

Chapter 1

Materials Testing Overview

Military engineers develop and maintain—

- Transportation facilities.
- Housing and special structures.
- Sanitary facilities.
- Military defenses.

Transportation facilities include roads, railways, airports and landing strips, pipelines, and harbor structures. These structures and facilities are built on and sometimes use the local soil, so engineers must know the type and characteristics of the soil at the site to design them. For example, in designing a road or an airfield, engineers must determine whether the soil can withstand the loads to be transported, including vehicle weights. They must also determine whether soil stabilization or paving will be needed. If the road or airfield requires pavement, then the engineers establish the suitability of available aggregate materials, since speed and efficiency of construction dictate the use of nearby sources. Bituminous paving mixtures and portland-cement concrete are made at or near the work site under the control of the local engineering officers. The engineers must design the mix and test the finished product's performance. They must have basic data concerning the properties of these materials to use them effectively in construction. Such data are obtained from the tests described in this manual.

MATERIALS TESTS

The properties of all materials are determined by their chemical composition and the physical structure in which the constituent compounds are arranged. Earth minerals and cementing materials are very complex, and the nature of the forces that bind them together is poorly understood on an atomic or molecular scale. However, the strength, stiffness, stability, and resistance to wear, erosion, or weathering can be determined by tests on the bulk material. Laboratory research related to field observation and experience with such materials enables engineers to establish limiting values of the measured properties to ensure satisfactory performance in service. Materials specifications based on this research give such limits. Tests of representative samples of a particular material available for engineering use are made, and the results are compared to the specifications to decide whether the material is adequate for the intended application. Materials tests also are used to identify or classify materials on the basis of their physical properties. These tests also provide basic data on the aggregates and cements necessary for the design of bituminous mixtures, stabilized soil, or portland-cement concrete.

SOIL PROPERTIES

A soil's physical characteristics determine its usefulness to support traffic or to serve as a subgrade or foundation material. These physical characteristics include the—

- Size and shape of the individual grains.
- Grain-size distribution.
- Specific gravity.
- Compaction characteristics.

Properties of many soils depend on moisture content. Tests for the moisture limits describe the soil's plasticity characteristics. Strength tests, such as the California Bearing Ratio (CBR) and the unconfined compression test, measure load-carrying capacity directly. Tests for these properties include expedient and deliberate testing procedures. The tests are used to identify and classify the type of soil represented by the samples. With the soil accurately tested and classified, its suitability for supporting traffic as a subgrade, base, or foundation material or as an aggregate, filler, or binder for mixtures can be evaluated. The construction of subgrades and bases for pavements, embankments, and other earth structures requires continual testing during the course of the work to adjust the mixtures and the construction methods that are needed.

CLASSIFICATIONS

Tests and evaluations of test results are more easily made by using a common reference or system that has a universal interpretation. Thus, no matter who performs the tests or the evaluation, the results can be understood by anyone familiar with the system. One reference for soils used by military engineers is the Unified Soil Classification System (USCS). Unified soil classification is found in ASTM D 2487-93. All soils are divided into three major categories, two of which are based on grain size. Further subdivision distinguishes between gravel, sand, silt, clay, and organic content and between well-graded and poorly graded soils. Each of these types is symbolized by a combination of two or four letters. A more detailed explanation of the USCS is in Chapter 2, Section I, of this manual and in Chapter 5 of FM 5-410.

DESIGN REQUIREMENTS

When engineers have the completed soil classification and all other information required for the proper design of an airfield or road, they can start the design. The design requirements are covered in FM 5-430-00-1 (for roads) and FM 5-430-00-2 (for airfields).

BITUMENS

Bituminous paving mixtures consist of aggregates, filler, and bitumen binder. Aggregate sources near the construction area are tested to give data on particle-size distribution and specific gravity. These data are used in designing the mix. Testing of bituminous cements received at the mixing plant may require identifying the material, determining its suitability as a binder, or providing data for determining what aggregates and fillers are required. The

tests of bitumens described in this manual are field-identification procedures to expedite the use of the material until more detailed tests can be performed.

CONCRETE

Portland-cement concrete is a mixture of fine and coarse aggregates, portland cement, and water. The cement and water chemically react to form compounds that hold the aggregates in a strong, rock-like mass. Concrete is made in mixing plants, field mixers, or truck mixers near or at the construction site. The quality of the concrete produced depends on the proper mix design to achieve the desired workability of the fresh concrete and strength of the hardened material. This manual describes tests of aggregates and fresh and hardened concrete, with instructions for using test data in mix design and control. Detailed information about concrete can be found in FM 5-428.

STABILIZATION

An accurate soil description, determined from test data, is necessary to determine whether its properties must be improved by stabilization to make it adequate for supporting traffic or for use as a base course. Test results indicate the method of stabilization and materials to be used and verify the adequacy of the stabilized soil.

EQUIPMENT

The equipment for all materials tests given in this manual consists of three sets:

- The soil test set.
- The asphalt test set.
- The concrete test set.

The soil test set is considered the basic set; the other two sets are used with it. In selected operations (such as control testing at a concrete batch plant), the concrete test set can be used without the soil test set. Certain items listed as part of the sets are not issued with the sets but must be requisitioned separately. Some of the test methods (such as the specific gravity of solids, the hydrometer analysis, and the shrinkage limit) describe items of equipment that are not issued with the test sets but would be available locally or from commercial sources.

TEST SET, SOIL (SC 6635-98-CL-E02)

The soil test set is the basic set for performing soil tests including sieve analysis, moisture content, Atterberg limits, CBR, and soil trafficability. The separately packaged soil-trafficability test set (SC 6635-97-CL-E01) is included in this set. Items such as DA forms, pencils, tracing paper, labels and tags, towels, twine, and wax are not issued initially with the set but must be requisitioned separately by stock or form number.

TEST SET, ASPHALT (SC 6635-98-CL-E03)

The asphalt test set is issued in three chests:

- Laboratory-centrifuge chest.

- Miscellaneous-equipment chest.
- 1,1,1-trichloroethane chest.

This set is not complete within itself; therefore, it must be used with the soil test set. Items such as forms, brushes, cloths, and chemicals (alcohol, sodium hydroxide, and 1,1,1-trichloroethane) are not issued with the set but must be requisitioned separately. The 1,1,1-trichloroethane is a hazardous substance. Numerous substitute agents are available. Consult your installation environmental office to find out which substitute is available and best suited to your needs.

TEST SET, CONCRETE (SC 6635-98-CL-E04)

The concrete test set is issued in three chests:

- Beam-testing-machine chest.
- Collapsible-steel-forms chest.
- Miscellaneous-equipment chest.

This set normally is used with the soil test set. Chemicals, DA forms, and some other items are not issued with the set but must be requisitioned separately.

NUCLEAR MOISTURE DENSITY GAUGE

The nuclear moisture density gauge (national stock number [NSN] 6635-01-030-6896) is used to perform moisture and density tests. The gauge is issued in its case with all necessary equipment except test forms. Forms should be locally reproduced from the United States Army Engineer School (USAES) or from manufacturers' samples. This equipment requires special storage considerations and licensing of operators. The Nuclear Regulatory Commission (NRC) requires that any unit that owns this equipment must have a qualified local radiation protection officer (RPO) and a licensed operator before it can be operated. Information concerning this equipment should be addressed to the USAES or to the Tank-automotive and Armaments Command (TACOM).

SAFETY AND ENVIRONMENTAL CONSIDERATIONS

Safety and environmental awareness must be planned and integrated as part of all military operations to protect personnel and the environment. Some of the tests described in this manual will require special safety equipment that may not be included in the test sets. Some of the tests in this manual will require the use of environmentally hazardous materials. Special care must be taken to minimize the potential harmful effects of exposure to hazardous substances. Violation of environmental laws through improper storage, handling, or disposal of hazardous materials can result in severe penalties, including fines and imprisonment. Proper training is necessary to ensure that all personnel performing materials tests know how to properly handle and dispose of the substances listed in the test procedures. If you are unsure what materials are hazardous or how to dispose of materials properly, or if you need training, consult your unit or post environmental representative.

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