CHAPTER 4

STABILIZATION WITH LIME

4-1. Stabilization approaches. Lime can be used either to modify some of the physical properties and thereby improve the quality of a soil or to transform the soil into a stabilized mass, which increases its strength and durability. The amount of lime additive will depend upon whether the soil is to be modified or stabilized. The lime to be used may be either hydrated or quicklime, although the preponderance of stabilization is accomplished using hydrated lime, since quicklime is highly caustic and dangerous to use. The design lime contents determined from the criteria presented herein are for hydrated lime. As a guide, the lime contents determined herein for hydrated lime should be reduced by 25 percent to determine a design content for quicklime.

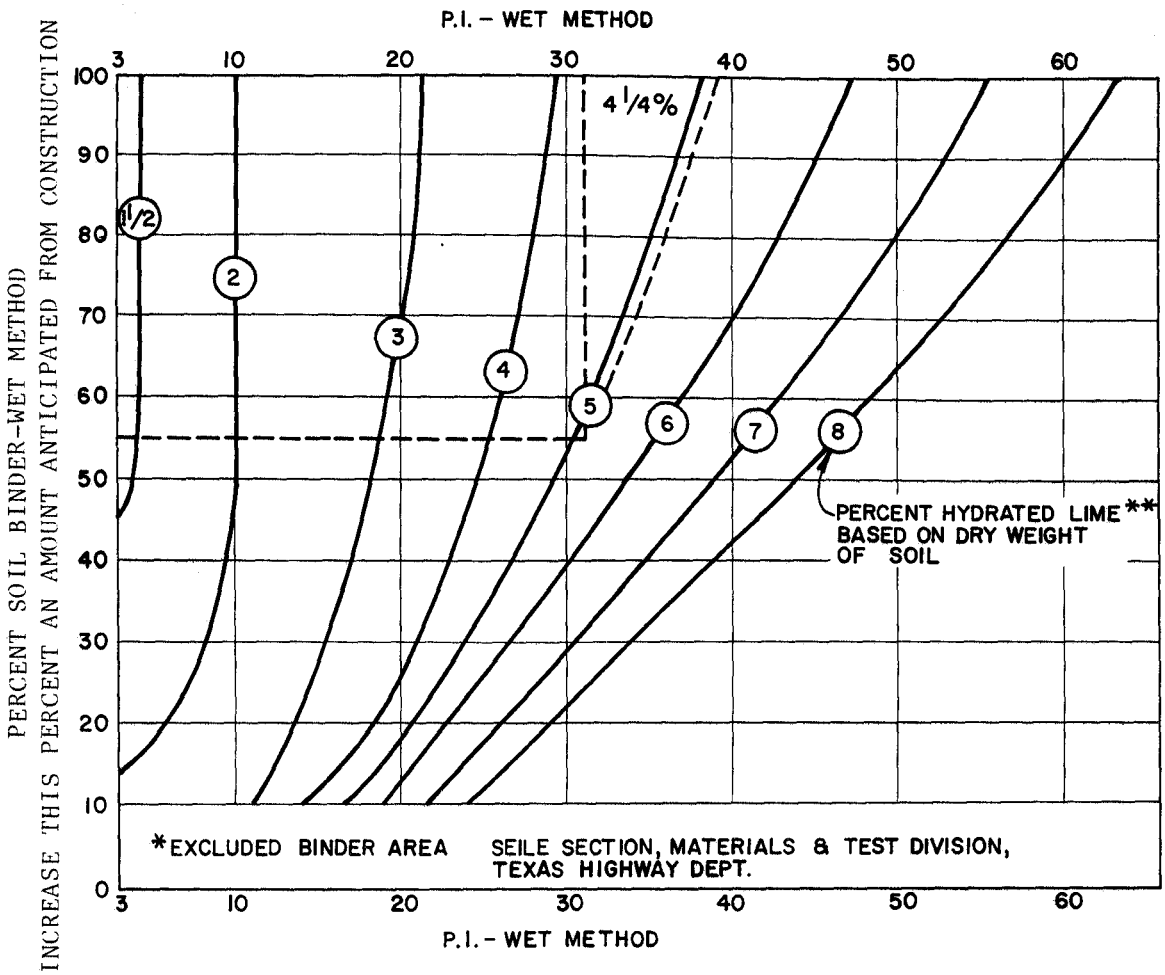
4-2. Lime content for lime-modified soils. The amount of lime required to improve the quality of a soil is determined through the same trial-and-error process used for cement-modified soils.

4-3. Lime content for lime-stabilized soils.

a. Strength requirements. To take advantage of the thickness reduction criteria, the lime-stabilized soil must meet the unconfined compressive strengths shown in table 2-1 as well as the durability requirements in table 3-5.

b. Procedures. When lime is added to a soil, a combination of reactions begins to take place immediately and is nearly complete within an hour, although substantial strength gain is not reflected for some time. These reactions result in a change in both the chemical composition and physical properties. Most lime, when placed in a water solution, has a pH of about 12.4. Therefore, the pH is a good indicator of the desirable lime content of a soil-lime mixture. The reaction that takes place when lime is introduced to a soil generally causes a significant change in the plasticity of the soil; therefore, the changes in the plastic and liquid limits also become an indicator of the desired lime content. Two methods are presented for the determination of the initial design lime content.

(1) Step 1. The preferred method is to prepare several mixtures at different lime treatment levels and determine the pH of each mixture after 1 hour. The lowest lime content producing the highest pH of the soil-lime mixture is the initial design lime content. Procedures for conducting a pH test on lime-soil mixtures are presented in appendix A. In frost areas, specimens must be subjected to the freeze-thaw test as discussed in Step 2 below. An alternate method of determining an initial design lime content is by the use of figure 4-1. Specific values required to use figure 4-1 are the PI and the percent of



EXAMPLE

1. Enter plot with Pl on top scale.
2. Follow curved line down to percent soil binder (o/o passing No. 40).
3. At intersection with percent soil binder, move vertically upward to the 100 percent soil binder line.
4. Read the percent lime represented at the intersection with the 100 percent soil binder line.
5. For soil having a Pl of 39 and 55 percent soil binder, the lime required is 4 - 1/4 percent.

* Exclude use of chart for materials less than 10 percent - No. 40 and cohesionless materials (P.I. less than 3).

** Percent of relatively pure lime usually 90 percent of more of CO and/or MG hydroxides and 85 percent or more of which pass the No. 200 sieve. Percentages shown are for stabilizing subgrades and base courses where lasting effects are desired. Satisfactory temporary results are sometimes obtained by the use of as little as 1/2 of above percentages. Reference to cementing strength is implied when such terms as "Lasting Effects" and "Temporary Results" are used.

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FIGURE 4-1. CHART FOR THE INITIAL DETERMINATION OF LIME CONTENT

material passing the No. 40 sieve. These properties are determined from plastic limit and gradation tests on the untreated soil following procedures established in MIL-STD-621.

(2) Step 2. After the initial lime content has been estimated, conduct a moisture-density test with the lime-soil mixture following the procedures for soil-cement in ASTM D 558, except that the mixture should be allowed to cure no less than 1 hour and no more than 2 hours in a sealed container before molding. Compaction will be accomplished in accordance with MIL-STD-621, Method 100, Compaction Effort Designation CE-55. The moisture-density should be determined at lime contents equal to design plus 2 and plus 4 percent for the preferred method and at design plus or minus 2 percent for the alternate method. In frost areas, cured specimens should be subjected to ASTM D 560 (but omitting wire-brushing) or other applicable freeze-thaw procedures, followed by frost susceptibility determinations in standard laboratory freezing tests (EM 1110-3-138). For mobilization, the use of ASTM D 560 may be altered to 6 cycles of 6 hours of freeze/wet - 6 hour thaw/dry. Percentages of stabilizer selected for use may be based on local performance history in lieu of these tests. For lime-stabilized or lime-modified soil used in lower layers of the base course, the frost susceptibility, determined after freeze-thaw cycling, should meet the requirements set forth for the base course (EM 1110-3-138). If lime-stabilized or lime-modified soil is used as the subgrade, its frost susceptibility, determined after freeze-thaw cycling, should be used as the basis of the pavement thickness design if the reduced subgrade strength design method is applied.

(3) Step 3. Unconfined compression tests should be performed at the design percent of maximum density on three specimens for each lime content tested. The design value would then be the minimum lime content yielding the required strength. Procedures for the preparation of lime-soil specimens are similar to those used for cement-stabilized soils with two exceptions. After mixing, the lime-soil mixture should be allowed to mellow for not less than 1 hour or more than 2 hours; after compaction, each specimen should be wrapped securely to prevent moisture loss and cured in a constant temperature chamber at 73 degrees plus or minus 2 degrees F for 28 days. For mobilization, the required curing of the sample may be reduced to 7 days at 140 F. as an approximation of the 28 day soil strength. Caution must be taken, however, since certain pozzolanic reactions may occur at higher test temperatures which would not be duplicated at construction temperatures. In addition, the relationship between age, temperature, and strength is not the same for all lime-soil mixtures. Procedures for conducting unconfined compression tests are similar to those used for soil-cement specimens except that in lieu of moist curing, the lime-soil specimens should remain securely wrapped until testing.

(4) Step 4. Compare results of the unconfined compressive tests with the criteria in table 2-1. The design lime content must be the

lowest lime content of specimens meeting the strength criteria indicated.

4-4. Lime and other additives. If lime is used as a preliminary additive to reduce the PI or alter the gradation of a soil preparatory to the addition of the primary stabilizing agent such as bitumen or cement, then the design lime content is the minimum treatment level that will achieve the desired results. For nonplastic and low-PI materials in which lime alone generally is not satisfactory for stabilization, the addition of fly ash may be needed to produce the necessary reaction.