DESIGN REQUIREMENTS FOR GRADED MIXTURES SUITABLE FOR ROAD SURFACES AND BASE COURSES

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It is important to recognize at the outset the distinctive requirements for graded soil mixtures which are to be used as a surface or wearing course as compared with those for the same type of materials which are to be used as a base course under a flexible pavement.

The first requisite of a graded soil type surface course is stability; that is, it must support the superimposed loads without detrimental deformation. Second, it must withstand the abrasive action of the traffic. Third, it should shed a large portion of the rain which falls on the surface since a large amount of water penetrating the surface might cause loss of stability in the wearing course or softening of the subgrade. Finally, it should possess capillary properties in amount sufficient to replace the moisture lost by surface evaporation and thus maintain the desirable damp condition in which the particles are bound together by thin moisture films.

A high density, then, is a virtual necessity where granular materials are to be used as surface courses. Dense mixtures afford high abrasive resistance, shed the greater portion of the rain water and maintain a more uniform moisture content by replacing the moisture lost through evaporation by capillarity. Experimentation both in the field and in the laboratory has indicated that a certain amount of clay in a granular mixture, will increase the density[1] and promote compaction during construction. After compaction such mixtures "set up" and become hard and firm and do not soften appreciably in wet weather. If a slight excess of clay is used during construction it will soften and swell and tend to work to the top where it will either dry up and dust off or it may be removed in the course of maintenance.

Graded soil type base courses under flexible pavements must possess the requisite stability to support wheel loads. Traffic abrasion is absorbed by the wearing course. Rain water is almost entirely shed by the impervious top and can only reach the subgrade by way of the shoulders. Evaporation is largely cut off by the pavement and capillary moisture will accumulate in the base course until capillary equilibrium has been reached. Density, then, is not important in base course construction except insofar as it is a measure of stability. Compaction to essentially the maximum practical density for a given material is highly important and should be secured before the impervious wearing course is constructed. Failure to do so will result in subsequent unequal compaction under traffic with resultant cracking and breakage of the flexible surfacing.

Clay is of no value in the base course material, except during the construction period, and may be decidedly harmful after the surface is in place if too much or too active a clay has been used. The reason for this is apparent. Evaporation has been cut off and where, before the construction of the bituminous mat there was a constant flow of capillary moisture there is now an accumulation of moisture, particularly around the minute clay particles. The wet clay acts as a lubricant for the granular particles and the stability of the base course is reduced. An excessive amount of the wet clay tends to work up under the wearing course where it is

[1] "Stabilized Soil Roads," by C. A. Hogentogler and E. A. Willis, *Public Roads*, Vol. 17, No. 3, May, 1936.

trapped and forms a layer which lifts the surfacing from the base.

There is only one common requirement for surface course and base course materials. That is stability. In all other respects service conditions demand different properties.

The American Association of State Highway Officials has recognized these essential differences and has adopted separate specifications for both surface courses (M-61-38) and base courses (M-56-38). The types of materials suitable for use in the two groups are similar in most respects, but have some marked differences as indicated in the essential requirements of these specifications which follow:

1. Surface course

Type A.—Sand-Clay mortar

Passing	Percentage by weight
1-in. sieve	100
No. 10 sieve	65–100

The material passing the No. 10 sieve should have gradings as follows:

Passing	Percentage by weight
No. 10 sieve	100
No. 20 sieve	55– 90
No. 40 sieve	35– 70
No. 200 sieve	8– 25

Type B.—Coarse-graded aggregate

Passing	Percentage by weight
1-in. sieve	100
¾-in. sieve	85–100
⅜-in. sieve	65–100
No. 4 sieve	55– 85
No. 10 sieve	40– 70
No. 40 sieve	25– 45
No. 200 sieve	10– 25

Type C.—Crusher-run materials

Passing	Percentage by weight
¾-in. sieve	100
No. 4 sieve	70–100
No. 10 sieve	35– 80
No. 40 sieve	25– 50
No. 200 sieve	8– 25

The fractions of surface course materials, A, B, and C, passing the No. 200 sieve should be less than ⅔ of the fraction passing the No. 40 sieve. The fraction passing the No. 40 sieve should have a liquid limit not greater than 35 and a plasticity index not less than 4 nor more than 9.

2. Base course

Type A.—Sand-clay mortar

Passing	Percentage by weight
No. 10 sieve	100
No. 20 sieve	55– 90
No. 40 sieve	35– 70
No. 200 sieve	8– 25

Types B-1 and B-2.—Coarse-graded aggregate

Passing	B-1 1-in. max. size	B-2 2-in. max. size
	Percentage by weight	
2-in. sieve		100
1½-in. sieve		70–100
1-in. sieve	100	55– 85
¾-in. sieve	70–100	50– 80
⅜-in. sieve	50– 80	40– 70
No. 4 sieve	35– 65	30– 60
No. 10 sieve	25– 50	20– 50
No. 40 sieve	15– 30	10– 30
No. 200 sieve	5– 15	5– 15

Type C.—Crusher-run materials

Passing	Percentage by weight
¾-in. sieve	100
No. 4 sieve	70–100
No. 10 sieve	35– 80
No. 40 sieve	25– 50
No. 200 sieve	8– 25

The fractions of base course materials, A, B, and C, passing the No. 200 mesh sieve should be less than ½ of the fraction passing the No. 40 sieve. The fraction passing the No. 40 sieve should have a liquid limit not greater than 25 and a plasticity index not greater than 6 for materials A and B and a liquid limit not greater than 25 and a plasticity index not greater than 3 for material C.

CIRCULAR TRACK TESTS CONDUCTED BY BUREAU OF PUBLIC ROADS

Results[2] of tests performed by the Bureau of Public Roads using a small circular track support the validity of the A.A.S.H.O. base course specifications. In these tests sand clay and sand-clay gravel mixtures covering a wide range in grading and plasticity index were tested as base courses under thin bituminous surfaces with varying conditions of moisture and traffic application.

The investigations resulted in a quite

[2] A Study of Sand-Clay Materials for Base Course Construction, by C. A. Carpenter and E. A. Willis. *Public Roads*, Vol. 19, No. 9, November, 1938.

definite classification of the abilities of the materials studied to withstand the disruptive action of traffic under unfavorable moisture conditions and indicated that to guard against unsatisfactory behavior it is necessary to control both the plastic properties and the grading of the soil materials Excellent behavior was observed in all materials meeting the A A S H O Specifications Wherever the materials departed materially in grading and plasticity index values from these requirements, instability in the base course became evident

In general the investigations showed that well-graded materials having a low but measurable plasticity index are to be preferred to absolutely nonplastic materials of comparable grading and are decidedly superior to those having appreciably higher plasticity indexes

The use of an excessive amount of fine mineral dust, even though it may be inert and, therefore, not productive of plasticity, was found to retard or prevent effective compaction The behavior of such materials was entirely different from those having very low dust contents, which because of their harshness never became particularly dense but showed excellent serviceability

It is significant that while the A A S H O specifications are generally applicable in all localities, there are some local sources from which may be obtained natural materials giving excellent service as road surface and base courses, even though they do not conform to the specifications This is particularly true in the southeastern part of the United States where soils of the lateritic type are encountered These materials will have to be judged on local service behavior until a satisfactory test has been devised for measuring the strength and permanence of the binder