Soil Stabilization for Pavements

An Online Continuing Education Course for Engineers

Course Number: G-5002

Credit: 5 Hours / 5 PDH / 5 CPD

© 2023 Decatur Professional Development, LLC. All rights reserved.

Soil Stabilization for Pavements

Chapter 1: Introduction

1-1. Purpose. This course establishes criteria for improving the engineering properties of soils used for pavement base courses, subbase courses, and subgrades by the use of additives which are mixed into the soil to effect the desired improvement. These criteria are also applicable to roads and airfields having a stabilized surface layer.

1-2. Scope. This course prescribes the appropriate type or types of additive to be used with different soil types, procedures for determining a design treatment level for each type of additive, and recommended construction practices for incorporating the additive into the soil.

1-3. References. Appendix A contains a list of references used in this course.

1-4. Definitions.

a. *Soils.* Naturally occurring materials that are used for the construction of all except the surface layers of pavements (i.e., concrete and asphalt) and that are subject to classification tests (ASTM D2487) to provide a general concept of their engineering characteristics.

b. *Additives.* Manufactured commercial products that, when added to the soil in the proper quantities, improve some engineering characteristics of the soil such as strength, texture, workability, and plasticity. Additives addressed in this course are limited to portland cement, lime, flyash, and bitumen.

c. *Stabilization.* Stabilization is the process of blending and mixing materials with a soil to improve certain properties of the soil. The process may include the blending of soils to achieve a desired gradation or the mixing of commercially available additives that may alter the gradation, texture or plasticity, or act as a binder for cementation of the soil.

d. *Mechanical stabilization.* Mechanical stabilization is accomplished by mixing or blending soils of two or more gradations to obtain a material meeting the required specification. The soil blending may take place at the construction site, a central plant, or a borrow area. The blended material is then spread and compacted to required densities by conventional means.

e. *Additive stabilization.* Additive stabilization is achieved by the addition of proper percentages of cement, lime, fly ash, bitumen, or combinations of these materials to the soil. The selection of type and determination of the percentage of additive to be used is dependent upon the soil classification and the degree of improvement in soil quality desired. Generally, smaller amounts of additives are required when it is simply desired to

Portions ©2015 Decatur Professional Development, LLC All rights reserved (r16A18)

modify soil properties such as gradation, workability, and plasticity. When it is desired to improve the strength and durability significantly, larger quantities of additive are used. After the additive has been mixed with the soil, spreading and compaction are achieved by conventional means.

f. *Modification.* Modification refers to the stabilization process that results in improvement in some property of the soil but does not by design result in a significant increase in soil strength and durability.

1-5. Uses of Stabilization. Pavement design is based on the premise that minimum specified structural quality will be achieved for each layer of material in the pavement system. Each layer must resist shearing, avoid excessive deflections that cause fatigue cracking within the layer or in overlying layers, and prevent excessive permanent deformation through densification. As the quality of a soil layer is increased, the ability of that layer to distribute the load over a greater area is generally increased so that a reduction in the required thickness of the soil and surface layers may be permitted.

a. *Quality improvement.* The most common improvements achieved through stabilization include better soil gradation, reduction of plasticity index or swelling potential, and increases in durability and strength. In wet weather, stabilization may also be used to provide a working platform for construction operations. These types of soil quality improvement are referred to as soil modification.

b. *Thickness reduction.* The strength and stiffness of a soil layer can be improved through the use of additives to permit a reduction in design thickness of the stabilized material compared with an unstabilized or unbound material. Procedures for designing pavements that include stabilized soils are outside the scope of this course. However, note that the design thickness of a base or subbase course can be reduced if the stabilized material meets the specified gradation, strength, stability, and durability requirements of the particular project.

CHAPTER 2: SELECTION OF ADDITIVE

2-1. Factors to be Considered. In the selection of a stabilizer, the factors that must be considered are the type of soil to be stabilized, the purpose for which the stabilized layer will be used, the type of soil improvement desired, the required strength and durability of the stabilized layer, and the cost and environmental conditions.

a. *Soil types and additives.* There may be more than one candidate stabilizer applicable for one soil type; however, there are some general guidelines that make specific stabilizers more desirable based on soil granularity, plasticity, or texture. Portland cement for example is used with a variety of soil types; however, since it is imperative that the cement be mixed intimately with the fines fraction (< .074 mm), the more plastic materials should be avoided. Generally, well-graded granular materials that possess sufficient fines to produce a floating aggregate matrix (homogenous mixture) and best

Portions ©2015 Decatur Professional Development, LLC All rights reserved (r16A18)

suited for portland cement stabilization. Lime will react with soils of medium to high plasticity to produce decreased plasticity, increased workability, reduced swell, and increased strength. Lime is used to stabilize a variety of materials including weak subgrade soils, transforming them into a "working table" or subbase; and with marginal granular base materials, i.e., clay-gravels, "dirty" gravels, to form a strong, high quality base course. Fly ash is a pozzolanic material, i.e. it reacts with lime and is therefore almost always used in combination with lime in soils that have little or no plastic fines. It has often been found desirable to use a small amount of portland cement with lime and fly ash for added strength. This combination of lime-cement-flyash (LCF) has been used successfully in base course stabilization. Asphalt or bituminous materials both are used for waterproofing and for strength gain. Generally, soils suitable for asphalt stabilization are the silty sandy and granular materials since it is desired to thoroughly coat all the soil particles.

b. *Selection of candidate additives.* The selection of candidate/stabilizers is made using figure 2-1 and table 2-1. The soil gradation triangle in figure 2-1 is based upon the soil grain size characteristics and the triangle is divided into areas of soils with similar grain size and therefore pulverization characteristics. The selection process is continued with table 2-1 which indicates for each area shown in figure 2-1 candidate stabilizers and restrictions based on grain size and/or plasticity index (PI). Also provided in the second column of table 2-1 is a listing of soil classification symbols applicable to the area determined from figure 2-1. This is an added check to insure that the proper area was selected. Thus, information on grain size distribution and Atterberg limits must be known to initiate the selection process. Data required to enter figure 2-1 are: percent material passing the No. 200 sieve and percent material passing the No. 4 sieve but retained on the No. 200 (i.e., total percent material between the No. 4 and the No. 200 sieves). The triangle is entered with these two values and the applicable area (1A, 2A, 3, etc.) is found at their intersection. The area determined from figure 2-1 is then found in the first column of table 2-1 and the soil classification is checked in the second column. Candidate stabilizers for each area are indicated in third column and restrictions for the use of each material are presented in the following columns. These restrictions are used to prevent use of stabilizing agents not applicable for the particular soil type under consideration. For example, assume a soil classified as a SC, with 93 percent passing the No. 4 and 25 percent passing the No. 200 with a liquid limit of 20 and plastic limit of 11. Thus, 68 percent of the material is between the No. 4 and No. 200 and the plasticity index is 9. Entering figure 2-1 with the values of 25 percent passing the No. 200 and 68 percent between the No. 4 and No. 200, the intersection of these values is found in area 1-C. Then going to the first column of table 2-1, we find area 1-C and verify the soil classification, SC, in the second column. From the third column all four stabilizing materials are found to be potential candidates. The restrictions in the following columns are now examined. Bituminous stabilization is acceptable since the PI does not exceed 10 and the amount of material passing the No. 200 does not exceed 30 percent. However, it should be noted that the soil only barely qualifies under these criteria and bituminous stabilization probably would not be the first choice. The restrictions under portland cement indicate that the PI must be less that the equation indicated in footnote b. Since the PI, 9, is less than that value, portland cement would be a candidate material. The

Portions ©2015 Decatur Professional Development, LLC All rights reserved (r16A18)

restrictions under lime indicate that the PI not be less than 12 therefore lime is not a candidate material for stabilization, The restrictions under LCF stabilization indicate that the PI must not exceed 25, thus LCF is also a candidate stabilizing material. At this point, the designer must make the final selection based on other factors such as availability of material, economics, etc. Once the type of stabilizing agent to be used is determined, samples must be prepared and tested in the laboratory to develop a design mix meeting minimum engineering criteria for field stabilization.

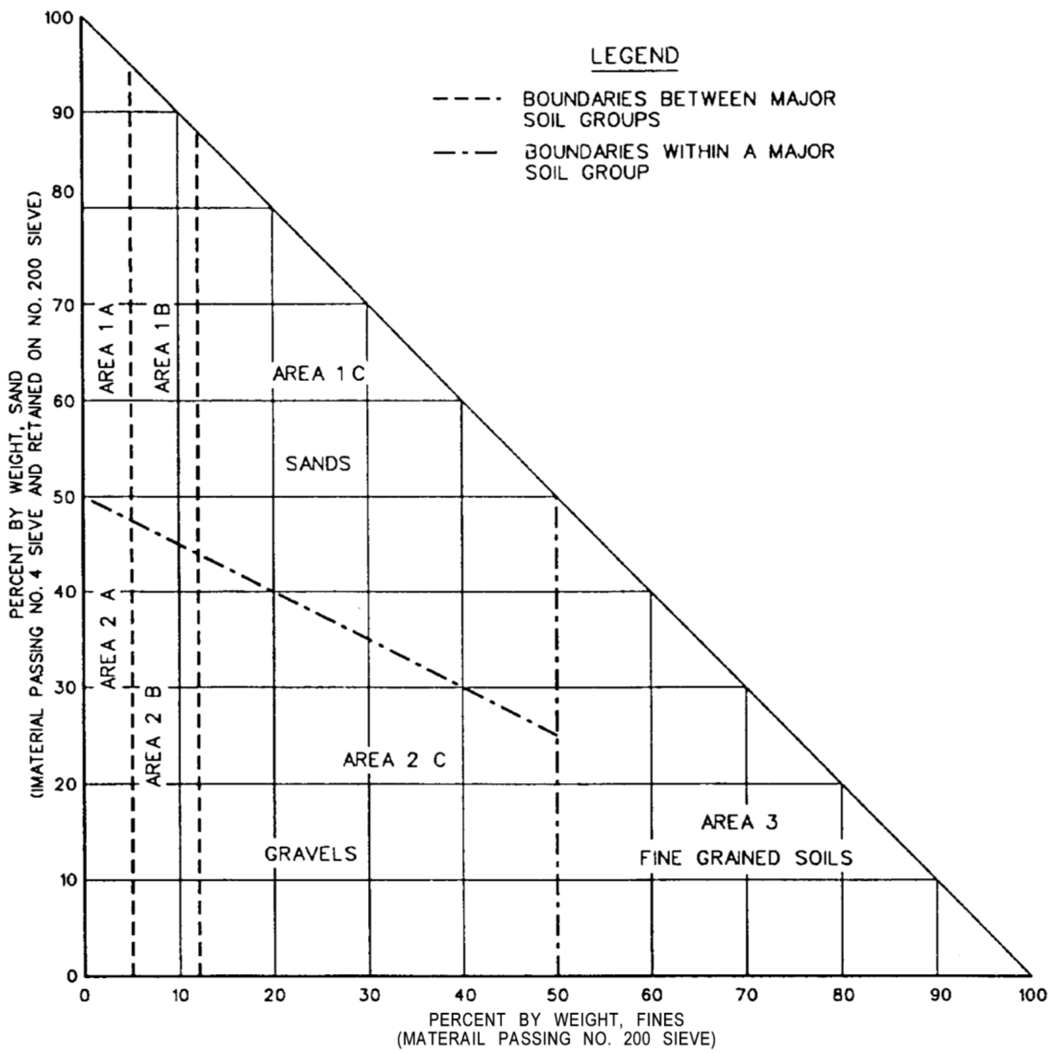


Figure 2-1. Gradation triangle for aid in selecting a commercial stabilizing agent.

2-2. Use of stabilized soils in Frost Areas.

a. *Frost considerations.* While bituminous, portland cement, lime, and LCF stabilization are the most common additives other stabilizers may be considered for pavement construction in areas of frost design.

b. *Limitations.* In frost areas, stabilized soil is only used in one of the upper elements of a pavement system if cost is justified by the reduced pavement thickness. Treatment with a

Portions ©2015 Decatur Professional Development, LLC All rights reserved (r16A18)

lower degree of additive than that indicated for stabilization (i.e., soil modification) should be used in frost areas only with caution and after intensive tests, because weakly cemented material usually has less capacity to endure repeated freezing and thawing than has firmly cemented material. A possible exception is modification of a soil that will be encapsulated within an impervious envelope as part of a membrane-encapsulated-soil-layer pavement system. A soil that is unsuitable for encapsulation due to excessive moisture migration and thaw weakening may be made suitable for such use by moderate amounts of a stabilizing additive. Materials that are modified should also be tested to ascertain that the desired improvement is durable through repeated freeze-thaw cycles. The improvement should not be achieved at the expense of making the soil more susceptible to ice segregation.

Table 2-1. Guide for selecting a stabilizing additive.

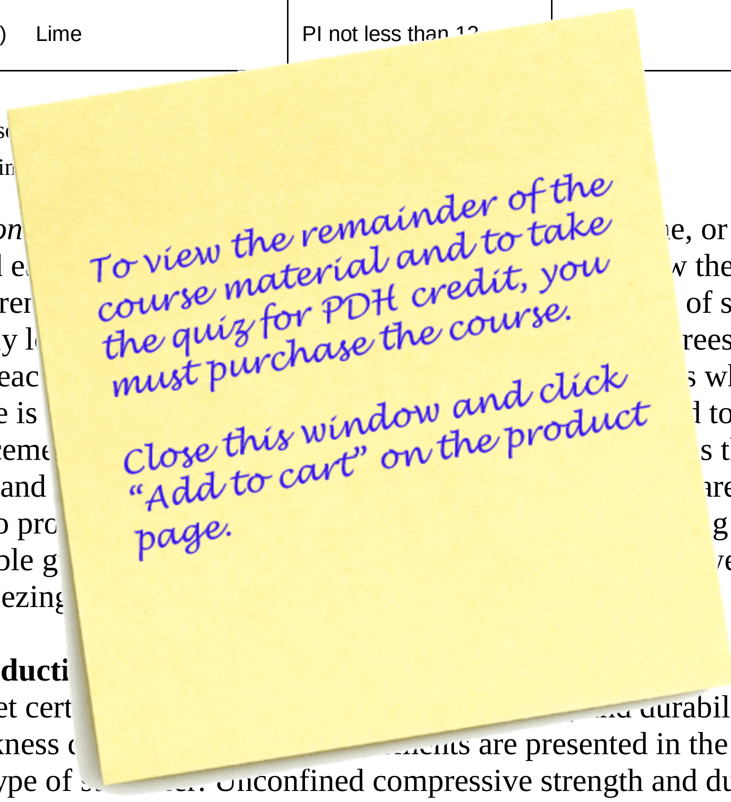
Area	Soil Class.[a]	Type of Stabilizing Additive Recommended	Restriction on LL and PI of Soil	Restriction on Percent Passing No. 200 Sieve[a]	Remarks
1A	SW or SP	1) Bituminous 2) Portland cement 3) Lime-cement - fly ash	PI not to exceed 25		
1B	SW-SM or SP-SM or SW-SC or SP-SC	1) Bitmuinous 2) Portland cement 3) Lime 4) Lime-cement-fly ash	PI not to exceed 10 PI not to exceed 30 PI not to exceed 12 PI not to exceed 25		
1C	SM or SC Or SM-SC	1) Bituminous 2) Portland cement 3) Lime 4) Lime-cement-fly ash	PI not to exceed 10 --[b] PI not less than 12 PI not to exceed 35	Not to exceed 30% by weight	
2A	GW or GP	1) Bituminous 2) Portland cement 3) Lime-cement-fly ash	PI not to exceed 25		Well-graded material only. Material should contain at least 45% by weight of material passing No. 4 sieve
2B	GW-GM or GP-GM or GW-GC or GP-GC	1) Bituminous 2) Portland cement 3) Lime 4) Lime-cement-fly ash	PI not to exceed 10 PI not to exceed 30 PI not less than 12 PI not to exceed 25		Well-graded material only. Material should contain at least 45% by weight of material passing No. 4 sieve
2C	GM or GC Or GM-GC	1) Bituminous 2) Portland cement 3) Lime 4) Lime-cement-fly ash	PI not to exceed 10 --[b] PI not less than 12 PI not to exceed 25	Not to exceed 30% by weight	Well-graded material only. Material should contain at least 45% by weight of material passing No. 4 sieve

Portions ©2015 Decatur Professional Development, LLC All rights reserved (r16A18)

Area	Soil Class.[a]	Type of Stabilizing Additive Recommended	Restriction on LL and PI of Soil	Restriction on Percent Passing No. 200 Sieve[a]	Remarks
3	CH or CL or MH or ML or OH or OL or ML-CL	1) Portland 2) Lime	LL less than 40 and PI less than 20 PI not less than 12		Organic and strongly acid soils falling within this area are not susceptible to stabilization by ordinary means

[a] See ASTM D2487 for s

[b] PI ≤ 20 + (50 – % passin



c. *Construction* ... e, or LCF should be constructed e... v the development of adequate stren... of strength gain is substantially l... rees Fahrenheit. Chemical reac... s when the soil temperature is ... d to increase for one month, or ceme... s than 40 degrees Fahrenheit and ... areas, it is not always sufficient to pro... g period as required by the applicable g... well in advance of the onset of freezing

2-3. Thickness Reducti... and subbase course materials must meet cert... durability to qualify for reduced layer thickness ... ents are presented in the sections covering design with each type of ... Unconfined compressive strength and durability requirements for bases and subbases treated with cement, lime, LF, and LCF are indicated in tables 2-2 and 2-3, respectively. For bituminous stabilized materials to qualify for reduced thickness, they must meet the strength requirements specified for the project. All stabilized materials except those treated with bitumen must meet minimum durability criteria to be used in pavement structures. There are no durability criteria for bituminous stabilized materials since it is assumed that they will be sufficiently waterproof if properly designed and constructed.

Portions ©2015 Decatur Professional Development, LLC All rights reserved (r16A18)