Designation: D 4609 – 94$^{\epsilon 1}$

Standard Guide for Evaluating Effectiveness of Chemicals for Soil Stabilization[1]

This standard is issued under the fixed designation D 4609; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ϵ^1 NOTE—Paragraph 1.5 was added editorially in October 1998.

1. Scope *

1.1 This guide describes laboratory techniques for evaluating the effectiveness of chemicals for improving the engineering properties of fine-grained soils.

1.2 Effectiveness is assessed by comparing the unconfined compressive strength (UCS), moisture susceptibility, and moisture-density relationships (MD) of treated and untreated soils.

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 421 Practice for Dry Preparation of Soil Samples for Particle Size Analysis and Determination of Soil Constants[2]

D 422 Method for Particle-Size Analysis of Soils[2]

D 698 Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb (2.49-kg) Rammer and 12-in. (305-mm) Drop[2]

D 2166 Test Method for Unconfined Compressive Strength of Cohesive Soil[2]

D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[2]

D 2217 Practice for Wet Preparation of Soil Samples for Particle Size Analysis and Determination of Soil Constants[2]

D 3877 Test Methods for One-Dimensional Expansion, Shrinkage, and Uplift Pressure of Soil-Lime Mixtures[2]

D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils[2]

2.2 *AASHTO Documents:*

SPEL Special Products Evaluation List[3]

T 88 Particle Size Analysis of Soils[3]

T 89 Determining the Liquid Limit of Soils[3]

T 90 Determining the Plastic Limit and Plasticity Index of Soils[3]

T 99 Moisture-Density Relations of Soils, Using a 5.5-lb (2.5-kg) Rammer and a 12-in. (305-mm) Drop[3]

T 208 Unconfined Compressive Strength of Cohesive Soil[3]

T 265 Laboratory Determination of Moisture Content of Soils[3]

3. Summary of Guide

3.1 Chemical soil stabilizers are screened by comparing the results of a suite of engineering soil tests conducted on untreated soil and the same soil treated at appropriate amounts of the material being evaluated. Effectiveness is assessed by comparing the Atterberg limits, MD, USC, and resistance to moisture of treated and untreated soil samples.

4. Significance and Use

4.1 This guide is intended to assist users and producers of chemicals, soil modifiers, and stabilizers in the evaluation of a product's potential for improving a soil's engineering properties (such as, deformation under load, shear strength, and volume stability).

[1] This guide is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.15 on Stabilization with Admixtures.

Current edition approved Sept. 15, 1994. Published November 1994. Originally published as D 4609 – 86. Last previous edition D 4609 – 86.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] Available from American Association of State Highway and Transportation Officials, 444 N. Capitol St., NW, Suite 225, Washington, DC 20001.

***A Summary of Changes section appears at the end of this standard.**

4.2 The results of these tests can be used to make a decision to continue experimentation to assess longevity, durability, and practical value, and establish appropriate rates of application for field trials.

5. Apparatus

5.1 *Harvard Miniature Compaction Apparatus*, or apparatus for preparing remolded specimens for UCS as described in Section 4 of Test Method D 2166. For instructions on calibration, see Annex A1.

6. Sampling and Test Specimens

6.1 Obtain a 150-kg (300-lb) supply or have easy access to four or five soil and soil-aggregate materials as reference materials for stabilizer evaluations. These samples should represent two or more fine-grained soils of different clay mineralogy that are widely distributed and would be likely candidates for stabilization. One or two of the samples could represent the minus No. 10 fraction of plentiful marginal aggregates in need of beneficiation.

6.2 Review literature and test results provided by the material manufacturer or supplier.

6.3 Consult publications such as Special Products Evaluation List (SPEL) or other product evaluation or qualified products lists maintained by state highway agencies.[4]

6.4 If background search demonstrates that the subject material has promise, proceed with testing program.

7. Procedure

7.1 Obtain 20-kg (45-lb) portions of two or more soil samples selected in 6.1 for an evaluation program. This quantity of soil will provide sufficient material for tests on the untreated soil and for soil-chemical mixtures at three rates of application: the amount recommended by the supplier, and amounts more and less than recommended.

NOTE 1—All the tests recommended in 7.2 do not need to be conducted at all four rates of application (raw soil or zero rate, recommended rate, a rate more than recommended, a rate less than recommended.)

NOTE 2—The 20-kg recommended sample size is from the following scenario:

Two compaction tests (untreated and optimum rate)	6 kg
Calibration of Harvard Apparatus	1 kg
Atterberg limits (untreated and of optimum rate)	1 kg
Expansion (untreated and optimum rates)	2 kg
Unconfined Compressive Strength (untreated and three rates of treatment)	4 kg
Reserve for rerun of any test	6 kg
	20 kg

7.2 Test each untreated soil by the several test methods listed in 7.2.1 through 7.2.6. Perform the same tests on soil-chemical mixtures. For each rate of additive, five batches of soil-chemical mixture are required. Prepare a batch by combining in a mechanical mixer carefully weighed portions of soil, additive, and water. Blend thoroughly (normally for about 5 min) to produce a high degree of homogeneity. Prepare each batch and test separately as follows:

7.2.1 *Moisture Content*—Method D 2216 or T 265.

7.2.2 *Particle-Size Analysis of Soils*—Method D 422 or T 88.

7.2.3 *Liquid Limit, Plastic Limit, and Plasticity Index*—Test Method D 4318 or T 89.

7.2.4 *Moisture-Density Relations*—Test Methods D 698 (Method A) or T 99 (Method A) (see Note 3).

7.2.5 *Volume Change*—Test Methods D 3877 (see Note 4).

7.2.6 *Unconfined Compressive Strength* (see Note 5)—Test Method D 2166 or T 208.

NOTE 3—The sample may be reused and water added for successive points on the moisture-density curve if the soil material is not fragile and will not reduce in particle size due to repeated compaction or is not a heavy-textured clay into which it is difficult to incorporate water.

NOTE 4—Although this test method is for soil-lime mixtures, other stabilizing admixtures may be used.

NOTE 5—Specimen preparation and determination of moisture absorption are described in Annex A2. The moisture absorption specimens are also used for determining unconfined compressive strength, which is determined in accordance with the methods indicated in 7.2.1-7.2.6.

7.3 On approximately 3 kg (7 lb), determine optimum moisture and maximum density in accordance with Test Methods D 698.

7.4 On approximately 1 kg (2.2 lb), as described in the calibration procedure given in Annex A1, determine with the Harvard apparatus the number of tamps and the spring pressure required to duplicate the standard density obtained by Test Methods D 698.

7.5 Prepare a 500-g (1-lb) batch at optimum moisture content. As soon as the mixing is completed, divide the mixture into three approximately equal portions. Perform liquid and plastic limit tests on one portion after air-drying overnight, on another after overnight storage at high-humidity, and on the other after 7 days of curing at high humidity.

7.6 On approximately 3600 g, determine expansion in accordance with Test Methods D 3877.

7.7 On approximately 1 kg (2.2 lb), with the Harvard apparatus, prepare six five-layer specimens (required for acceptable homogeneity) compacted to Test Methods D 698 density, and determine moisture absorption and unconfined compressive strength as described in Annex A2.

8. Interpretations of Results

8.1 The recommendations in 8.1.1-8.1.5 are provided to evaluate whether a chemical additive has improved the engineering properties of fine-grained soils. Changes in one or more, but not necessarily all, of the properties in 8.1.1-8.1.5 may be used to judge effectiveness. The results of these tests may or may not be useful for determining the cost-effectiveness or practical value of the chemical treatment; that decision will most probably need to be made after additional testing and data analysis.

8.1.1 *Particle-Size Analysis*—For chemical stabilizers whose mechanism is through cementing fine particles together, a shift in the particle-size distribution curve demonstrating a coarsening or granulation of the soil may be interpreted as an improvement in engineering properties. Particle-size analysis should be performed on the treated material after an appropriate curing period has elapsed.

NOTE 6—If mechanical pulverization using Practice D 421 is too severe

[4] Illinois, Louisiana, and New Jersey are three states that publish such lists.