The use of fly ash in soil stabilization*

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This paper interests me because it gives a further application of the use of fly ash.

The cost of the cement in soil stabilization is about 25% of the total cost of the work. The saving of 1 bag in 8 quoted by the authors will not, however, mean a corresponding reduction in cost, since the fly ash does cost something to transport and, being awkward material to handle, will increase labour costs. Consequently, it does not appear that there will be any appreciable saving in cost by the substitution of fly ash for cement. The use of fly ash will, however, save cement for more important work and eliminate the dumping of fly ash in the sea. The substitution of fly ash for cement, whenever possible, is also in accordance with the principle of conservation of material—an important principle which we must observe if generations to come are not to suffer.

I find the behaviour of the fly ash specimens in the tests recorded surprising. Fly ash is essentially a pozzolan and requires time for the chemical action to develop. Experiments in this country and America have shown that at 7 days the amount of pozzolanic action which has taken place is negligible. It would appear, therefore, that the reason why the “with fly ash” curve is in all cases above the “without fly ash” curve in Figures 6, 7 and 8 is not due to its value as a pozzolan but possibly to its action as a filler.

It is noted that the authors carried out dry density tests with sand plus 10% cement and used the optimum water content from these tests throughout the experiments. But will the optimum water content for sand plus 6% cement be the same as for sand plus 10% cement? I have my doubts. It is clear, however, that the optimum water content for sand plus 10% cement will be very nearly equal to that for sand plus 6% cement plus 4% fly ash. Perhaps, therefore, the favourable figures for fly ash are due more to this reason than to its value as a pozzolan.

In due course, however, the fly ash will develop its pozzolanic activities and should after six months or so show up even more favourably.

Since the pozzolanic action takes place in the presence of lime, a useful field for further research by the authors might be to use a combination of cement, lime and fly ash. Lime has been used in conjunction with fly ash for road construction in America.⁽¹⁾ The writer confesses, however, that experiments he has performed with lime and fly ash together have not been very successful.

The saving of 1 bag of cement in 4 for the heavy blue clay sounds economical, but one doubts if a fine clay of this nature would ever be used for soil stabilization.

It is a pity that, in this case (Figure 8), no experimental

point on the “without fly ash” curve at a cement content of 15% is given. The remarks previously made with regard to optimum water content will apply even more forcibly in this case.

REFERENCE

1. MINNICK, L. J. and MILLER, R. H. Lime-fly-ash-soil compositions in highways. Washington, Proceedings of the Highway Research Board 31st annual meeting, 1952. pp. 511–528.

Reply by the authors

In our article we suggested that, where a power station was relatively close to the site of laying of stabilized roads, some economy could be effected by the replacement of a portion of the cement by fly ash. In the discussion, it is quite rightly pointed out that this would not of itself mean a corresponding reduction in cost. The over-all picture is, we feel, rather happier, since the cost of dumping at sea is eliminated and, where transport hauls are short, economy will surely result.

It is interesting to note that Professor Marshall agrees that part of the fly ash is probably acting as a filler, and suggests that the pozzolanic action of the fly ash will show up more favourably with the passage of time. This view is confirmed by the additional work proposed in the original article and now carried out.

With the moisture content kept at optimum, a series of specimens for each soil was made using the percentages of fly ash and cement required to yield a 7-day strength of 200 lb/in²; a second set for each soil was made using the percentage of cement alone necessary to yield the same 7-day strength, these percentages being those determined in the earlier work. Unconfined compression tests were carried out at 7 days and at 4, 12, and 52 weeks for each set for each soil.

The increases in strength with time for soil-cement using the same cohesionless sand as in the previous work are shown in Figure I, and show a considerably greater strength at 12 months when fly ash is present. The material, in fact, appears to be behaving as a weak concrete, and the results are in line with those obtained with fly ash concrete used in the Hungry Horse Dam, Montana, U.S.A.⁽¹⁾ The corresponding results for the lighter grey clay and the heavy blue clay are given in Figures II and III; here it will be noted that, for both cohesive soils, the gain in strength with time is less where the fly ash is present. It is thought that organic matter present in the clays is probably interfering with the chemical action. It should be noted, however, that the clay soil-cement incorporating fly ash does increase in strength with age, and that the slower rate of increase would not invalidate substitution of cement by fly ash if the design criterion is based on a 7-day strength of, say, 200 lb/in² as supposed in our article.

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Figure I: Variation of strength with time for sand soil-cement.

Figure III: Variation of strength with time for blue clay soil-cement.

Figure II: Variation of strength with time for grey clay soil-cement.

In order to limit the variables involved—soil, cement, water and age—and to reduce the work to manageable proportions, it was decided to carry out the work for each soil at the moisture content indicated as optimum in the dry density test made with the original percentage of cement, and to maintain this moisture content through the tests with that soil. Professor Marshall suggests that the optimum moisture content where the cement percentage is reduced may be significantly different, which may considerably influence results. This may be partially true, but it is known from other work that the grey clay with 5% cement has an optimum moisture content of 15.6%, whilst the present work shows that, with 17½% cement, optimum moisture content is 18.4%. It is reasonable to suppose, therefore, that the figure for 10% cement is only a matter of about 1% lower than that actually used, which would not seriously affect results. It must be admitted, however, that where a water content is gradually increased from a low value upwards through optimum, the curve relating unconfined compressive strength and water content normally reaches its peak at about 1–2% less than optimum. This would put the soil-cement made with the reduced quantity of cement at a disadvantage compared with that where the total percentage of additives was kept constant.

REFERENCE

1. Hungry Horse Dam in Montana. *The Engineer*. Vol. 200. No. 5190. 15th July 1955. pp. 94–96. No. 5191. 22nd July 1955. pp. 130–132.