the addition of foundry waste sand alone, has a limited influence. There is however significant reduction in the values of the plasticity index with the addition of the foundry waste sand at reasonable proportions. This can not be ignored. The foundry waste sand stockpiles can be disposed of, for this application, where strength is not the critical measure of improvement.