

Laboratory Testing

Laboratory testing is a critical component of geotechnical investigations, providing essential data for soil and rock classification, strength assessment, permeability, and other engineering properties. This chapter outlines the key laboratory tests performed for geotechnical evaluations and provides guidance on documentation and reporting. A table of accepted test procedures, including applicable AASHTO and ASTM standards, is included for reference.

While this chapter outlines the commonly utilized laboratory tests, specific project conditions or unique site characteristics may necessitate additional or specialized testing not explicitly detailed herein. Such requirements should always be determined in consultation with the project geotechnical engineer and laboratory personnel.

All laboratory testing should be performed in AASHTO-accredited laboratories following standardized procedures.

Documentation and Reporting of Laboratory Test Results

Proper documentation and reporting of laboratory test results are crucial for geotechnical design and construction. The following guidelines should be followed:

- **Standard Formats for Lab Reports** – Laboratory data sheets and summary tables should adhere to standardized formats for consistency and clarity in reporting test results.
- **Interpretation of Test Results** – Test data should be analyzed and interpreted thoroughly within the context of project-specific geotechnical requirements.
- **Electronic Data Management** – Efficient and accurate management of laboratory test data is essential for project continuity, long-term data accessibility, and integration with broader design and analysis workflows. Results should be integrated into geotechnical reports and plans using appropriate digital tools and databases to ensure accessibility and traceability.
- **Quality Control of Test Data** – Rigorous quality control and assurance procedures, including regular calibration and verification of testing equipment, should be performed to maintain the accuracy and reliability of test results.

Table of Laboratory Tests and Standards

This section provides a quick reference guide to the laboratory tests discussed in this chapter, including their common official names and the primary AASHTO and ASTM standards under which they are typically performed.

Important Notes:

- **Latest Standards:** Standards are continuously updated. Always refer to the latest published editions from AASHTO and ASTM.
- **Multiple Standards:** Some tests may have multiple relevant standards or variations. The ones listed are generally the most common or primary.

| Common Test Name | Official | AASHTO Standard(s) | ASTM Standard(s) |
|---|---|---------------------------|-------------------------|
| Soil Classification (USCS, AASHTO) | Unified Soil Classification System (USCS) / AASHTO Soil Classification System | M145 | D2487 / D3282 |
| Particle Size Distribution (Sieve Analysis) | Sieve Analysis of Soils | T27 | D6913 |
| Particle Size Distribution (Hydrometer Analysis) | Particle-Size Analysis of Soils (Hydrometer) | T88 | D7928 |
| Atterberg Limits | Liquid Limit, Plastic Limit, and Plasticity Index of Soils | T89 / T90 | D4318 |
| Moisture Content | Water Content of Soil and Rock by Mass | T265 | D2216 |
| Specific Gravity | Specific Gravity of Soil Solids by Water Pycnometer | T100 | D854 |
| Organic Content Testing | Organic Content of Soils by Loss on Ignition | T267 | D2974 |
| Unit Weight Determination | Density and Unit Weight of Soil Specimens | --- | D7263 / D4718 |
| Direct Shear Test | Direct Shear Test of Soils Under Consolidated Drained Conditions | T236 | D3080 |
| Triaxial Compression Tests (UU) | Unconsolidated-Undrained Compressive Strength of Cohesive Soils in Triaxial Compression | T294 | D2850 |
| Triaxial Compression Tests (CU) | Consolidated-Undrained Triaxial Compression Test for Cohesive Soils | T297 | D4767 |
| Triaxial Compression Tests (CD) | Consolidated-Drained Triaxial Compression Test for Soils | T296 | D7181 |
| Unconfined Compressive Strength (UCS) of Cohesive Soils | Unconfined Compressive Strength of Cohesive Soil | T208 | D2166 |
| Vane Shear (Laboratory) | Laboratory Miniature Vane Shear Test for Cohesive Soil | --- | D4648 |
| One-Dimensional Consolidation Test | One-Dimensional Consolidation Properties of Soils | T216 | D2435 |
| Swell Potential | Swell Potential of Cohesive Soils | --- | D4546 |
| Proctor Compaction (Standard) | Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop | T99 | D698 |
| California Bearing Ratio (CBR) | Bearing Ratio of Laboratory-Compacted Soils | T193 | D1883 |
| Unconfined Compressive Strength (UCS) of Rock | Unconfined Compressive Strength of Intact Rock Core Specimens | --- | D7012 (Method A) |
| Point Load Strength Index | Point Load Strength Index of Rock | --- | D5731 |

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| Acid-Producing Material (APM) Testing | Refer to APM Chapter | --- | --- |
| Rock Durability Testing (Slake Durability) | Slake Durability of Shales and Similar Weak Rocks | --- | D4644 |
| Rock Durability Testing (Sodium Soundness) | Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate | T104 | C88 |

Soil Classification and Index Properties

Proper classification of soils is fundamental to understanding their engineering behavior. The following tests are used to determine soil classification and index properties:

- **Soil Classification** (USCS, AASHTO) – Utilizes the results of other index property tests to classify soils according to recognized systems (e.g., Unified Soil Classification System or AASHTO Soil Classification System).
- **Particle Size Distribution** (Sieve and Hydrometer Analysis) – Determines the grain size distribution of soils.
- **Atterberg Limits** (Liquid Limit, Plastic Limit, Plasticity Index) – Defines the plasticity characteristics of cohesive soils.
- **Moisture Content** – Measures the water content of soil samples.
- **Specific Gravity** – Determines the relative density of soil solids.
- **Organic Content Testing** – Identifies the presence and percentage of organic materials in soil.
- **Unit Weight Determination** – Evaluates the density of soil in both natural and compacted states.

Shear Strength Testing

Strength testing is necessary to evaluate the load-bearing capacity and stability of soil and rock materials. The following tests are typically conducted:

- **Direct Shear Test** – Determines shear strength parameters under controlled normal loads.
- **Triaxial Compression Tests** (Unconsolidated-Undrained, Consolidated-Undrained, Consolidated-Drained) – Measures strength under different drainage and confinement conditions.
- **Unconfined Compressive Strength (UCS) of Cohesive Soils** – Measures the compressive strength of cohesive soils.
- **Vane Shear (Laboratory)** – Used for estimation of shear strength in soft clays in a laboratory setting.

Consolidation and Compressibility Testing

These tests evaluate the time-dependent settlement characteristics of fine-grained soils and their potential for volume change under varying moisture conditions.

- **One-Dimensional Consolidation Test** – Measures the magnitude and rate of consolidation (settlement) of cohesive soils under applied loads.
- **Swell Potential** – Determines the volumetric expansion or pressure generated by expansive soils when subjected to changes in moisture content.

Compaction and Pavement Material Tests

Compaction characteristics of soils affect their density, strength, and stability, particularly for pavement and fill applications. The following tests are commonly performed:

- **Proctor Compaction (Standard)** – Determines the optimum moisture content and maximum dry density of soil for compaction.
- **California Bearing Ratio (CBR)** – Assesses the load-bearing capacity of subgrade materials for pavement design.

Rock Testing

Laboratory testing of rock provides essential data for characterizing rock mass behavior, assessing strength, and designing foundations and excavations in rock. The following tests are commonly conducted on rock specimens:

- **Unconfined Compressive Strength (UCS) of Rock** – Measures the compressive strength of intact rock core specimens.
- **Point Load Strength Index** – Provides an indirect measure of rock strength, often used for preliminary assessment or large numbers of samples.

Specialty Testing

In certain geologic settings or for specific project requirements, specialized laboratory testing may be required to assess unique soil and rock characteristics beyond routine engineering properties. These tests include:

- **Acid-Producing Material (APM) Testing** – Identifies the potential for rock or soil to generate acidic drainage, which can impact concrete and steel. (Refer to the dedicated APM chapter in this manual for detailed guidance).
- **Soluble Sulfate Testing** – Assesses the sulfate content in soil or groundwater to evaluate risks of sulfate-induced heave in foundations and pavements.
- **Rock Durability Testing (Slake Durability, Sodium Soundness)** – Evaluates the resistance of rock materials to weathering and disintegration when exposed to cycles of wetting and drying.