CHAPTER 2

PURPOSE OF STABILIZATION

2-1. Uses of stabilization. Pavement design is based on the premise that specified levels of quality will be achieved for each soil layer in the pavement system. Each layer must resist shearing within the layer, avoid excessive elastic deflections that would result in 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 enough to permit a reduction in the required thickness of the soil and surface layers.

a. Improve quality. The most common soil quality improvements through stabilization include better soil gradation, reduction of plasticity index or swelling potential, and increases in durability and in strength. It is also common to stabilize a soil by an additive in order to provide an all-weather working platform for construction operations. These types of soil quality improvement are referred to as soil modifications.

b. Reduce thickness. The tensile strength and stiffness of a soil layer can be improved through the use of additives and thereby permit a reduction in the thickness of the stabilized layer and overlying layers within the pavement system. Before a stabilized layer can be used to reduce the required thickness in the design of a pavement system, the stabilized material must meet the durability requirements given in paragraph 2-2 on various types of additive stabilization and the minimum strength requirements shown in table 2-1.

Table 2-1. Minimum Unconfined Compressive Strengths for Cement, Lime, and Combined Lime-Cement-Fly Ash Stabilized Soils

Stabilized Soil Layer	Minimum Unconfined Compressive Strength, psi[a]	
	Flexible Pavement	Rigid Pavement
Base course	750	500
Subbase course, select material or subgrade	250	200

[a]Unconfined compressive strength determined at 7 days for cement stabilization and 7 or 28 days for lime or lime-cement-fly ash stabilization (See chapter 4)

2-2. Selection of stabilizer additive. In the selection of a stabilizer additive, 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 quality improvement desired, the required strength and durability of the stabilized layer, and cost and environmental conditions.

a. The soil gradation triangle in figure 2-1 is based upon the pulverization characteristics of the soil that, when combined with certain restrictions relative to liquid limit (LL) plasticity index (PI), and soil gradation contained in table 2-2, provide guidance for the selection of the additive best suited for stabilization. Figure 2-1 is entered with the percentage of gravel (percent material retained on No. 4 sieve), sand (percent material passing No. 4 sieve and retained on the No. 200 sieve), and fines (percent material passing the No. 200 sieve) to determine the area in which the soil gradation falls. The area (1A, 2C, 3, etc.) indicated at the intersection of the three material percentages is used to enter table 2-2 to select the type of stabilizing additive considering the various restrictions and remarks. For example, a soil having a PI of 15 and containing 67 percent gravel, 26 percent sand, and 7 percent fines falls in Area 2B of figure 2-1. Table 2-2 indicates that cement, lime, lime-cement-fly ash, or bitumen could be considered. However, the PI of 15 eliminates bitumen, and the fact that only 33 percent of the material passes the No. 4 sieve indicates that lime or a combination of lime-cement-fly ash will be the better additive for stabilization.

b. The next consideration in the selection of an additive will be the use of the stabilized layer. If it is only desired to modify the properties of the soil (i.e., lower the PI and increase percent fines) so that it would qualify as a subbase or base course material, lime may well be the best additive. If, however, high strengths and good durability are required to effect a reduction in pavement thickness, the use of a lime-cement or lime-cement-fly ash combination may be the best additive. Actually, the best additive can only be determined by studies as outlined later in this manual. The success of additive stabilization depends, to a large extent, upon attaining complete and uniform distribution of the additive in the soil. This step is most critical when using bitumens or portland cement as additives. These materials work well in coarse-grained soils that pulverize more easily. Generally, as the percent fines and the PI increase, pulverization becomes more difficult, and it is harder to obtain uniform distribution of the stabilizing additive. For these types of soils, preprocessing or pretreatment with other additives may be necessary. For example, fine-grained soils may be pretreated with lime to aid in their pulverization, making mixing of a bitumen or cement additive more successful.

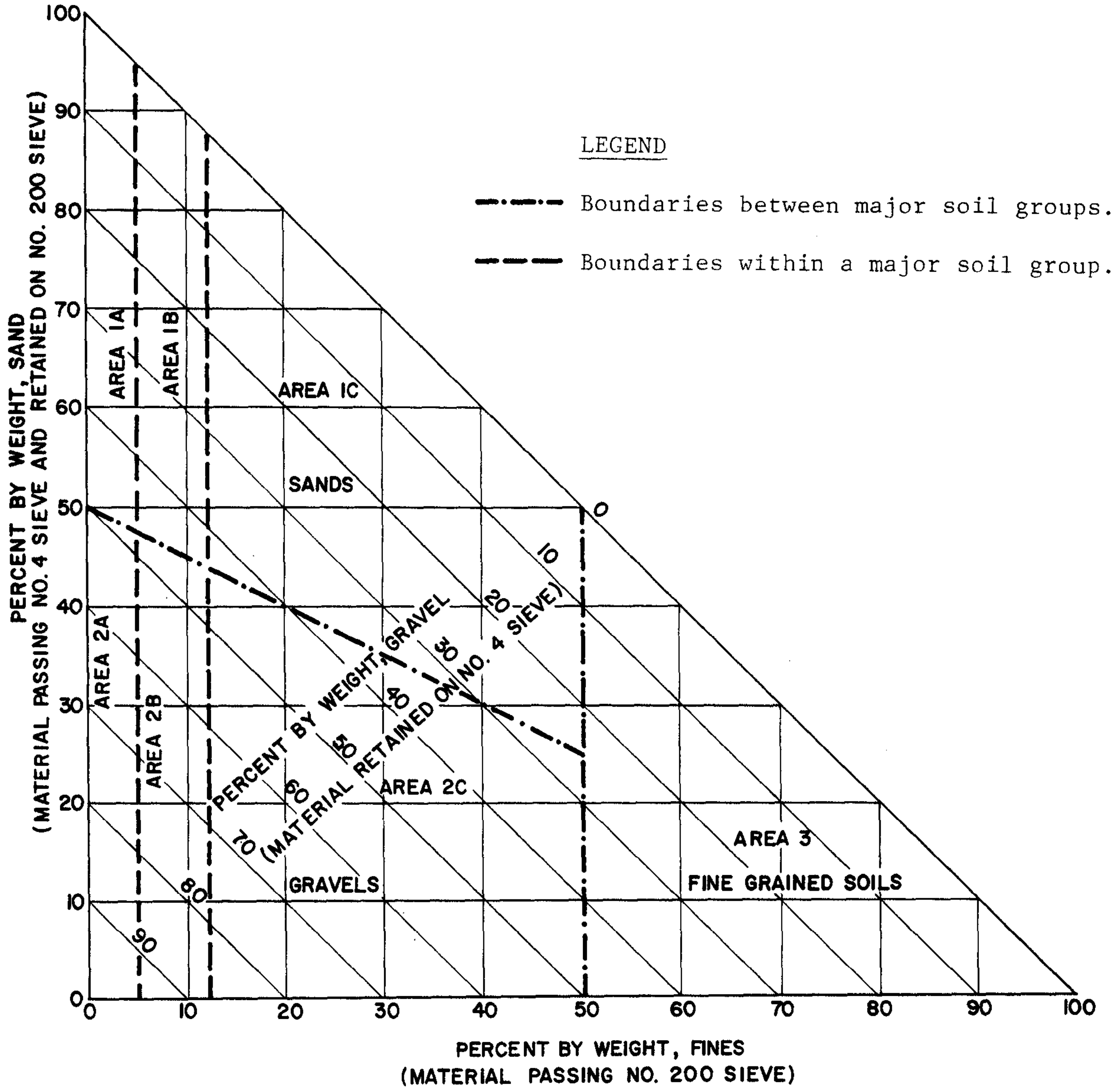

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FIGURE 2-1. GRADATION TRIANGLE FOR AID IN SELECTING A COMMERCIAL STABILIZING AGENT

Table 2-2. Guide for Selecting a Stabilizing Additive

Area	Soils 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) Bituminous	PI not to exceed 10		
		(2) Portland Cement	PI not to exceed 30		
		(3) Lime	PI not less than 12		
		(4) Lime-Cement-Fly Ash	PI not to exceed 25		
1C	SM or SC or SM-SC	(1) Bituminous	PI not to exceed 10	Not to exceed 30 percent by weight	
		(2) Portland Cement	----b		
		(3) Lime	PI not less than 12		
		(4) Lime-Cement-Fly Ash	PI not to exceed 25		
2A	GW or GP	(1) Bituminous			Well-graded material only
		(2) Portland Cement			Material should contain at least 45 percent by weight of material passing No. 4 sieve
		(3) Lime-Cement-Fly Ash	PI not to exceed 25		
2B	GW-GM or GP-GM or GW-GC or GP-GC	(1) Bituminous	PI not to exceed 10		Well-graded material only
		(2) Portland Cement	PI not to exceed 30		Material should contain at least 45 percent by weight of material passing No. 4 sieve
		(3) Lime	PI not less than 12		
		(4) Lime-Cement-Fly Ash	PI not to exceed 25		
2C	GM or GC or GM-GC	(1) Bituminous	PI not to exceed 10	Not to exceed 30 percent by weight	Well-graded material only
		(2) Portland Cement	---b		Material should contain at least 45 percent by weight of material passing No. 4 sieve
		(3) Lime	PI not less than 12		
		(4) Lime-Cement-Fly Ash	PI not to exceed 25		
3	CH or CL or MH or ML or OH or OL or ML-CL	(1) Portland Cement	LL less than 40 and PI less than 20		Organic and strongly acid soils falling within this area are not susceptible to stabilization by ordinary means
		(2) Lime	PI not less than 12		

[a] Soil classification corresponds to MIL-STD-619. Restriction on liquid limit (LL) and plasticity index (PI) in accordance with Method 103 in MIL-STD-621.

[b] $PI \quad 20 + \frac{50 - \text{percent passing No. 200 sieve}}{4}$

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2-3. Use of stabilized soils in frost areas.

a. Additives. Bitumens, portland cement, lime, and combinations of lime, portland cement, and fly ash (LCF) are the most common additives for use in stabilized soils.

b. Limitations of use. In frost areas, stabilized soil usually will be used only in a layer or layers comprising one of the upper elements of a pavement system and directly beneath the pavement surfacing layer, where the added cost of stabilization is compensated for by its structural advantage in effecting a reduction in the required thickness of the pavement system. Treatment with a lower degree of chemical stabilization 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 firmly cemented material. A possible exception is the use of a low level of stabilization to improve 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 by small amounts of a chemical additive to improve certain properties of the soil without significant cementation also should 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. Additional discussions on the use of stabilized soil in seasonal frost areas are presented in EM 1110-3-138.

c. Construction cutoff dates. For materials stabilized with cement, lime, or LCF whose strength increases with time of curing, it is essential that the stabilized layer be constructed sufficiently early in the season to allow the development of adequate strength before the first freezing cycle begins. The rate of strength gain is substantially lower at 50 degrees F. than at 70 or 80 degrees F. Chemical reactions will not occur rapidly for (1) lime-stabilized soils when the soil temperature is less than 60 degrees F. and is not expected to increase for 1 month, or (2) cement-stabilized soils when the soil temperature is less than 40 degrees F. and is not expected to increase for 1 month. In frost areas, it is not always sufficient to protect the mixture from freezing during a 7-day curing period as required by the applicable guide specifications, and a construction cutoff date well in advance of the onset of freezing conditions may be essential.