

Technical Requirements for Construction Materials Testing

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INTRODUCTION

This document describes accreditation requirements for laboratories operating in the Construction Materials Testing (CMT) field. It was prepared by the Construction Materials Testing Subcommittee of the National Association for Laboratory Accreditation Cooperation (NACLA) Technical Requirements Committee and reflects requirements established by the Federal Highway Administration, Federal Aviation Administration, United States Army Corps of Engineers, and the Bureau of Reclamation to meet their needs for competent construction materials services.

NACLA CMT Subcommittee members include both government and private sector representatives: Michael Rafalowski, Federal Highway Administration; David Cross, Federal Aviation Administration; Bradley James, United States Army Corps of Engineers; Tim Dolen, Bureau of Reclamation; Keith Lane, Connecticut Department of Transportation; Warren Merkel, American Association for Laboratory Accreditation; Peter Spellerberg, American Association of State Highway and Transportation Officials (AASHTO) Materials Reference Laboratory; Patrick McCullen, International Accreditation Service Inc.; Carroll Brickenkamp, National Voluntary Laboratory Accreditation Program; Richard Kistner, American Council of Independent Laboratories; and Mary Jo DiBernardo, National Institute of Standards and Technology (NIST).

NIST is publishing this document as a public service pursuant to the Institute's responsibilities under the National Technology Transfer and Advancement Act of 1995, which directed NIST to "coordinate Federal, State, and local technical standards activities and conformity assessment activities, with private sector technical standards activities and conformity assessment activities, with the goal of eliminating unnecessary duplication and complexity in the development and promulgation of conformity assessment requirements and measures."

Internationally accepted criteria for the operation of accreditation bodies and accreditation of laboratories - ISO/IEC Guide 58, *Calibration and Testing Laboratory Accreditation Systems – General Requirements for Operation and Recognition* and ISO/IEC 17025 *General Requirements for the Competence of Testing and Calibration Laboratories* - and guidance documents developed by the American Society of Testing and Materials International Corporation (ASTM) committees form the basis for this document. The document contains additional requirements to both ISO/IEC Guide 58 and ISO/IEC 17025 specific to the CMT field as stipulated to meet U.S. Federal agency requirements. Technical requirements contained herein are related to the AASHTO document R18, "Recommended Practice for Establishing and Implementing a Quality System for Construction Materials Testing Laboratories."

This document is organized such that paragraph numbering is in line with the paragraphs (sections and subsections) of ISO/IEC 17025.

PURPOSE

The purpose of this document is to define the process for third-party accreditation of testing laboratories and to specify the minimum criteria for those accreditations to meet requirements of the Federal Highway Administration, Federal Aviation Administration, United States Army Corps of Engineers, and the Bureau of Reclamation. This manual is not intended as a restatement of ISO/IEC 17025. In addition, there are also additional requirements for two elements of ISO/IEC Guide 58.

The additions, or modifications, or where clarifications are considered necessary, are only listed. Table I provides quick reference to those sections for which additional requirements are listed.

Accreditation is defined in ISO/IEC Guide 2 as the formal recognition that a laboratory is competent to carry out specific types of tasks. "Formal recognition" comes about as the result of a full laboratory assessment. Assessment includes quality system and documentation review as well as on-site assessment of technical competence. Accreditation is granted for the specific tests/calibrations that are documented in the Scope section of the Letter of Accreditation.

For the purposes of this document an accredited laboratory is one that complies with ISO/IEC 17025 and the additional requirements of this document. Compliance is determined by the results of assessment and documented in the Letter of Accreditation from a recognized accrediting body.

SCOPE

Accreditation is defined in ISO/IEC Guide 2 as the formal recognition that a laboratory is competent to carry out specific types of tasks. "Formal recognition" comes about as a result of a full laboratory assessment. Assessment includes quality system and documentation review as well as on-site assessment of technical competence. Accreditation is granted for the specific tests/calibrations that are documented in the Scope section of a Letter of Accreditation issued by an independent third party.

The scope of the CMT field, as described in this document, includes the following materials areas: concrete and aggregates, cement, soils, bituminous materials, roofing materials, masonry, steel, and non-destructive tests related to construction. Accreditation may be offered for one or more tests in each area. Additional areas may be added upon request. As an option, a laboratory may also obtain accreditation for one or more of the following construction materials engineering standards:

ASTM E329	Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction
ASTM C1077	Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM D3666	Specification for Minimum Requirements for Agencies Testing and Inspecting Bituminous Paving Materials
ASTM D3740	Practice for Evaluation of Agencies Engaged in Testing and/or Inspection of Soils and Rock as Used in Engineering Design and Construction
ASTM C1093	Practice for Accreditation of Testing Agencies for Unit Masonry
ASTM E1212	Practice for Establishment and Maintenance of Quality Control Systems for Nondestructive Testing Agencies
ASTM E543	Practice for Evaluating Agencies that Perform Nondestructive Testing
ASTM A880	Practice for Criteria for Use in Evaluation of Testing Laboratories and Organizations for Examination and Inspection of Steel, Stainless Steel and Related Alloys

When accredited for one of these engineering standards, the laboratory's scope of accreditation shall indicate "Construction Materials Testing".

Table 1. "Clauses with Additional Requirements"

Clause	Topic
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ISO/IEC Guide 58

4.3.2	Quality Manual
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6.2	Assessment
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6.7.2	Surveillance and Reassessment of Accredited Laboratories
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ISO/IEC 17025

4.1	Organization
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4.2.1	The Quality Manual
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4.12	Control of Records
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4.14	Management Reviews
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5.2	Personnel
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5.5	Equipment
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5.9	Assuring the Quality of Test and Calibration Results
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5.10.1	Reporting Results
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Additional Requirements to ISO Guide 58 for Accreditation Bodies

This section defines both general and specific requirements for the application of the ISO/IEC Guide 58 to accreditation bodies in the CMT field.

The Accreditation Body in developing and implementing its accreditation program shall follow the requirements in the NACLA Recognition Document and ISO/IEC Guide 58. In addition, the following requirements shall also apply.

4.3.2 Quality Manual

The Accreditation Body shall, as a minimum, hold annual meetings with all assessors in the appropriate construction/test area to discuss complaints, inconsistencies in assessments, changes in procedures, etc.

6.2 Assessment

The assessor shall verify that the laboratory has the appropriate equipment, calibration and verification records, test procedures, and trained personnel to perform every procedure in the proposed scope.

The assessor shall observe a complete demonstration of each test on the scope that appears on the list of test procedures listed in Appendix B. The assessor shall use checklists to record all findings. Test procedures shall be performed with applicable materials.

The assessor shall observe a sampling of all test procedures from areas not covered by test procedures listed in Appendix B. For those tests not listed in Appendix B, the assessor must also observe a complete demonstration of at least 25% of the tests within a particular discipline. The assessor shall use checklists to record all findings.

The accreditation body shall verify that the laboratories' testing equipment used in the test procedures listed in Appendix B meet the standards. The accreditation body shall either own all the appropriate equipment for this verification or have a third party provide the equipment. A recommended list of equipment that can be used for verification is contained in Appendix C. The assessor has the option of either verifying the test equipment him/herself or observing laboratory personnel verify the test equipment with the equipment that is owned or controlled by the accreditation body. This program shall ensure that the measurements made are traceable to the International System of Units (SI) or if appropriate a consensus standard.

6.7.2 Surveillance and Reassessment of Accredited Laboratories

The accreditation body shall evaluate a laboratory's status at least annually. The annual evaluation shall, at a minimum, take into consideration the laboratory's performance in proficiency testing programs.

Additional Requirements to ISO/IEC 17025 for Laboratories

This section defines both general and specific requirements in addition to those contained in ISO/IEC 17025. Paragraph numbering is aligned with 17025. As a minimum, it is expected that all requirements of 17025 be satisfied, with the exception of clauses that can be justified, and documented, as "Not Applicable" to a particular laboratory.

The requirements for the CMT field are based on the applicable requirements of the specific standards for which accreditation is sought. The requirements of AASHTO R18, *Establishing and Implementing a Quality System for Construction Materials Testing Laboratories*, were considered in developing this document.

Each of the following statements should be understood to be mandatory laboratory requirements.

4 Management Requirements

4.1 Organization

- 4.1 Operational position descriptions shall identify the position and include a description of the duties associated with the position, required skills, education and experience, and supervision exercised and received.

4.2 Quality System

- 4.2.1a The quality manual or related documentation shall contain a brief biographical sketch, noting the education, work experience, licensure, certifications, and current position of supervisory technical staff involved in testing areas included in the scope of accreditation.

4.12.2 Technical Records

- 4.12.2.1a The laboratory shall retain results of participation in proficiency sample programs including data sheets, summary reports, and documentation describing steps taken to determine the cause of outlying results and the corrective actions taken.
- 4.12.2.1b Records pertaining to testing, equipment calibration and verification, test reports, Internal audits and management reviews, proficiency sample testing, test Technician training and evaluation, and personnel shall be retained by the laboratory in a secure location for a minimum of three (3) years.
- 4.12.2.1c The laboratory shall maintain calibration and verification records for all

equipment used for the correct performance of the tests on the scope of accreditation. Such records shall include:

- a) detailed results of the work performed (dimensions, mass, force, frequency, temperature, time, etc.)
- b) description of the equipment calibrated or verified including model and serial number or other acceptable identification
- c) date the work was done
- d) identification of the individual performing the work
- e) identification of the calibration or verification procedure used
- f) the previous calibration or verification date, the next due date, and the identification of any in-house calibration or verification device used (including serial numbers, lab numbers or other identification used to establish traceability of items such as standard masses, proving rings, standard thermometers, balances, calipers, etc.)

4.14 Management Reviews

- 4.14 The laboratory's management shall review the quality system established to satisfy the requirements of this standard at least annually. In addition, the laboratory shall also have a policy to perform a management review when there is a reason to suspect problems in the quality of the CMT work, such as technical complaints, proficiency testing results, etc.

5. Technical Requirements

5.2 Personnel

- 5.2.2a The training procedure shall indicate what position(s) or employee(s) is responsible for the laboratory's training program and maintenance of training records, shall describe the distribution of records to management and, shall identify the location of resulting records.
- 5.2.2b The training procedure shall also describe the method(s) used to evaluate staff competency to ensure that each test covered by the scope of accreditation is performed in accordance with standard procedures. This description shall include the frequency of evaluations for each technician and indicate what position(s) or employee(s) is responsible for evaluating staff competency and maintaining records, shall describe the distribution of records to management and shall identify the location of resulting records. The procedure shall ensure that each technician performing each test method is evaluated.

- 5.2.2c Training records shall include a form for recording training and competency evaluation activities summarized under 5.2.2 including the name of the trainee, name of the evaluator, test method evaluated, the dates, and results.

5.5 Equipment

- 5.5.5a The laboratory's records shall include a list(s) giving a general description of equipment for performing the test methods on the scope of accreditation which require calibration or verification, a reference to the calibration or verification procedure used, and the location of the calibration or verification records.
- 5.5.5b The test equipment listed in Tables 2-6 Appendix A shall be calibrated or verified at intervals no greater than those shown in those Tables unless the laboratory has documentation that a different calibration/verification interval is appropriate.
- 5.5.5c Each piece of equipment shall be labeled to identify the specific calibration due date or usage equivalent.
- 5.5.6 The laboratory shall have detailed written procedures for all in-house calibration and verification activities not addressed in standards. These procedures shall indicate the equipment required to perform the calibration or verification.

5.9 Assuring the Quality of Test and Calibration Results

5.9a Proficiency Testing

Applicants under Construction Materials Testing are required to participate in all the available proficiency testing programs for the tests included in their scope of accreditation. Enrollment in the following programs related to a laboratory's scope of accreditation satisfies this requirement.

Proficiency Sample Programs of the Cement and Concrete Reference Laboratory
(For further information, call 301-975-6704.)

- A. Concrete Applicable Standards: ASTM C39, C138, C143, C173, and C192.
- B. Cement Applicable Standards: ASTM C109, C114, C115, C151, C185, C186, C187, C188, C191, C204, C266, C430, and C451.
- C. Masonry Applicable Standards: ASTM C91, C109, C151, C185, C187, C188, and C266.

Proficiency Sample Programs of the AASHTO Materials Reference Laboratory
(For further information, call 301-975-6704.)
(AASHTO equivalent standards are in parentheses after each ASTM designation)

- D. Bituminous Applicable Standards: ASTM D5 (AASHTO T49), D70 (T228), D92 (T48), D1754 (T179), D2042 (T44), D2170 (T201) D2171 (T202), D2872 (T240).
- E. Soils Applicable Standards: ASTM D422 (AASHTO T88), D698 (T99), D854 (T100), D2844 (T190), D4318 (T89 & T90).
- F. Aggregate Applicable Standards: ASTM C88 (AASHTO T104), C117 (T11), C127 (T85), C128 (T84), C131 (T96), C136 (T27).
- G. Bituminous Applicable Standards: ASTM D5 (AASHTO T49),
Concrete D1559 (T245), D1560 (T246), D1856 (T170), D2041 (T209),
 D2170 (T201), D2171 (T202), D2172 (T164), D2726 (T166),
 D3203 (T269), D5444 (T30).

5.9b If a laboratory's results are deemed outliers or unacceptable (ratings of "0" or "1" for the above programs), then the laboratory shall promptly investigate and determine the cause(s) for such unacceptable results, correct any problems identified, and report to AB.

5.10 Reporting Results

5.10.1 General

5.10.1 The laboratory shall have a procedure that describes methods used to prepare, check and amend test reports. The procedure shall identify the individual(s) responsible for maintaining test reports, shall describe the distribution of test reports, and shall identify the location of stored test reports.

Appendix A: Equipment Calibration and Verification Intervals

TABLE 2 Bituminous Materials Test Equipment

Equipment—Test Method	Requirement	Interval (Month)
Saybolt Viscometers—T 59, D 244	Calibrate	36
Mechanical Shakers	Ck. Sieving Thoroughness	12
Gen. Purpose Balances, Scales & Weights	Verify	12
Test Thermometers—T 201, T 202, T 209, T 228 T 49, T 51, T 295, D 5, D 70, D 113, D 2041, D 2170, D2171, D 3142	Calibrate	6
Analytical Balances & Weights	Verify	24
Comp. Test. Mach.—T 165, T 167, T 245, T 246, D 1074, D 1075, D 1959, D 1560	Verify Load Indications	12
Mechanical Compactor—T 245, D 1559	Calibrate	36
CA Kneading Compactor—T 247, D 1561	Calibrate	24
Timers—T 201, T 202, D 2170, D 2171	Ck. Accuracy	6
Ovens	Verify Temp. Settings	4
Penetrometer and Accessories—T 49, D 5	Ck. Dial & Timer Acc. & Needle Cond.	6
Ductility Machine—T 51, D 113	Ck Molds & Speed of Travel	12
TFO & RTFO Oven—T 179, T 240, D 1754, D 2872	Shelf/Carriage Ck. Rotation Speed & Temp.	12
Vacuum System—T 209, D 2041	Ck. Pressure	12
Sieves	Coarse ($\geq 4.75\text{mm}$): Ck. Openings & Physical Condition Fine ($< 4.75\text{ mm}$): Ck. Physical Condition	6
Molds, Followers, Calib Cylinders—T 246, T 247 D 1560, D 1561	Ck. Critical Dimensions	12
Molds, Manual Comp. Hammers, Breaking Heads—T 245, D 1559	Ck. Critical Dimensions & Mass of Hammer	12
Molds & Plungers —T 167, D 1074	Ck. Critical Dimensions	12
Brass Rings & Assembly—T 53, D 36	Ck. Critical Dimensions	12
Pycnometers—T 228, D 70	Ck. Critical Dimensions & Phys. Cond.	12
Collars & Floats—T 50, D 139	Ck. Critical Dimensions	12
Flowmeters—T 170, T 240, D 1856, D 2872	Calibrate	12
Flash Cups—T 48, T 79, D 92, D 3143	Ck. Critical Dimensions	12

TABLE 3 Soils Test Equipment

Equipment—Test Method	Requirement	Interval (Month)
Mechanical Shakers	Ck. Sieving Thoroughness	12
Gen. Purpose Balances, Scales & Weights	Verify	12
Compression or Loading Device—T 193, T 208, T 216, T 236, T 296, T 297, D 1883, D 2166, D 2435, D 2850, D 3080, D 4767	Verify Load Indications	12
Mechanical Compactor—T 99, T 180, D 698, D 1557	Calibrate	12
CA Kneading Compactor—T 190, D 2844	Calibrate	24
Ovens	Verify Temperature Setting(s)	4
Vacuum System—T 100, D 854	Ck. Pressure	24
Molds—T 99, T 134, T 135, T 136, T 180, T 190, T 193, D 698, D 558, D 559, D 560, D 1557, D 1883, D 2844	Ck. Critical Dimensions	12
Manual Hammer—T 99, T 180, D 698, D 1557	Ck. Wt. & Critical Dimensions	12
Sieves	Coarse (≥ 4.75 mm): Ck. Openings & Physical Condition Fine (< 4.75 mm): Ck. Physical Condition	6
Liquid Limit Device—T 89, D 4318	Ck. Wear & Critical Dimensions	12
Grooving Tool—T 89, D 4318	Ck. Critical Dimensions	12
Hydrometers—T 88, D 422	Ck. Critical Dimensions	24
Straightedge—T 99, T 134, T 135, T 136, T 180, D 698, D 558, D 559, D 560, D 1557	Ck. Planeness of Edge	6
Weighted Foot Assembly—T 176, D 2419	Ck. Weight	12
CBR Annular and Slotted Weights—T 193, D 1883	Ck. Weight	12
CBR Penetration Piston—T 193, D 1883	Ck. Diameter	12
Standard Metal Specimen—T 190, D 2884	Ck. Outside Diameter	12
Metal Follower—T 190, D 2844	Ck. Diameter	12

TABLE 4 Aggregate Test Equipment

Equipment—Test Method	Requirement	Interval (Month)
Unit Weight Measures—T 19, C 29	Calibrate	12
Mechanical Shakers	Ck. Sieving Thoroughness	12
Gen. Purpose Balances, Scales & Weights	Verify	12
Sieves	Coarse (≥ 4.75 mm): Ck. Openings & Physical Condition Fine (< 4.75 mm): Ck. Physical Condition	6
Ovens	Verify Temp. Settings	4
Sulfate Oven—T 104, C 88	Ck. Rate of Evaporation	12
L.A. Machine—T 96, C 131	Ck. RPM & Crit Dimensions	24
Conical Mold, Tamper—T 84, C 128	Ck. Critical Dimensions	24
Steel Balls—T 96, C 131	Ck. Indiv. Wt. & Charge Wt.	24
Sodium Sulfate Containers—T 104, C 88	Ck Physical Condition	12

TABLE 5 Portland Cement Concrete Test Equipment

Equipment—Test Method	Requirement	Interval (Month)
Unit Weight Measures—T 121, C 138	Calibrate	12
Air Meters—T 152, T 196, C 173 C 231	Calibrate	3
Comp. Testing Machine—T 22, C 39	Verify Load Indications	12
Flex. Testing Machine T97, C78, T177, C293	Verify Load Indications	12
Capping Material	Check Strength	3
Slump Cones—T 119, C 143	Check Critical Dimensions	12
Metallic Reusable Molds—T 22, T 23, C 31, C 39	Check Critical Dimensions	12
Single Use Molds—T 22, T 23 C 31, C 39, C192	Check Dimensions of Each Ship-ment	—
Moist Room/ Storage Tanks—C 31, C 39	Temp. Verified with Recording Thermometer	—
Gen. Purpose Balances, Scales & Weights	Verify	12

TABLE 6 Hydraulic Cement Test Equipment

Equipment—Test Method	Requirement	Interval (Month)
Moist Cabinet/Water Task Recording Thermometer— T 106, C 109	Check for Accuracy	6
Storage Water—T 106, C 109	Check for Lime Saturation	6
General Purpose Balances, Scales & Weights	Verify	12
Analytical Balances & Weights	Verify	12
No. 325 Sieves—T 192, C 430	Clean after 5 Determinations Calibrate after 100 Determinations	—
No. 325 Nozzle—T 192, C 430	Check Flow Rate	6
Compression Testing Machine—T 106, C 109	Verify Load Indications	12
Bearing Blocks—T 106, C 109	Check Planeness	12
Wagner Turbidimeter—T 98, C 115	Calibrate	6
Standard Sand	Each new Shipment Check for Conformance to C 778	—
Air-Permeability Apparatus—T 153, C 204	Standardize Using NIST 114	30
Flow Tables—M 152, C 230	Verify Flow Results	30
Air Content Measures—T 137, C 185	Calibrate	30
Cube Molds and Tampers—T 106, C 109	Ck. Crit. Dim. And Phy. Cond.	30
Vicat Apparatus and Vicat Ring—T 129, T 131, T 186, C 187, C191, C 451	Ck. Crit Dim., Phy. Cond. and Mass	30
Gillmore Test Apparatus—T 154, C 266	Ck. Crit. Dim., Phy. Cond. and Mass	30
Mechanical Mixing Apparatus—T 162, C 305	Ck. Crit. Clearances and Speeds	30
Water-Retention Apparatus—C 91	Ck. Crit. Dimensions	30

Appendix B: Test Methods Which Require Complete Demonstration

SOIL Test Methods

Dry Preparation	T87/D421
Particle-Size Analysis (Hydrometer)	T88/D422
Liquid Limit	T89/D4318
Plastic Limit	T90/D4318
Shrinkage Factors	T92/D427
Standard Proctor (5.5-lb)	T99/D698
Specific Gravity	T100/D854
Moisture-Density Soil-Cements	T134/D558
Wetting and Drying Soil-Cements	T135/D559
Freezing and Thawing Soil-Cements	T136/D560
Wet Preparation	T146/D2217
Sand Equivalent	T176/D2419
Modified Proctor (10-lb)	T180/D1557
R-Value	T190/D2844
California Bearing Ratio (CBR)	T193/D1883
Unconfined Compressive Strength	T208/D2166
Sand Permeability	T215/D2434
Consolidation	T216/D2435
Direct Shear	T236/D3080
Moisture Content	T265/D2216
Unconsolidated Undrained (UU) Triax	T296/D2850
Consolidated Undrained (CU) Triax	T297/D4767
Nuclear Gauge - Density	T310/D2922
Nuclear Gauge - Moisture Content	T310/D3017
No. 200 Wash	D1140
Classification of Soils	D2487
Description / Identification of Soils	D2488
Flexible-Wall Permeability	D5084
Density & Unit Weight by Sand Cone	D1556
Density & Unit Weight by Rubber Balloon	D2167
Calibration of Laboratory Mechanical-Rammer Soil Compactors	D2168
Description & Identification of Soils (Visual-Manual Procedure)	D2488
Density by Drive Cylinder Method	D2937
Preserving & Transporting Samples	D4220
Maximum Index Density by Vibratory Table	D4253
Minimum Index Density	D4254
One-Dimensional Swell or Settlement Potential	D4546
Density by Sleeve Method	D4564
Determination of Water Content of Soil by Microwave Oven	D4643

BITUMINOUS Test Methods

Solubility	T44/D2042
Cleveland Flash	T48/D92
Penetration	T49/D5
Float	T50/D139
Ductility	T51/D113
Softening Point	T53/D36
Water in Petroleum	T55/D95
Distillation of Cut-Back	T78/D402
Tag Flash	T79/D3143
Thin-Film Oven (TFO)	T179/D1754
Kinematic Viscosity	T201/D2170
Absolute Viscosity	T202/D2171
Specific Gravity	T228/D70
Rolling Thin-Film Oven (RTFO)	T240/D2872
Hydrometer	T295/D3142
Force Ductility	T300
Elastic Recovery	T301
Bending Beam Rheometer (BBR)	T313
Direct Tension (DT)	T314
Dynamic Shear Rheometer (DSR)	T315
Rotational Viscosity (Brookfield)	T316/D4402
Residue of Specified Penetration	D243
Nickel Crucible	D3289
Toughness and Tenacity	D5801
Pressurized Aging Vessel (PAV)	R28

EMULSIFIED ASPHALT Test Methods

Residue by Distillation	T59 / D244
Residue by Evaporation	T59 / D244
Particle Charge	T59 / D244
Saybolt Viscosity	T59 / D244
Demulsibility	T59 / D244
Settlement	T59 / D244
Cement Mixing	T59 / D244
Sieve Test	T59 / D244
Storage Stability	T59 / D244

HOT-MIX ASPHALT Test Methods

Mechanical Analysis of Extracted Aggregate	T30/D5444
Moisture or Volatile Distillates	T110/D1461
AC Content by Extraction	T164/D2172
Effect of Water on Cohesion	T165/D1075
Bulk Specific Gravity	T166/D2726
Compressive Strength	T167/D1074
Abson Recovery	T170/D1856
Max. Specific Gravity (Rice)	T209/D2041
Marshall	T245/D1559
Hveem	T246/D1560
California Kneading Compactor	T247/D1561
Percent Air Voids	T269/D3203
Paraffin Bulk Specific Gravity	T275/D1188
Resistance to Moisture (TSR)	T283/D4867
AC Content by Nuclear Method	T287/D4125
AC Content by Ignition Oven	T308/D6307
Gyratory Compactor	T312
Density of Bituminous Concrete in Place by Nuclear Methods	D2950
Rotavapor Recovery	D5404
Unit Weight, Marshall Stability, and Flow of Bituminous Mixtures	CRD-C649
Density and Percent Voids	CRD-C650

AGGREGATE Test Methods

No. 200 Wash	T11/C117
Unit Weight	T19/C29
Organic Impurities	T21/C40
Sieve Analysis	T27/C136
Sieve Analysis of Mineral Filler	T37/D546
Fine Agg Specific Gravity	T84/C128
Coarse Agg Specific Gravity	T85/C127
L.A. Abrasion	T96/C131
L.A. Machine, Large Size Coarse Aggregate	T96/C535
Sulfate Soundness	T104/C88
Clay Lumps and Friable Particles	T112/C142
Lightweight Pieces	T113/C123
Sand Equivalent	T176/D2419
Aggregate Durability	T210/D3744
Reducing Field Samples	T248/C702
Moisture Content	T255/C566
Uncompacted Void Content	T304/C1252
Surface Moisture in Fine Aggregate	C70
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Abrasion Resistance of Concrete (Underwater Method)	C1138
Length Change Alkali-Silica Reaction	C1293
Sampling	D75
Flat & Elongated Particles	D4791
Fractured Faces	D5821
Fineness Modulus	CRD-C104
Flat & Elongated Particles	CRD-C119
Scratch Hardness	CRD-C130
Percentage of Crushed Particles in Aggregate	CRD-C171
Scales	

CONCRETE Test Methods

Plastic Concrete

Bleeding of Concrete	T-158/C232
Making and Curing Concrete Test Specimens in the Field	T-23/C31
Making and Curing Concrete Test Specimens in the Laboratory	T-126/C192
Slump of Hydraulic Cement Concrete	T-119/C143
Mass per Cubic Meter (Cubic Foot), Yield, and Air Content (Gravimetric) of Concrete	T-121/C138
Sampling Freshly Mixed Concrete	T-141/C172
Air Content of Freshly Mixed Concrete by the Pressure Method	T-152/C231
Air Content of Freshly Mixed Concrete by the Volumetric Method	T-196/C173
Time of Setting of Concrete Mixtures by Penetration Resistance	T-197/C403
Capping Cylindrical Concrete Specimens	T-231/C617
Density of Plastic and Hardened Portland Cement Concrete In-Place by Nuclear Methods	T-271/C1040
Temperature of Freshly Mixed Portland Cement Concrete	T-309/C1064
Ball Penetration	C360

Hardened Concrete for Strength

Compressive Strength of Cylindrical Concrete Specimens	T-22/C39
Obtaining and Testing Drilled Cores and Sawed Beams of Concrete	T-24/C42
Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)	T-97/C78
Compressive Strength of Concrete Using Portions of Beams Broken in Flexure	T-140/C116
Comparing Concrete on the Basis of the Bond Developed with Reinforcing Steel	T-159/C234
Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading)	T-177/C293
Splitting Tensile Strength of Cylindrical Concrete Specimens	T-198/C496
Developing Early-Age Compression Test Values and Projecting Later-Age Strengths	T-276/C918
Test Method for Compressive Strength of Lightweight Insulating Concrete	C495
Test Method of Making, Accelerated Curing, and Testing of Concrete Compression Test Specimens	C684
Test Method for Compressive Strength of Concrete Cylinders Cast in Place	C873
Cylindrical Molds	
Test Method for Pullout Strength of Hardened Concrete	C900
Practice for Estimating Concrete Strength by the Maturity Method	C1074

Test Method for the Break-Off Number of Concrete	C1150
Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders	C1231
Molds for Forming Concrete Test Cylinders Vertically	C470
Capping Cylindrical Specimens	C617

Hardened Concrete for Other than Strength

Measuring Length of Drilled Concrete Cores	T-148/C174
Length Change of Hardened Hydraulic Cement Mortar and Concrete	T-160/C157
Resistance of Concrete to Rapid Freezing and Thawing	T-161/C666
Cement Content of Hardened Hydraulic Cement Concrete	T-178/C1084
Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration	T-277/C1202
Test Method for Fundamental Transverse, Longitudinal, and Torsional Frequencies of Concrete Specimens	C215
Test Method for Length Change of Drilled or Sawed Specimens of Hydraulic-Cement Mortar and Concrete	C341
Test Method for Abrasion Resistance of Concrete by Sandblasting	C418
Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete	C457
Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression	C469
Test Method for Creep of Concrete in Compression	C512
Test Method for Unit Weight of Structural Lightweight Concrete	C567
Test Method for Pulse Velocity Through Concrete	C597
Test Method for Specific Gravity, Absorption and Voids in Hardened Concrete	C642
Test Method for Critical Dilation of Concrete Specimens Subjected to Freezing	C671
Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals	C672
Test Method for Abrasion Resistance of Horizontal Concrete Surfaces	C779
Test Method for Determining the Mechanical Properties of Hardened Concrete Under Triaxial Loads	C801
Test Method for Penetration Resistance of Hardened Concrete	C803
Test Method for Rebound Number of Hardened Concrete	C805
Practice for Examination and Sampling of Hardened Concrete in Construction	C823
Practice for Petrographic Examination of Hardened Concrete	C856
Test Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete	C876
Test Method for Abrasion Resistance of Concrete or Mortar Surfaces by the Rotating-Cutter Method	C944

Density of Concrete by Nuclear Method	C1040
Cement Content of Freshly Mixed Concrete	C1078
Water Content of Freshly Mixed Concrete	C1079
Portland Cement Content of Hardened Concrete	C1084
Test Method for Acid-Soluble Chloride in Mortar and Concrete	C1152
Determining Consistency and Density	C1170
Making Roller-Compacted Concrete	C1176
Test Method for Water-Soluble Chloride in Mortar and Concrete	C1218
P-Wave Speed	C1383
Residual Strength	C1399
Bond Strength	C1404
Soundness by Freezing and Thawing of Concrete	CDR-C114
Air-Entraining Admixtures for Concrete	

HYDRAULIC CEMENT Test Methods

Physical Tests

Fineness - Wagner Turbidimeter	T98/C115
Compressive Strength	T106/C109
Autoclave Expansion	T107/C151
Normal Consistency	T129/C187
Vicat Time of Setting	T131/C191
Air Content	T137/C185
Fineness - Air Permeability	T153/C204
Gillmore Time of Setting	T154/C266
Mechanical Mixing	T162/C305
Early Stiffening (False Set)	T186/C451
Fineness - No. 325 Sieve	T192/C430
Water Retention	C91

Chemical Tests

Silicon Dioxide (SiO_2)	T105/C114
Aluminum Oxide (Al_2O_3)	T105/C114
Ferric Oxide (Fe_2O_3)	T105/C114
Calcium Oxide (CaO)	T105/C114
Magnesium Oxide (MgO)	T105/C114
Sulfur Trioxide (SO_3)	T105/C114
Loss on Ignition (LOI)	T105/C114
Sodium Oxide (Na_2O)	T105/C114
Potassium Oxide (K_2O)	T105/C114
Titanium Dioxide (TiO_2)	T105/C114
Phosphorous Pentoxide (P_2O_5)	T105/C114
Zinc Oxide (ZnO)	T105/C114
Manganic Oxide (Mn_2O_3)	T105/C114
Sulfide Sulfur (S)	T105/C114
Chloride (Cl)	T105/C114
Insoluble Residue (IR)	T105/C114
Free Calcium Oxide (C_a)	T105/C114
Water-Soluble Alkali (Alk_{sol})	T105/C114
Chloroform - Soluble (Chl_{sol})	T105/C114

ROCK Test Methods

Triaxial Compressive Strength, Undrained w/o Pore Pressures	D2664
Pulse Velocity and Ultrasonic Elastic Constants	D2845
Direct Tensile Strength of Intact Rock Core	D2936
Unconfined Compressive Strength	D2938
Modulus of Elasticity (Static) in Uniaxial Compression	D3148
Tensile Strength, Splitting (Brazilian) Method	D3967
Rock Bolt Anchor Pull Test	D4435
Preparing Rock Core Specimens and Determining Tolerances	D4543
Slake Durability of Shales and Weak Rocks	D4644
Durability of Rock to Freezing and Thawing	D5312
Durability of Rock to Wetting and Drying	D5313
Laboratory direct Shear Tests on Rock Under Constant Normal Force	D5607
Point Load Index	D5731
Rock-Mass Classification for Engineering Purposes	D5878
Resistance of Rock to Freezing and Thawing	CRD-C144
Expansive Breakdown on Soaking in Ethylene Glycol	CRD-C148
Resistance of Rock to Wetting and Drying	CRD-C169

METAL Test Methods

Zinc-Coated Steel Wire Rope and Fittings for Highway Guardrail

Ductility of Steel (Wrap Test)	M30
Adherence of Coating	M30
Mass of Zinc Coating	T65/A90
Tensile Strength	T244/A370

Steel Wire, Plain, for Concrete Reinforcement

Steel Wire, Deformed, for Concrete Reinforcement

Tension Test	T244/A370
Bend Test	M32

Steel Welded Wire Fabric, Plain, for Concrete Reinforcement

Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement

Tensile Strength	T244/A370
Bend Test	M32/A82
Weld Shear Test	M55/A185

Gray Iron Castings

Tensile Strength	T68/E8
Flexure Test	M105

Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

Adhesion of Coating	M111/A123
Thickness of Zinc Coating	M111/A123

High-Strength Bolts for Structural Steel Joints

Brinell Hardness	F606
Rockwell Hardness	F606
Tensile Strength	F606
Proof Load Determination	F606
Rotational Capacity	F606

Structural Steel

Charpy V-Notch	T266/E23
Tension Test	T68/E8
Bend Test	T244/A370

Steel Strand, Uncoated Seven-Wire for Concrete Reinforcement

Tensile Strength	T244/A370
Low Relaxation Strand	E328

Epoxy Coated Reinforcing Bars

Film Thickness	G12
Continuity of Coating (Holidays)	G62
Adhesion of Coating (Bend Test)	M284/A775

PLASTIC PIPE Test Methods

Corrugated Polyethylene Drainage Pipe

Pipe Stiffness	D2412
Pipe Flattening	M252
Elongation	M252

ABS and PVC Composite Sewer Piping

Stiffness and Deflection	D2412
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Class PS46 PVC Pipe

Impact Resistance	D2444
Pipe Stiffness	D2412
Pipe Flattening	M278

Corrugated Polyethylene Pipe, 300 to 1200-mm (12 to 48-in.) Diameter

Pipe Stiffness	D2412
Pipe Flattening	M294
Brittleness	D2444

MASONRY Test Methods

Compressive Strength of Hydraulic Cement Mortar	T106/C109
Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency	T162/C305
Air Content of Hydraulic Cement Mortar	T137/C185
Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete	M210/C490
Sampling and Testing Brick and Structural Tile Clay	C67
Sampling and Testing Concrete Masonry Units and Related Units	C140
Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry	C780
Sampling and Testing Grout	C1019
Compressive Strength of Masonry Prisms	C1314

Appendix C: Equipment for Verification Checks

Several of the checklists for construction materials tests require assessors to perform verification checks of laboratory equipment. The following list includes recommended equipment for performing those checks. This list is not considered mandatory or exhaustive. The Accreditation Body is responsible for ensuring that the appropriate equipment is used for each verification, and that it is appropriately calibrated.

Dimensional Equipment

- Angle gauge ($90 \pm \frac{1}{2}^\circ$) for cube molds
- 45° with 2 $\frac{1}{2}$ - in. circumference gauge (for flexure apparatus)
- Bar mold height/width gauge
- Bar mold length gauge
- Calipers – Inside, outside; various sizes
- Dividers (for measuring gauge length)
- Feeler gauges
- Feeler wires (for mechanical mixer)
- Gage blocks - for flow table, verification of dimensional hand tools
- Micrometers – Inside, outside; various sizes
- Protractor
- Pocket optical comparator (7X)
- Rulers (scales)
- Squares with level (6" & 12")
- Tampering rod gauge
- Telescoping gauges (0.5", 2")

Mechanical Equipment

- Charpy Samples
- Durometers (A, D)
- Glass Plate (12" x 12")
- Hardness blocks (Rockwell, Brinell)
- Hoke valve
- Load cells
- Masses
 - Assorted set (Class S)
 - Set of 4 2000g weights, 2 1000g, 2 500g, Class S
 - Set of tolerance weights for unit weight scales
- Resilience Tester
- Spherometer
- Stopwatch
- Tachometer
- Tee mount for gauges
- Torque wrench (50 foot pounds capacity)
- Vacuum Gauge and accessories
- Vibration tester

Temperature/Thermodynamic Equipment

Barometer

Brass Wells (3)

Motorized psychrometer

Sling psychrometer

Sling thermometers

Thermometers – Autoclave, 110° C, 150° C

Electrical

Microammeter test set

Pair of leads with alligator clips