top inch of the mix during the compacting period due to excess evaporation but such additions must be carefully mixed to avoid scaling. After all blading is completed the surface is again rolled with pneumatic-tired rollers.

Compaction of the mix is one of the essential operations and great care should be exercised during this part of the work. The compaction of the top one-half inch of soil-cement mixtures appears to be one of the weak points in the present construction methods and there have been evidences of softness and scaling for this depth in a few places.

No curing has been specified on any projects constructed to date. So far it has not been demonstrated that this expense is justified. A tar prime is usually applied to the base within 48 hours after construction and in some cases it has been applied the day of construction as soon as the surface dries. A bituminous wearing surface consisting of a single treatment of asphalt and stone or a mixed-in-place treatment with 50 lb. of aggregate and cut-back asphalt is applied before traffic is allowed on the base. The single treatment does not appear to be adequate for ordinary traffic needs.

SAMPLING, SOIL CLASSIFICATION AND CEMENT REQUIREMENT—NORTH CAROLINA

By L. D. Hicks

Four soil-cement base projects were built in North Carolina from 1937 to 1939 comprising totals of 7 miles and 80,984 sq. yd. These bases are considered satisfactory.

A considerable range in soils was covered and the methods of sampling, soil classification and determination of amounts of cement to use are particularly interesting.

SAMPLING PROCEDURE

In order to determine the proper amount of portland cement to use, durability tests must be made of soil-cement mixtures in which varying amounts of cement are used with the particular soil. Since the necessary amounts vary with the kind of soil, it is imperative that the samples truly represent the material to be encountered.

The Bureau of Chemistry and Soils places soils having the same character of profile, the same range in color, structure, consistency, the same sequence of horizons and degree of horizontal development, the same general conditions of relief and drainage and usually a common or similar origin and mode of formation in groups called series. This is the unit of soil classification. Soils from the same horizons of the same series, the A horizon excepted, are very similar. If a sample is taken from the B horizon of a certain series in one locality it will have similar characteristics to another sample taken from the same horizon of the same series in a different locality. It is logical then to conclude that samples taken from all of the horizons of each of the several soil series to be encountered on a project will represent all of the soils on that project. By this same token, it is reasonable to conclude that samples from the same horizons of the same series and taken from different parts of the country will have similar characteristics. The A horizon or topsoil is generally ignored, as soil from this horizon is usually only a few inches thick and rarely occurs alone in the subgrade after the grading work is done. In fact, such a condition should be avoided during grading operations as this horizon generally contains a high percentage of organic matter, which in sandy soils prevents them from reacting with a normal amount of cement.

When a soil stabilization project is contemplated in North Carolina samples are taken of the B and C horizons of each soil series occurring on the project. These samples are called "key" samples and are mixed with various amounts of stabilizing agents—portland cement or bituminous materials—and tested for durability. These samples should weigh at least 200 lb. if portland cement is to be used and 50 lb. if bituminous materials are to be used. When the grading work has been completed, 30 lb. samples are taken from the grade at intervals of 1000 ft. and for the depth to be stabilized. These samples are tested for mechanical analysis, physical test constants, pH, specific gravity, optimum moisture, density; and when portland cement is to be used, compression tests are made on specimens composed of 6 and 10 per cent mixtures of the soil and cement at 2 and 7 days.

TABLE 1

PERCENTAGE OF CEMENT BY VOLUME NECESSARY FOR STABILIZATION

Soil series	No. of tests	B horizon	C horizon
		%	%
Cecil.......	2	10	6-10
Appling.....	2	12	10
Durham....	2	10	8
Orange.....	1	10	..
Georgeville..	1	12	10
Tirzah......	1	10	8
Iredell......	1	12	8
Mecklenburg	1	10(B_1), 12(B_2)	..
Orangeburg..	1	8	..
Ruston.....	1	10	10
Norfolk.....	3	6	..
Bradley.....	1	10	12
Portsmouth..	2	12(A_2)	

Durability tests have been performed, and amounts of cement necessary have been determined for the following North Carolina soils given in Table 1.

Descriptions of the soils in Table 1 are as follows:

Cecil: Derived from acid crystalline rocks such as granites and gneisses. The A horizon is a brownish gray to brownish sandy loam to clay. The B horizon is a stiff, brittle red clay with mica and free quartz.

Appling: Derived from acid crystalline rocks. The A horizon is a yellowish gray sandy loam. The B horizon is a yellowish red or mixed yellow and red gritty clay.

Durham: Derived from acid crystalline rocks. The A horizon is a yellowish gray sandy loam. The B horizon is a yellow friable sandy clay.

Orange: Derived from slates and fine grained volcanic rocks. The A horizon is a gray to light gray silt loam or gravely silt loam. The B horizon is a yellow and gray mottled clay. The soil in this horizon is very plastic.

Georgeville: Derived from slates and fine grained volcanic rocks. The A horizon is a grayish brown to light grayish brown silt loam, gravelly silt loam or slate loam. The B horizon is a red, compact clay to silty clay.

Tirzah: Derived from slates and fine grained volcanic rocks. The A horizon is a dark-brownish red clay. The B horizon is a deep red or maroon-red granular clay.

Iredell: Derived from basic crystalline rocks such as diorite, gabbro, etc. May occur in small deposits due to intrusions of the basic rock in the native rock. The A horizon is a brown to grayish-brown loam or sandy loam. The B horizon is a very plastic dull yellow to greenish-yellow clay.

Mecklenburg: Derived from basic crystalline rocks. The A horizon is a dark brown clay loam. The B horizon is in two layers, B_1 and B_2. The B_1 horizon is red to yellow clay while the B_2 is a plastic yellow clay.

All of the above soils are residual soils and are found in the Piedmont region of the State. The following are found in the coastal plain region and are derived from sedimentary sands and clays.

Orangeburg: Occurs in areas where the drainage is well established. The A horizon is a gray sand to sandy loam and the B horizon is a friable, bright red sandy clay. This series also occurs as a sand with two layers of A horizon and no B horizon. The A_1 horizon is a brownish-gray sand and the A_2 is a bright red sand.

Ruston: Occurs in areas where the drainage is well established. The A horizon is a gray sand to sandy loam and the B horizon is a friable, yellowish-red sandy clay. This series also occurs as a sand with two layers in the A horizon and no B horizon. The A_1 horizon is a brownish-gray sand and the A_2 is a yellowish-red sand.

Norfolk: Occurs in areas where the drainage is well established. The A horizon is a gray sand to sandy loam and the B horizon is a friable, yellow sandy clay. This series also occurs as a sand with two layers in the A horizon. The A_1 horizon is a gray sand and the A_2 is a pale yellow sand.

Bradley: Occurs in areas where the drainage is well established. The A horizon is a gray sand to sandy loam and the B horizon is a friable, bright red sandy clay to clay. The B horizon is residual Piedmont material which has been covered with sedimentary material. This series is found near the border line between the Piedmont and coastal plain regions.

Portsmouth: Occurs in areas where the drainage is poorly established. The A horizon is a black sand to loamy sand and the B horizon is a gray, sandy clay, frequently mottled with yellow. This series also occurs as a sand with two layers in the A horizon. The A_1 horizon is a black sand and the A_2 is a dull gray sand. This series contains a fairly high percentage of organic matter.

FIELD TESTING

Moisture and density are determined by a laboratory inspector in the field during the processing operations. After the soil has been pulverized, several moisture determinations are made and the number of loads of water necessary to raise the moisture to the optimum plus evaporation plus 1 per cent for the cement are calculated. When the soil, cement and water have been thoroughly mixed, more moisture determinations are made and if found deficient by more than 1 per cent, more water is added; or if found in excess of the optimum by more than 2 per cent, the mixture is allowed to dry out to about the correct amount. Proctor density determinations are made at intervals of 500 ft. after the proper moisture content is reached. At these same points, road density determinations are made when the base has been thoroughly compacted, and reported in terms of the Proctor density test. We find that 95 per cent of the Proctor density is a very good average and insist upon 90 per cent.

Two methods are in use for determining road density; by cores removed from the base by a core drill and by the so-called sand method. Cores cannot be drilled until the base is thoroughly hardened and so the information is obtained too late to improve low densities. Also the densities of the cores are always greater than the freshly compacted base, due to shrinkage. The density of the base prior to hardening is more important because it represents the thoroughness of compaction, a most important factor in the quality of the base.

The sand method consists of cutting a hole in the base, weighing and determining the moisture of the material, and filling the hole with a sand of known density. The road density is the weight in pounds of the material taken from the hole, corrected for moisture at the time of weighing, divided by the volume of the hole in cubic feet.