PCA soil primer

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PCA Soil No. 3948, AASHO Group A-7-6(13)

Gradation	Per cent
Plus No. 10 sieve size	0
Sand (No. 10 to No. 270 sieve)	7
Silt (0.05 to 0.002 mm.)	65
Clay (< 0.002 mm.)	28
Passing No. 200 sieve size	94
Physical test constants	
L.L.	44
P.I.	20
S.L.	20
F.M.E.	29
Volume change at F.M.E.	16

The first step is to classify the soil:

The AASHO soil classification will be found to be A-7-6(13) by referring the above data to Figs. 4 and 5 and Table 3.

The United classification will be found to be CL (clay) by referring the data to Table 4.

The CAA classification will be found to be E-7 by referring the data to Table 5 and Fig. 7.

The next step is to interpret this soil in terms of the general characteristics of the AASHO group to which it belongs:

The general characteristics of this soil are given in the discussion of A-7 soils in the section on AASHO classification of soils, page 41. Also, comments on the significance of physical test constants given in Chapter 1, page 21, assist in analyzing the soil. The general characteristics of CL soils as defined by the Unified classification are given in Table 4.

Discussion: Soil No. 3948. The textural classification is silty clay loam as defined by the Department of Agriculture textural classification given on page 16.

A-7 soils are elastic and rebound after removal of load or compaction force. They have high volume changes accompanying moisture variations above the S.L., and they have low bearing value.

The L.L. of 44 is in the lower range of this value for clays, which may run as high as 80 or 100. Therefore this soil belongs to the better clays although it is still an inferior subgrade soil.

The P.I. of 20 shows that a considerable increase in moisture content may take place before it changes from the P.L. (at 24) to a liquid condition.

The P.L. of 24 and the S.L. of 20 show that only a small amount of moisture need be absorbed to change the load-carrying capacity of the soil from a high value at the S.L. to a rapidly decreasing value at the P.L.

The F.M.E. of 29 is higher than the P.L. of 24, showing that the soil will absorb free surface water sufficiently to exceed the P.L., where load-carrying capacity decreases very rapidly. This explains the necessity of considering the load-carrying capacity of this soil at the higher moisture contents above the P.L.

subgrade characteristics

For flexible pavements: Since A-7 soils are elastic and rebound after removal of load, they are difficult to compact. When they serve as a subgrade for a flexible pavement, it is also difficult to compact the granular material. And, of more importance, after construction each passing load tends to compact the base and the subgrade but subsequent rebound tends to loosen and open up the granular base; this permits easy entrance of water and leads to loss of load-carrying capacity. The low load-carrying capacity of A-7 soils requires maximum thickness of granular base materials. A-7 soils also have high volume change with moisture changes. They are particularly undesirable as subgrades for flexible pavements.

For concrete and soil-cement pavements: The bridging or load-distribution characteristics of concrete and soil-cement are very valuable engineering properties on this soil. They permit full utilization of the maximum bearing capacity of the soil at various moisture contents. No subbase is required to prevent infiltration of the subgrade into the pavement.

Subbase requirements are less critical than those given for the A-4 soil since frost-heave will be less.

Soil-Cement Design and Construction

The details of soil-cement tests and testing and the meaning and explanation of these details are given in *Soil-Cement Laboratory Handbook.** Similar information on construction is given in *Soil-Cement Construction Handbook,** and will not be repeated here. Familiarity with these details is needed to permit a complete understanding of the following comments.

The test data for the three soils given in the preceding pages supply many of the answers to problems of soil-cement testing, design and construction. The highlights of analysis of the use of these soils for soil-cement follow.

PCA Soil No. 3937, AASHO Soil Group A-1-b(0). From Table 1 in *Soil-Cement Laboratory Handbook,* it is seen that a cement content of 8 per cent by volume will probably prove adequate in test.

*Available free only in the United States and Canada on request to Portland Cement Association.

The high sand content, 89 per cent, shows the soil will require little pulverizing effort and that mixing of water and cement will be a rapid, efficient operation. The maximum density will be about 120 lb. per cu.ft. and the optimum moisture will be about 11 per cent, using ASTM Designation: D 558-44 or AASHO Designation: T 134-45. Air-dry moisture content of a soil of this gradation will probably be about 2 per cent, and for a 6-in. compacted thickness, approximately 6½ gal. of water per sq.yd. will be required.

Soil-cement made of this soil will be of excellent quality and strength. A 6-in. depth of construction on such soils will have much higher load-carrying capacity than the average, and hence will withstand considerably more traffic and heavier loads.

It is probable that the soil can be compacted with sheepsfoot rollers but if it continues to displace with sheepsfoot rolling, required densities can be easily obtained with pneumatic-tired and steel-wheel rollers.

PCA Soil No. 3977, AASHO Soil Group A-4(8). From Table 1 in *Soil-Cement Laboratory Handbook,* it is seen that A-4 soils require from 8 to 12 per cent cement for adequate hardening. Since this A-4 contains very little sand or clay, the higher cement content, 12 per cent, should be selected for cement estimates.

This soil will pulverize readily under a wide range of moisture conditions since the silt itself has little or no cohesion and there is little cohesion imparted to the soil by the low clay content. Mixing operations will be easy and rapid. The maximum density will be about 106 lb. per cu.ft. and the optimum moisture will be about 17 per cent, using ASTM Designation: D 558-44 or AASHO Designation: T 134-45. Air-dry moisture content of a soil of this gradation will probably be about 5 per cent, and for a 6-in. compacted thickness approximately 8 gal. of water per sq.yd. will be required during construction.

Soil-cement made of this soil will be of good quality and strength.

The mixture will compact readily with sheepsfoot rollers and finish out well. Usual attention to the production of surface mulch of 1-in. thickness will eliminate surface compaction planes produced by the sheepsfoot roller, tractor plates, motor patrol wheels, etc. Final rolling with pneumatic-tired and steel-wheel rollers, with the mulch at optimum moisture or slightly above will produce a tight, even surface.

PCA Soil No. 3948, AASHO Soil Group A-7-6(13). From Table 1 in *Soil-Cement Laboratory Handbook,* it is seen that a cement content of 12 per cent by volume for an A-7 soil will probably prove adequate in test.

This soil will pulverize above the shrinkage limit and below the plastic limit. As its moisture content decreases below the shrinkage limit, clods tend to form. These can be pulverized by moistening for 24 hours to bring them above the shrinkage limit, or they may be crushed with sheepsfoot rollers.

Mixing operations will be rapid and efficient when the soil is air-dry.

Cement should not be added when the percentage of moisture in the soil exceeds the quantity that will permit a uniform, intimate mixture of soil and cement during mixing operations. The pulverized soil can be protected from rains by windrowing or by covering it with waterproof paper. Should it become wet after pulverizing, it should not be disturbed until its moisture content is below the plastic limit; otherwise, it will compact and require pulverizing again.

The maximum density will be about 110 lb. per cu.ft. and the optimum moisture will be about 16 per cent. Air-dry moisture content of this soil will be about 8 per cent, and for a 6-in. compacted thickness approximately 8 gal. of water per sq.yd. will be required during construction.

Soil-cement made of this soil will be of good quality and strength.

The mixture will compact readily. Usual attention to production of a 1-in. surface mulch will produce a tight, even surface after rolling. Such soils should not be compacted below optimum moisture.

The foregoing examples of soil reconnaissance, detailed soil survey, sampling and testing, and design analysis for flexible, concrete and soil-cement paving are offered to show not only the physical steps and work involved but also the mental processes followed in arriving at the required answer. It is this latter phase that is the key to success in soil work because it requires selecting all the soil properties that have specific bearing on the problem at hand. No effort has been made to bring all factors influencing design into the discussion and several points on drainage, capillarity, frost-heave, etc., for example, have not been included in the interest of brevity. However, these examples will show the methods of analysis used by soils and design engineers in their work.

conclusion

THIS PRIMER HAS BEEN INTENDED TO SERVE AS A STARTING point for obtaining a working knowledge of soils as they apply to pavement design and construction.

After the substance of this handbook has been absorbed the engineer can begin talking the soil man's language. By continued study, by specific discussions of specific points with others, and by field work on specific problems, it will be possible to make soil information a useful and essential tool in the adequate and economical design of pavements.