EFFECT OF QUALITY OF CLAY ON SOIL MORTAR

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SYNOPSIS

The results of compaction and swell tests indicate that the plasticity index limits of 4 to 12 as allowed in the present specifications for stabilized soil roads satisfactorily cover the range of conditions usually encountered in various localities However, it appears that there is a specific maximum plasticity index that should not be exceeded depending on the quality of clay binder soil used The tests also indicate that for each ratio of binder soil to fine sand or soil fines there is an optimum coarse sand content at which maximum density is obtained

It is generally recognized that the quality of soil mortar used in stabilized soil roads determines to a large extent the degree of stability that can be obtained The present specifications for this type of road stress that the soil fines, or fraction passing the No 40 sieve, should have a plasticity index of not less than 4 nor greater than 12, and that a combination of high amounts of soil fines and a high plasticity index should be avoided These general specifications have satisfactorily covered the range of conditions encountered in various localities It was felt worthwhile to conduct a laboratory investigation to determine whether or not there is a specific maximum plasticity index the soil fines should have when a given clay binder soil was used

The ideal soil mortar should possess high cohesive and internal friction values with low volume change properties. These features are obtained when there is a high density, which results in a minimum of voids and high surface area contact of the soil particles, and when the clay content does not exceed that productive of detrimental swelling in wet weather Compaction and swell tests were selected, therefore, as the methods for determining the soil mortar compositions that produce the highest density and least volume change when a given quality of clay binder soil was used All series of tests were made with the ratio of binder soil to fine sand constant while the coarse sand content was varied

In order that the results obtained might be comparable, the particle size grading of the fine and coarse sand used was kept constant as follows:

Passing	Retained on	Fine Sand %	Coarse Sand %
No 10 sieve	No 18 sieve	—	50
No 18 sieve	No 40 sieve	—	50
No 40 sieve	No 60 sieve	30	—
No 60 sieve	No. 140 sieve	40	—
No 140 sieve	No 270 sieve	30	—

In making the compaction tests, a modification of the Proctor tamping device was used as shown in Figure 7 This was essentially a long thin handled tamper that was kept in a fixed position by a tubular guide. A rope attached to the end of the handle worked over a pulley which permitted the tamper to be lifted and dropped as desired. Guide stops controlled the height to which the tamper could be lifted and were so placed that a one foot drop occurred for each soil layer. The mold rested on a base beneath the tamper and was held in a fixed position by three guide pins although it was free to rotate and so placed that the tamper head struck the soil from the center to the edge of the mold The base of the mold was marked off in equal divisions to control the degree of rotation given after each blow After two complete revolutions, 25 blows had been made With this device the impacts from the tamper were constant and made a constant pattern on each layer of soil

Typical moisture-density curves were obtained from the compaction tests with an optimum moisture content at which maximum density was obtained Figures 1, 2, and 3 are the results of plotting

2 There is an optimum (binder soil)-(fine sand) ratio at which maximum density is obtained

3. The optimum (binder soil)-(fine sand) ratio producing maximum density varies with the quality of binder soil used

These latter two indications are more clearly illustrated in Figure 4 wherein

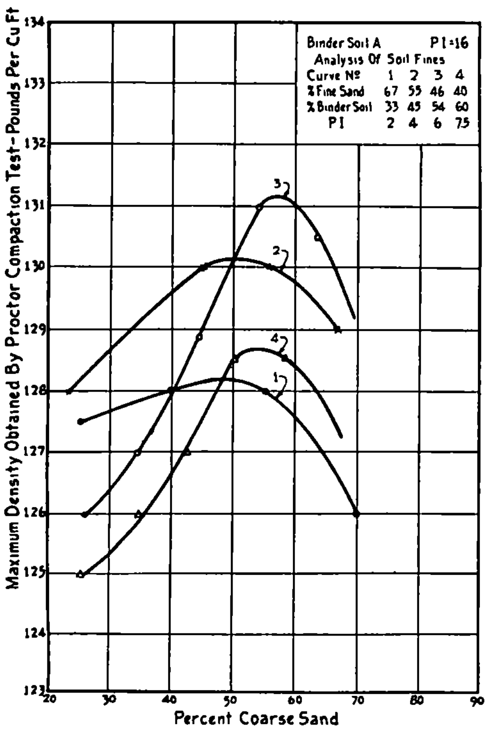

Figure 1

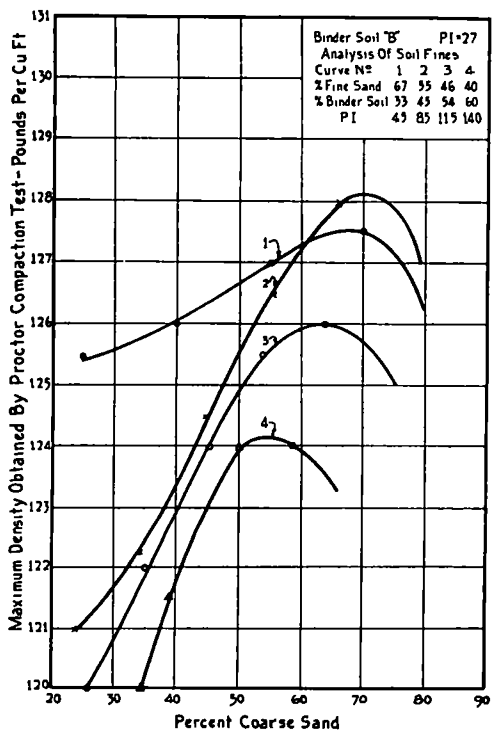

Figure 2

the densities obtained at these optimum moisture contents against the coarse sand content when different ratios of binder soil to fine sand were used In each of these figures a different binder soil was used The data from these tests indicate:

1 For each (binder soil)-(fine sand) ratio or soil fines there is an optimum coarse sand content at which maximum density is obtained.

the percentage of binder soil in the soil fines is plotted against the density at the optimum coarse sand content for each binder soil used

Figure 5 is a plot of the plasticity index of the soil fines at the optimum binder soil content, as shown in Figure 4, against the plasticity index of the binder soil used. It is indicated, therefore, that for a given quality of binder soil there is a maximum plasticity index the soil fines should have Such a result as this appears logical since it would be expected that thicker films of clay can be used to coat aggregate when the clay used has a lower plasticity index

In making the swell tests the soil specimens were compacted to a density of 125 lb per cu ft in molds similar to those used in making the compaction tests A hydraulic press was used for compacting the soils instead of the tamping device The specimens were 3 in in height and 4 in in diameter and were left in the molds throughout the test After the specimens had air dried until no loss in weight was noted for two days, they were clamped onto a flat porous plate A thin perforated plate with an adjustable center stem was placed in the mold so that it rested firmly on the soil specimen A dial gauge reading to a thousandth of an inch and mounted on a tripod was placed on the mold and the stem on the perforated plate adjusted until it made contact with the foot of the dial gauge. Water was then poured into the box containing the specimens until it was within one-fourth inch of the top of the porous plates As the soil specimens absorbed water, the amount of swelling was read on the dial gauge When no further increase in volume occurred for two days, a final reading was recorded and considered to be the maximum extent to which the specimen would swell

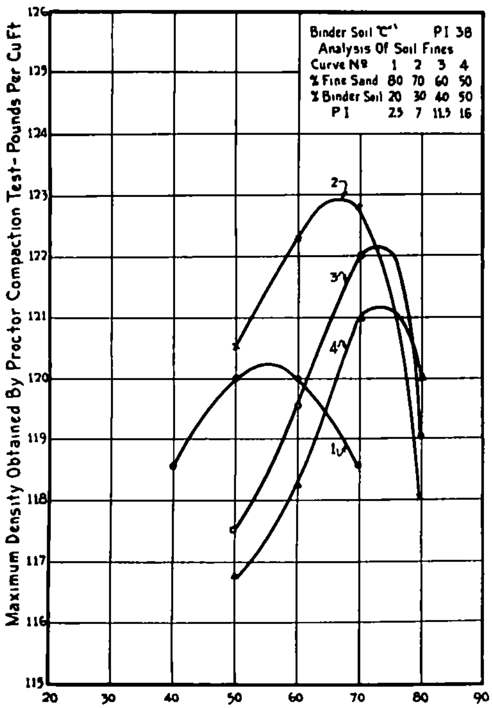

Figure 3

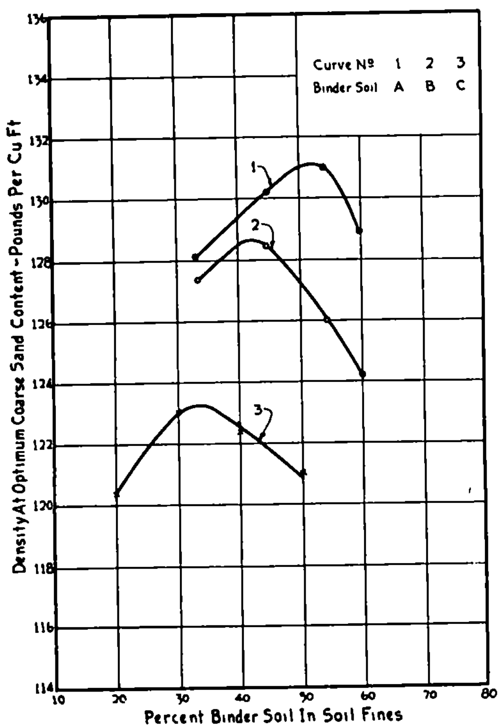

Figure 4

Figure 6 is a plot of the swell test results The percentage of coarse sand is plotted against the percentage of swell for constant ratios of binder sand to fine sand and for the three binder soils used It will be noted that if the plasticity index of the soil fines is no greater than that shown in Figure 5 to be the maximum permitted for each binder soil, and if the coarse sand content is equal to the optimum values shown in Figures 1, 2, and 3, no large volume changes occur These swell tests cannot be used to establish definitely the limits of plasticity index the soil fines may have but do indicate that a slightly lower coarse sand content may be used than shown as the optimum without seriously affecting the volume change properties A lowering of the coarse sand content would be in conformity with actual practice since it has been found advantageous to use a slight excess of soil fines over that required to fill the voids of the coarse sand

In conclusion it may be said that these tests confirm the fact that a combination of high amounts of soil fines and a high plasticity index is undesirable For a given quality of clay binder soil there is a maximum plasticity index which the soil fines should have in order to avoid excessive lubricating effects and volume changes It is believed that a further study along these lines using a greater variety of clay binder soils may prove of practical value in designing stabilized soil roads

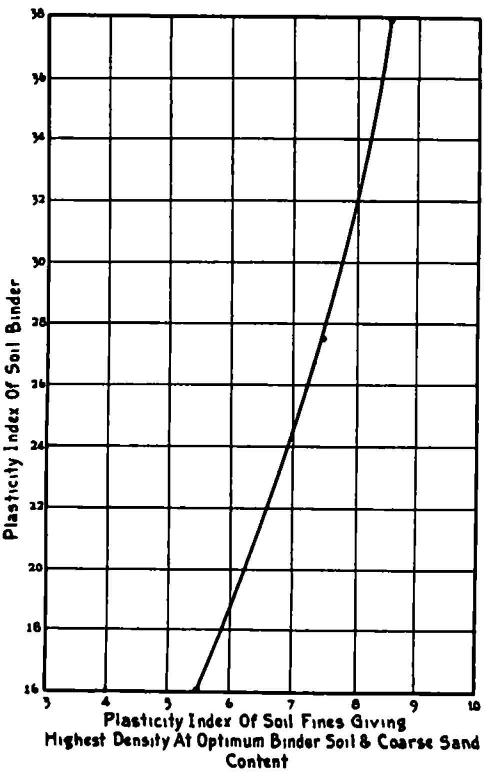

Figure 5

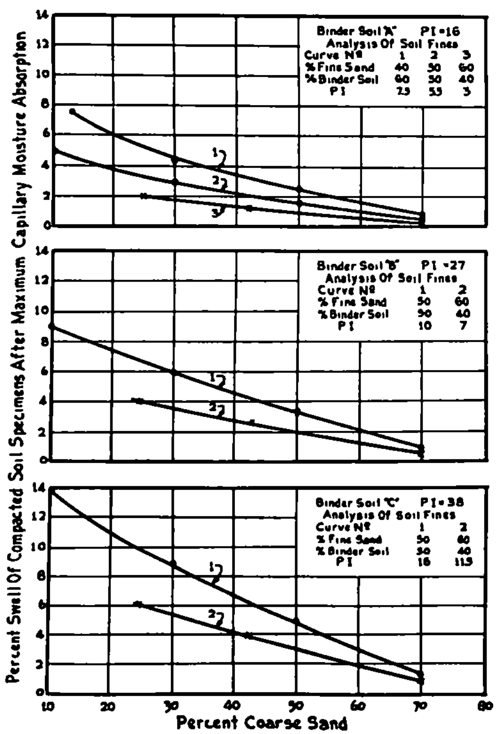

Figure 6

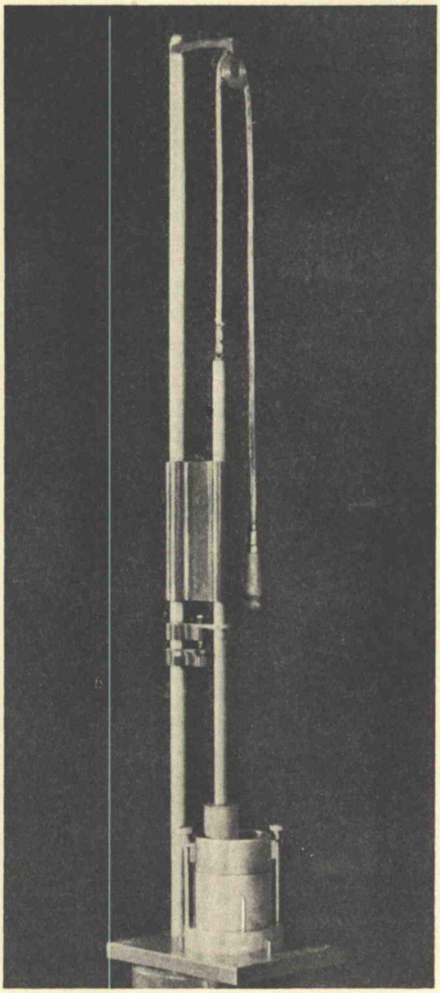

Figure 7. Compaction Apparatus

DISCUSSION

MR. G. A. RAHN, *Pennsylvania Department of Highways:* Mr. Miller has demonstrated in the laboratory the possibilities of departing (within limits) from the set gradation curve and obtaining results. It would be interesting to observe these mixes in the road surface under actual field service tests.

He has demonstrated from the density standpoint that it is possible to produce mortars of desirable density with materials containing 30 to 75 per cent of No. 40 mesh size and between 10 and 40 per cent of No. 270 mesh size. These extremes produced mixtures having densities of 128 and 126 lb. per cu. ft. respectively, which in itself is a remarkable coincidence when compared with the maximum density of 130 lb. per cu. ft. obtained by Hogentogler and Willis,[1] on the ideal mortar gradation. These are comparable at the optimum moisture content.

MR. MILLER: I would like to make one point clear. We were rather disappointed about this gradation when we first started looking into these results, in view of the fact that the 4 per cent content seemed to be considerably higher than what we had been using in practice. However, it is very simple, I think, because what we reached here was really a theoretical amount of soil fines to just fill the voids of the coarse sand whereas in actual practice we know that we have to have a slight excess of fines.

[1] Public Roads, Volume 17, No. 3, May 1936, Page 51.