MATERIALS AND DESIGN OF STABILIZED SOIL ROAD MIXTURES

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SYNOPSIS

Five designs for mixtures of materials found in Pennsylvania based upon cohesion, internal friction and gradation as developed by the researches of the Bureau of Public Roads are presented These mixtures range from fine combinations of soil with sand or screenings to coarser mixtures of properly stabilized soil with graded coarse aggregate Provision is also made for two course work

It is recommended that the shoulders be stabilized with the same mixtures as the traveled way, and that field control of construction be accomplished through frequent analysis of samples, methods for which are given The soil-mortar gradation is the heart of the stabilized soil road, and in all cases should be of the right composition Coarse graded materials are added where practicable but in all cases whether the best coarse material is available or not, the voids in the coarse material should be filled with properly composed soil mortar

This discussion is premised primarily on soil studies and research of the United States Bureau of Public Roads, in which cohesion, internal friction and gradation as laid down by these researches are applied to soils and admixtures such as are encountered in Pennsylvania

The first question which might arise is what materials and procedure fit into the scheme of things? The stabilized soil road is in the low cost field which means that if we are to keep it in this category, local materials must be utilized to the fullest extent

Naturally the first concern is the soil in the road to be improved Is it adaptable to stabilization or would adjacent soil be more economical? By adjacent soil is meant that in the banks adjoining the roadway, or within a short distance of the roadway Also, could it be used in base course construction or could it be used in the top course or is it possible to use it in both bottom and top courses? These questions can be answered by making routine tests on samples from the possible sources of supply

If the soil is fine and plastic in nature what granular material is available which might supply the deficient fractions, is it sand, stone, slag, or gravel screenings? Are there any stone quarries, gravel banks or shale banks in the vicinity or are there industrial waste or mine waste banks close by from which a granular admixture can be secured? Of course if the roadway contains excessive granular material the reverse procedure would have to be applied, in other words, a suitable soil or binder soil secured

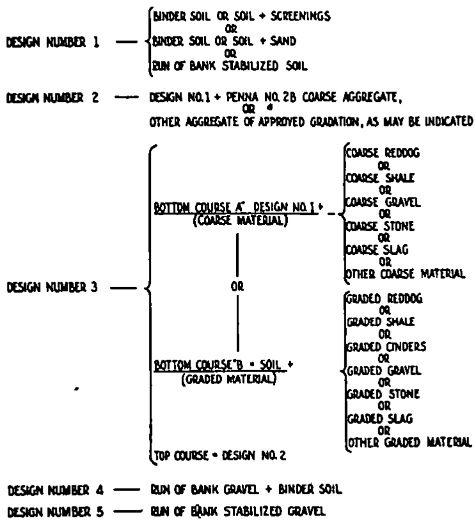

Figure 1 Design of Mixtures, Pennsylvania Highway Department

DESIGN OF MIXTURES

A brief glance at Figure 1 will demonstrate the possibilities of various materials as they fit into the stabilization picture This is a page taken from the Pennsylvania Specifications and headed "Design of Mixtures "

There are five designs covering a wide range of possibilities In these combinations are shown what has been found applicable to construction in the low country, the mountainous country, the industrial and mining countries In other words, we have endeavored to utilize the material available and incorporate it judiciously in order to obtain the best possible results

soil This design can also be regarded as the basic mix, and it will be seen how it fits into the designs which follow

Following is the gradation of the mixture for Design No 1

	%
Passing 1 in screen	100
Passing ⅝ in screen	60-100
Passing ⅜ in screen	50-100
Passing No 4 sieve	40-100
Passing No 10 sieve	30-100

At this point we reach the heart of the stabilized soil road, that is, the actual design of the soil mortar, or the fraction

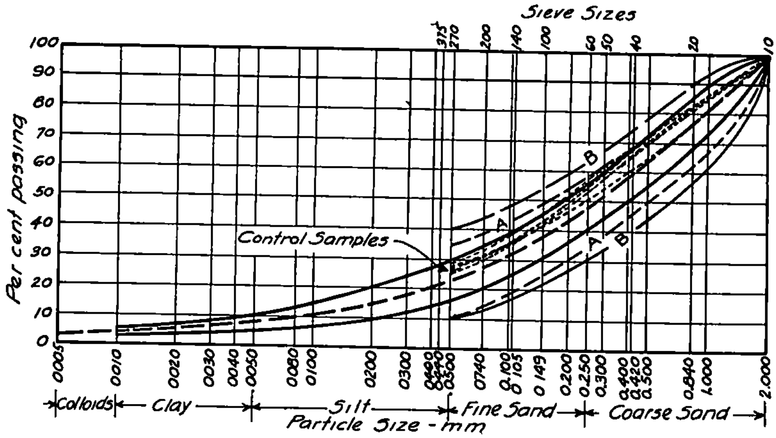

Figure 2 Soil Mortar Gradation Chart

A coordinating factor, namely, that of soil mortar gradation, which comprises the basis of the five designs, will be found in Figure 2

Design No 1 This is composed of binder soil or soil plus screenings, or binder soil or soil plus sand, or run of bank stabilized soil We differentiate between binder soil and soil in this way binder soil is recognized as possessing plasticity, soil does not possess plasticity By screenings we mean the product obtained by crushing stone, slag or gravel, the top size being ⅝-in or ⅜-in down to and including dust Run of bank stabilized soil is a soil possessing the required gradation and plasticity for a stabilized

passing the No 10 mesh sieve, and with this in mind the following gradations have been set up

	Soil Mortar % "A"	Soil Motar % "B"
Passing No 10 sieve	100	100
Passing No 40 sieve	45-70	40-75
Passing No 270 sieve	10-35	10-40

Oversized material is taken care of in the usual manner

In a top course mix this design will have a plasticity index between 0 and 9, and will comply with gradation of soil mortar "A" , in the bottom course mix it will have a plasticity between 0 and 6, and will comply with gradation of soil mortar "B" A liquid limit of not over 35 applies in both cases

Design No 2 This is no more than the addition of a graded coarse aggregate to Design No 1 In the case of Pennsylvania No 2B coarse aggregate this would have a top size of 1¼ in and be retained on the ⅜-in screen, as Design No 1 will consist largely of material passing the ⅝-in or ⅜-in screen The expression "or other aggregate of approved gradation as may be indicated" is to leave it open to trial jobs with aggregate over the 1¼-in size The proportions of Design No 1 mix and coarse aggregate to be combined to form the finished mix for Design No 2 is governed by the amount of the fraction passing the No 10 mesh sieve contained in the Design No 1 mix The finished mix should contain between 30 and 40 per cent of this fraction The plasticity index should be 0 to 9, the liquid limit not over 35 The soil mortar will comply with gradation of soil mortar "A"

Design No 3 This is a two course construction There are two separate designs for the bottom course, which are designated as "A" and "B"

Bottom Course "A" comprises the Design No 1 mix in combination with coarse shale, gravel, stone, slag or other coarse material This coarse material is composed of 2-in to 3-in particles with no appreciable amount of fine material passing the No 10 sieve Taking void content into consideration, a mixture composed of 50 per cent of the coarse material and 50 per cent of the Design No 1 mix are suggested for this design The plasticity index should be from 0 to 9, with the liquid limit not over 35 Soil mortar is to comply with gradation of soil mortar "B"

Bottom Course "B" is composed of soil plus graded shale, cinders, gravel, stone, slag or other graded material Graded material in this case is construed to mean one composed of coarse (maximum size 3 in) and fine particles, with an appreciable amount of fine material passing the No 10 sieve The inclusion of this fine material eliminates the necessity of developing the Design No 1 mix and makes it possible to combine the soil or binder soil directly with the admixture material The plasticity index should be 0 to 6, with the liquid limit not over 35, the soil mortar to comply with gradation of soil mortar "B"

The top course of Design No 3 is similar to that of Designs No 1 or No 2

Designs No 4 and No 5: No 4 represents run of bank gravel combined with binder soil to form the stabilized mix, while the No 5 is a "natural", in other words, it contains all of the characteristics of a stabilized soil The top size for the gravel should not exceed 2¾ in unless used in base course The plasticity index should be between 0 and 9, and the liquid limit 35 The soil mortar is to comply with the gradation of soil mortar "A"

Subgrades When applied to subgrades either Design No 1, Design No 3 bottom course, Design No 4, or Design No 5 may be used and the plasticity index will be between 0 and 12

Shoulders In shoulder construction either one of the five designs may be used, with a plasticity index between 3 and 12

Cross Section Apart from the stabilization of the roadway proper the shoulders are also built of the same stabilized material, dropping from the established depth at the theoretical pavement edge to a feathered edge at the ditch line In conjunction with sound design this cross section provides ease of maintenance

The working out of these various designs in practice is illustrated in Figures 3 to 8 The illustrations start from the fine graded and go through to the coarse graded mixes.

CONTROL

The master gradation chart developed by the Bureau of Public Roads is shown in Figure 2.

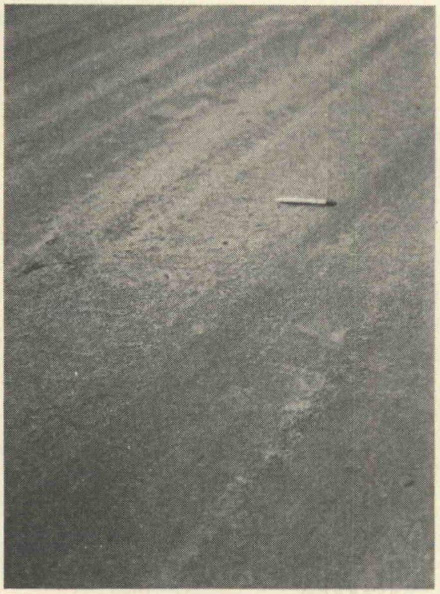

Figure 3. Close Up of a Fine Graded Sand and Soil Mix with a Top Size of Approximately ⅝ In. with 93 Per Cent of Soil Mortar (Passing No. 19 Sieve). This Was Built of Two Materials, a Sand and a Binder Soil Obtained Adjacent to the Road.

Regardless of the selection of materials and their suitability for work of this type, if the job is not satisfactorily constructed poor results can be expected. That control can be exercised is very well demonstrated in Figure 2. Samples taken from the mix at the time of construction are depicted by short dash lines and are designated as "control" samples.

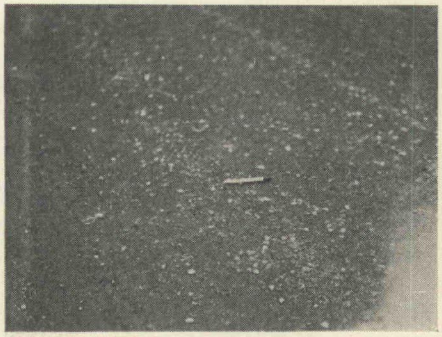

Figure 4. Close Up of a Screenings and Binder Soil Mix with a Top Size of ⅝ to ¾ In. This is a Mixture of Limestone Screenings and Soil.

Such control can be exercised in the field by the washout method, by drying and grading the finished mixture through the coarser screens in the usual manner, while the soil mortar sizes can be determined by

Figure 5. Coarser Mix, Top Size Approximately 1¾ In. Run of Crusher Slag, Including Fines, Was Incorporated with the Soil in the Roadway

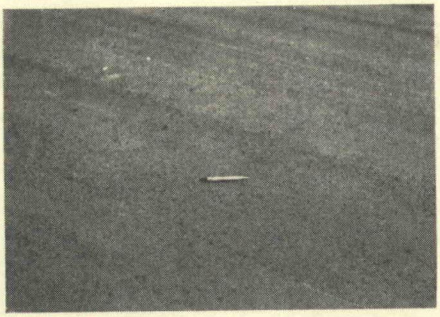

Figure 6. This Is a Close Up of the Surface in Figure 5

dried and sieved over the No. 10 sieve, the lumps of soil and soil adhering to the stone being broken down with the fingers. A predetermined quantity is then weighed out in a tin pan on a small and inexpensive balance. This is soaked in water 15 minutes, then agitated in an egg beater in the presence of water in order to bring about further dispersion, then placed in a metal cylinder with water added to bring the mixture up to a predetermined level, and agitated fur-

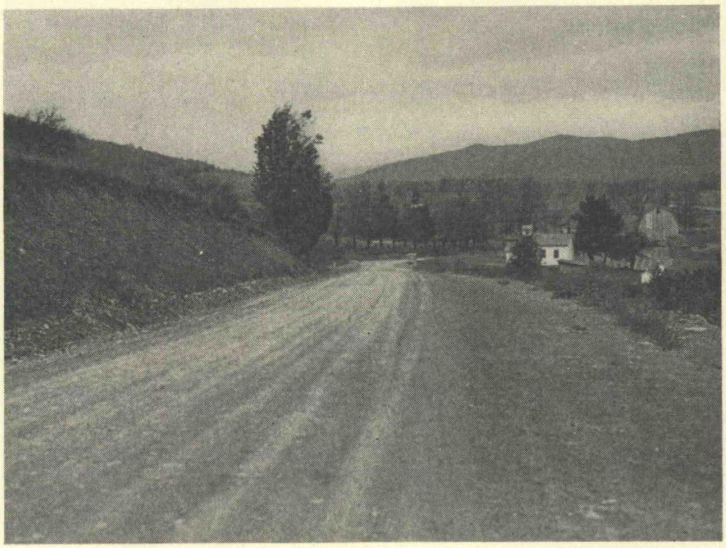

Figure 7. A Coarse Graded Mix with a Top Size of Approximately 2¾ In. In this Case Run of Bank Gravel Was Mixed with the Roadway Soil

washing the mortar through the No. 10, No. 40 and No. 270 mesh sieves, then drying and weighing these fractions, or by means of a hydrometer which has been devised for this purpose. The plasticity indexes are controlled between 0 and 9 since we feel that where restraint is obtained, as in the case of the bottom courses, a zero plasticity can be used satisfactorily. In the wearing surface proper we lean to the lower plasticity index rather than the higher.

In using the hydrometer field control method a sample of the finished mix is ther for approximately one minute. Following this the cylinder is placed on a firm surface and allowed to stand for 1½ min., at which point a metal hydrometer is lowered into the mixture and allowed to stand another ½ min. Then the quantity of No. 270 mesh material present is read directly on the stem of the hydrometer at the top of the meniscus. The temperature of the mixture is taken and the hydrometer reading corrected by a temperature correction chart.

The apparatus and steps in this operation are illustrated in Figure 9. The hydrometer is made of very thin metal and calibrated in the laboratory to read in percentage of No. 270 mesh material present in the mixture.

coarse material where possible. However, at times it is economically impossible to follow the orthodox gradation, as in the case of waste piles, bank run

Figure 8. Representative Surface Five Years Old. The Picture Was Taken in January 1937

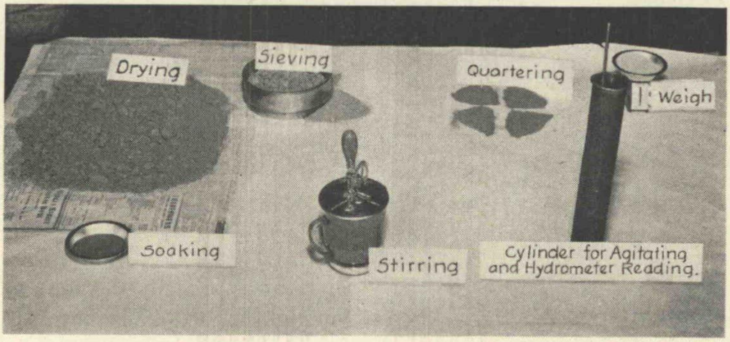

Figure 9. The Hydrometer Method of Determining the Material Finer than the 270 Mesh Sieve

CONCLUSION

In this discussion I have tried to present the basic design; namely, the following out of the gradation prescribed in the soil mortar gradation curve, which insures density and utilization of graded

gravels, etc. In all cases see that the soil mortar gradation is properly carried through, insure the correct filling of the voids of the large particles with the stabilized soil mortar and accept the grading as it exists above the soil mortar sizes.